The Effects of For-profit and Nonprofit Subsidized Schools on Academic Performance

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Abstract

In a context with multiple treatments, I estimate the effects of attending for-profit and nonprofit secondary schools in Chile. I fit my model to rich administrative data for the universe of Chilean students attending public and voucher subsidized private (for- and nonprofit) schools. My results show that attending a public secondary school decreases verbal scores by about 0.11–0.15 standard deviations (σ), and decreases math scores by about 0.18–0.24σ. Attending a for-profit secondary school has associated the following treatment effects: -0.07–0.04σ for verbal, and -0.09–0.11σ for math. Finally, attending a nonprofit secondary school increases verbal scores by about 0.11–0.13σ, and increases math scores by about 0.13–0.21σ. I also show important heterogeneity in the treatment effects with respect to the unobserved ability, with low ability students benefitting most from nonprofit schools, and high ability adolescents experiencing greater returns with for-profit enrollment.

Keywords: for-profit schools, private education, Chile, vouchers

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1 Introduction

In the past few decades, private schools have experienced a boom in developing countries. The enrollment shares of private schools are as high as 35% in Pakistan (primary education, in 2013), and have been rapidly increasing over time, with countries such as Sierra Leone seeing its private enrollment share for primary education doubling in two years (going from 3.5% in 2011 to 7.8% in 2013).[1] This rapid emergence of private schools in the developing world is thought to come as a response to a general parental dissatisfaction with government schools, that are characterized by teachers absenteeism, and bad teaching practices (Ashley et al., 2014). In this paper, I study the private sector of education in Chile, a middle-income country with more than forty years of experience with subsidized private schools, to draw conclusions on whether private schools are effective in providing quality education.

In contrast to what happens in the United States and other developed countries, where private schools are a privilege of the rich, in poorer countries families of all social classes send their children to private institutions. Most of these schools are single operators that charge a few dollars a month, and many use abandoned warehouses to instruct the lectures. Chains of schools are also part of the supply.[2] The costs of education delivery are known to be low, and lower than those of public schools, often due to lower salaries for teachers compared to their government counterparts (Ashley et al., 2014). In spite of this, recent studies argue that the quality of teaching is better in private schools than in government schools, in terms of higher levels of teacher presence and teaching activity.[3] Also, private school students achieve relatively higher learning outcomes. The evidence is ambiguous about whether private schools reach the most disadvantaged, but it does note that private schools are more prevalent in urban than in rural areas, and that financial constraints limit poorer households from enrolling private schools.

Despite the fact that our understanding of the channels through which private schools impact children's learning in developing countries has advanced rapidly in recent years, there still remain gaps and challenges for research that have not been paid enough attention to. Crucially, it is often hard to distinguish between for-profit and nonprofit schools due to data limitations. This distinction is critical as the profit motive can significantly influence school practices, resource allocation, and ultimately, student outcomes. In this paper, I uses tax records that allow me to observe the profit motive of private schools.

I estimate the effects of attending public, private for-profit, and private nonprofit schools on students' learning, by estimating a model of school choice and academic performance in the spirit of Roy (1951) and Willis and Rosen (1979), that allows for endogenous outcomes, and controls

[1] All these numbers are according to The World Bank.

[2] Bridge International Academies in Kenya, and BRAC in Bangladesh are two good examples of these chains.

[3] See Kremer and Muralidharan (2008), Muralidharan and Sundararaman (2015), and Ashley et al. (2014).

for unobserved heterogeneity.[4]

My results show that private schools do a better job in increasing learning outcomes relative to public schools. The effects are heterogeneous in the profit motive of the school and in the administrative type of the school attended in primary level. Specifically, attending a for-profit secondary school increases test scores only for students having attended a public or a private for-profit school in primary. On the other hand, attending a nonprofit secondary school has positive effects on test scores for everybody. On the contrary, attending a public secondary school decreases test scores for all students.

Heterogeneity exercises show that the negative effects of attending public secondary schools are found in the entire distribution of treatment (on the treated) effects. Interestingly, low ability students experience the greatest gains in standardized test scores when enrolling in nonprofit secondary schools, while high ability students achieve higher scores when attending nonprofit secondary schools.

This paper contributes to the literature twofolds. First, it adds to the existing evidence on the effectiveness of private-voucher schools and, in particular, of for-profit institutions.[5] My closest predecessor is Singleton (2017), that studies for-profit management in charter schools in Florida. He finds that an equivalent level of per-pupil expenses purchases 0.03σ higher student proficiency in math and reading at network for-profit charter schools. However, such schools spend 11% less per pupil. Other papers include Sahlgren (2011), that finds no significant difference on academic performance between for-profit and nonprofit schools in Sweden, and Elacqua (2015), that documents a slightly poorer performance of profit-seeking schools in Chile. I extend and improve these papers' analyses by estimating joint distributions of counterfactual gains from a model that accounts for school selection and individuals' unobserved heterogeneity.

I also contribute to the literature that analyzes for- and nonprofit operation in industries that, similar to education, feature mixed production (Malani et al., 2003; Steinberg and Weisbrod, 2005). The health sector is the focus of numerous comparisons (Keeler et al., 1999; Duggan, 2002; Sloan, 2000; Sloan et al., 2001; Deneffe and Masson, 2002; Ballou and Weisbrod, 2003; Silverman and Skinner, 2004; Lindrooth and Weisbrod, 2007). Overall, the evidence is mixed, and suggests that for- and nonprofit hospitals are more similar than different.

The remainder of the paper is organized as follows. Section 2 describes and characterizes the education system in Chile. Section 3 presents the empirical approach of the paper. It describes a structural model of school-type choice and academic performance, presents the estimation strategy, and defines the treatment effect parameter of interest. Section 4 describes the data and their

[4]See, also, Heckman et al. (2018).

[5]See Rouse (1998), Nechyba (2000), McEwan (2001), Angrist et al. (2002), Angrist et al. (2006), Rouse and Barrow (2009), Lara et al. (2011), Chung (2012), Cellini and Chaudhary (2014), Elacqua (2015), Singleton (2017), Abdulkadiroglu et al. (2018), Cellini et al. (2020), among others.

relation to the model. Section 5 shows and discusses the results. Section 6 concludes.

2 The Context

2.1 Administrative Types of Schools in Chile

Schools in Chile can be grouped into three main groups according to their administration and financing scheme: public schools, private-voucher schools, and private-fee-paying schools. Both public and private-voucher schools are financed by a per-student voucher subsidy paid by the government directly to the schools. Private-fee-paying schools are financed by fees charged to parents. They serve the country's richest families, and the high amount of their fees makes of them an unrealistic alternative for the vast majority of students in Chile (Sanchez, 2023). Private-fee-paying schools enroll about 7% of all students, and school transitions between these schools and public/private-voucher schools are very rare (around 3%).

Private-voucher schools can be either for-profit or nonprofit. Among for-profit schools, we find schools that belong to chains, and schools that are independent. Chains are usually controlled by a group of owners, and are characterized by networks of campuses. Independent schools are small in size, and are often owned by former public school teachers. Nonprofit schools include religious and non-sectarian organizations. They receive donations, and are most of the time subsidized by the Church or local businesses. They are also characterized by networks of campuses (Elacqua et al., 2015).

Table 1 displays the number and share of schools and students for each type of school, for the year 2013.[6] Panel *i* presents figures for all schools offering primary and/or secondary levels.[7] Panel *ii* does the same for schools offering primary education—that may or may not offer secondary education—and for children attending primary grades. Panels *iii* and *iv* do analogously for conventional secondary education and vocational secondary education, respectively. Overall, a little more than half of all schools are publicly administered. 27.3% of all schools are private-voucher for-profit, and 12.4% are private-voucher nonprofit. Only 4.7% of all schools are private-fee-paying. In terms of enrollment, 39.7% of students attend pubic schools, while almost a third attend voucher for-profit schools, and a fifth go to nonprofit institutions. Only 7.8% of all students are enrolled in private-fee-paying schools. Very similar figures are observed in panel *ii* for primary education. In conventional secondary education (panel *iii*), the private-fee-paying sector becomes more important, at the expense of public schools. The share of enrollment for voucher for-profit schools is similar to that observed for public schools—33.1% and 32.9%, respectively. Nonprofit

[6] All numbers come from administrative data from the Ministry of Education of Chile.

[7] In Chile, primary education consists of grades 1st-8th, while secondary education consists of grades 9th-12th.

schools enroll 21.7% of all students. In the vocational secondary level, the private-fee-paying sector is virtually nonexistent. The public and private-voucher sector equally split the market, with both for-profit and nonprofit voucher schools enrolling a quarter of all students.

Table 1: Schools and Enrollment by Type of School

type of school		schools		enrollment	
		obs.	%	obs.	%
i. overall					
public		5,098	55.7	1,120,811	39.7
private-voucher					
	total	3,629	39.6	1,480,889	52.5
	for-profit	2,495	27.3	903,097	32.0
	nonprofit	1,134	12.4	577,792	20.5
private-fee-paying		428	4.7	219,487	7.8
ii. primary					
public		4,740	55.3	785,042	40.4
private-voucher					
	total	3,412	39.8	1,013,514	52.1
	for-profit	2,385	27.8	634,195	32.6
	nonprofit	1,027	12.0	379,319	19.5
private-fee-paying		419	4.9	145,805	7.5
iii. secondary - conventional					
public		624	25.2	196,532	32.9
private-voucher					
	total	1,476	59.6	327,820	54.8
	for-profit	926	37.4	198,078	33.1
	nonprofit	550	22.2	129,742	21.7
private-fee-paying		375	15.2	73,658	12.3
iv. secondary - vocational					
public		445	50.6	139,237	49.9
private-voucher					
	total	433	49.2	139,555	50.1
	for-profit	233	26.5	70,824	25.4
	nonprofit	200	22.7	68,731	24.7
private-fee-paying		2	0.2	24	0.0

Notes: Calculated using administrative data from the Ministry of Education. All figures are for the year 2013. Only schools offering primary and/or secondary education for children and adolescents are included. Schools that offer both primary and secondary levels are included in both the panel for primary education and in the respective panel for secondary level.

2.2 Characterizing Public, For-profit and Nonprofit Schools

Schools in each school-type share common characteristics, and therefore attending a school of a particular type implies having access to characteristics that are distinctive to that type. This section characterizes each school-type in terms of regulation, school organization, and institutional and peers characteristics.

In terms of regulation, in public schools, teachers' job contracts are governed by the Teacher Statute, wages are based on uniform pay-scales, and schools have dismissal restrictions. In private schools, teachers' job contracts are ruled by the Labor Code, which allows schools to more freely hire and dismiss teachers. In addition, the regulation for for-profit schools is different than the one for nonprofits. The main difference is that nonprofit organizations in Chile are eligible for tax exemptions that for-profits are not eligible for, including exemptions on income, valued added, inheritance, and real estate taxes, as well as industrial and commercial patents, custom tariffs, and social security.[8] However, the process of creating a nonprofit organization is slower, more costly, and more bureaucratic than the process for creating a for-profit organization.

Tables 2–8 display a number of school characteristics by type of school in 2013, where I compare public, for-profit, and nonprofit institutions in terms of enrollment, class size, fees, teacher inputs, religious orientation, admission criteria, and demographic characteristics.

Table 2 displays the average enrollment, number of classes, and class size in the public, for-profit, and nonprofit sectors. Panel *i* presents numbers for both primary and secondary education levels, while the rest of the panels do the same separately for primary, conventional secondary, and vocational secondary education levels. Overall, for-profit schools are smaller than nonprofit schools, both in terms of enrollment (362 vs. 509.5) and number of classes (12.1 vs. 15.2). For-profit schools also have on average slightly smaller class sizes (24.6 vs. 29.1 in nonprofit schools). Public schools are significantly smaller than both for-profits and nonprofits, and also have smaller class sizes. This pattern remains the same when I compare the sectors separately by education level. In panel *ii*, we additionally observe that public schools have the largest share of multigrade teaching (23.2%), followed by for-profit schools (10.9%), and then by nonprofit schools (5.5%).[9]

[8] For a description of the legal requirements of nonprofit organizations in Chile and the liability of their members, see Viveros (2007) and Chile-Transparente (2008).

[9] Schools are allowed to combine grades only in preschool and primary levels, and the grades that can be combined in primary are 1st–6th and 7th–8th.

Table 2: Enrollment and Classes by Type of School

	public	for-profit	nonprofit
i. overall			
enrollment	219.9	362.0	509.5
number of classes	8.9	12.1	15.2
class size	17.8	24.6	29.1
ii. primary			
enrollment	154.0	254.2	334.5
number of classes	6.8	8.8	10.1
class size	16.8	24.3	29.1
% of multigrade classes[a]	23.2	10.9	5.5
iii. secondary - conventional			
enrollment	38.6	79.4	114.4
number of classes	1.2	2.4	3.3
class size	30.2	31.1	32.9
iv. secondary - vocational			
enrollment	27.3	28.4	60.6
number of classes	0.9	0.9	1.8
class size	25.3	28.1	30.9

Notes: Calculated using administrative data from the Ministry of Education. All figures are for the year 2013. Only schools offering primary and/or secondary education for children and adolescents are included.
[a] Multigrade classes are allowed only in preschool and primary levels. Schools can combine 1st to 6th grades and 7th and 8th grades for the case of primary education.

Table 3 presents statistics on monthly tuition charged by schools. Each cell represents the percentage of schools in a particular administrative type (public, for-profit, or nonprofit) charging an amount within the price range given by the row title. I include all public, for-profit, and nonprofit schools that offer primary and/or secondary levels for children and adolescents. For-profit schools and nonprofit schools charge similar monthly tuition, where 45.5% of for-profit schools and 42.2% of nonprofit schools charge zero, and almost ten percent of both types of schools charge more than CLP 50,000.[10]

[10] As of March 16th, 2015, one dollar exchanges for 640 Chilean pesos.

Table 3: Monthly Tuition by Type of School - Schools Offering Primary and/or Secondary Education

	public	for-profit	nonprofit
no charge	96.1	45.6	42.2
1,000–10,000	2.3	8.4	7.9
10,001–25,000	0.2	19.8	19.5
25,001–50,000	0.0	16.5	17.5
50,001–100,000	0.0	9.0	9.6

Notes: Calculated using administrative data from the Ministry of Education. All figures are for the year 2013, and represent percentages of schools by each type of school. Only schools offering primary and/or secondary education for children and adolescents are included. Tuition values are in Chilean pesos. As of March 16th, 2015, one dollar exchanges for 640 Chilean pesos.

In Table 4, I present the same analysis as in Table 3, but restricted to schools that offer secondary education levels—that may or may not offer primary level, as well. The majority of public schools charge no monthly tuition, 13.4% charge less than CLP 10,000, and 1.3% charge between CLP 10,001 and CLP 25,000. There is a lower percentage of for-profit schools charging zero monthly tuition than nonprofit schools (16.1% vs. 24.2%). In general, for-profit secondary schools charge higher monthly tuition than nonprofit schools.

Table 4: Monthly Tuition by Type of School - Schools Offering Secondary Education

	public	for-profit	nonprofit
no charge	84.6	16.1	24.2
1,000–10,000	13.4	8.1	9.9
10,001–25,000	1.3	26.1	22.5
25,001–50,000	0.0	30.7	25.3
50,001–100,000	0.0	18.7	15.5

Notes: Calculated using administrative data from the Ministry of Education. All figures are for the year 2013, and represent percentages of schools by each type of school. Only schools offering secondary education for children and adolescents are included. Tuition values are in Chilean pesos. As of March 16th, 2015, one dollar exchanges for 640 Chilean pesos.

Table 5 compares a number of teacher inputs by type of school. Specifically, I show figures on pupil-teacher ratios, teachers' degree characteristics, and type of teachers' contract. I present the numbers for primary and secondary education levels in panel *i*, and separately for primary, conventional secondary, and vocational secondary in panels *ii*, *iii*, and *iv*, respectively. In general, public schools have smaller pupil-teacher ratios than both for-profit and nonprofit schools, and for-profit schools are similar to nonprofit school in that respect—except in secondary education, where all three types of school have similar ratios. All three types of school have very similar percentages of teachers with a degree in education, of teachers with a degree from a university, and of teachers with a degree from a 2- or 4-year higher education technical institutions. In general, there is a larger share of teachers with permanent contracts in nonprofits schools than in for-profit schools, while the opposite is observed for teachers with contract jobs. Public schools have a smaller share of teachers with permanent positions and a larger share of teachers with temporary contracts than both for-profit and nonprofit schools.

Table 5: Teacher Inputs by Type of School

	public	for-profit	nonprofit
i. overall			
pupil-teacher ratio	11.1	16.4	16.9
teachers' degree			
degree in education (%)[a]	96.1	95.2	94.3
institution attended: university (%)	90.0	89.4	91.0
institution attended: 2-y or 4-y technical (%)[b]	6.4	6.3	5.8
type of contract			
permanent (%)	46.8	57.2	60.6
contract (%)	43.8	37.9	35.3
ii. primary			
pupil-teacher ratio	10.7	15.8	16.4
teachers' degree			
degree in education (%)[a]	97.5	96.9	97.4
institution attended: university (%)	90.3	89.4	91.5
institution attended: 2-y or 4-y technical (%)[b]	6.2	6.5	5.8
type of contract			
permanent (%)	46.7	58.3	61.2
contract (%)	43.3	36.6	34.3
iii. secondary - conventional			
pupil-teacher ratio	12.5	13.0	12.7
teachers' degree			
degree in education (%)[a]	92.9	92.1	94.1
institution attended: university (%)	92.2	92.4	93.4
institution attended: 2-y or 4-y technical (%)[b]	4.1	2.7	3.4
type of contract			
permanent (%)	43.6	49.8	59.5
contract (%)	51.5	47.4	38.4
iv. secondary - vocational			
pupil-teacher ratio	16.7	19.2	16.6
teachers' degree			
degree in education (%)[a]	63.3	66.2	71.5
institution attended: university (%)	78.0	77.9	81.9
institution attended: 2-y or 4-y technical (%)[b]	15.9	15.9	12.5
type of contract			
permanent (%)	36.8	54.5	63.7
contract (%)	59.5	43.0	34.2

Notes: Calculated using administrative data from the Ministry of Education. All figures are for the year 2013. Only schools offering primary and/or secondary education for children and adolescents are included. [a] Only degrees in education obtained from higher education institutions are considered. [b] Only 2-years technical institutions (CFT) and 4-years professional institutes (IP) are considered.

Table 6 compares public, for-profit, and nonprofit schools in terms of religious orientation and admission criteria. Non-profit schools are in general less secular and more Catholic than for-profit schools, which in turn are fairly similar to public schools in their religious orientation. Both types of private schools are shown to be more selective than public schools, at least with respect to the requirements asked to parents at the moment of trying to enroll their children in a school. Nonprofit schools are also more selective than for-profit schools.

Table 6: Religious Orientation and Admission Criteria by Type of School

	public	for-profit	nonprofit
religious orientation (% of schools)[a]			
secular	52.0	54.0	17.9
catholic	40.9	30.5	65.0
other religion	7.1	15.4	13.7
admission requirements (% of schools)[a]			
preschool evaluation	18.1	24.0	29.4
civil marriage certificate	2.4	3.4	11.4
transcripts from former school	68.8	69.8	64.2
baptism and/or marriage through the Church certificates	0.9	2.1	28.5
income certificate	2.4	6.1	9.9
parents' interview	18.3	42.3	57.6
exam	20.6	41.7	55.5
psychological evaluation/report	19.6	26.3	25.3

Notes: Administrative data from the Ministry of Education for schools offering primary and/or secondary education for children and adolescents were used to construct the indicators on religious orientation. Responses to the SIMCE parents' questionnaire were used to construct the indicators on admission requirements. All figures are for the year 2013. [a] All numbers represent percentages of schools by each type of school.

Table 7 shows demographic characteristics at the municipality level for each type of school, as well as the urban status of the school as defined by the Ministry of Education. Public schools are in general located in less wealthy, predominantly poorer, and smaller in population municipalities than both for-profit and nonprofit schools. Public schools are also more rural. For-profit schools do not differ much from nonprofit schools in terms of the average income per capita and the poverty rate of the municipality where they are located. For-profit schools are, however, located in areas with larger population, and are somewhat more rural than nonprofit schools.

Table 7: Municipality Characteristics and Urban Status by Type of School

	public	for-profit	nonprofit
municipality's monthly income per capita (CLP)	305,158	325,939	328,806
municipality's poverty rate	17.6	14.4	15.3
municipality's population	121719	223629	168975
school urban status (%)	42.1	73.5	83.2

Notes: Municipality characteristics come from CASEN 2013 survey data. School's urban status comes from administrative data from the Ministry of Education for schools offering primary and/or secondary education for children and adolescents. All figures are for the year 2013. As of March 16th, 2015, one dollar exchanges for 640 Chilean pesos.

Table 8 displays average test scores and family background characteristics for each type of school. Students in nonprofit schools have higher test scores (on average) on standardized exams than students in for-profit schools, which in turn have higher test scores than students in public schools. Parents of students in private schools are slightly more educated than parents of students in public schools. Finally, students in private schools come from families that are predominantly wealthier than families of students in public schools.

Table 8: Average Tests Scores and Family Background Characteristics by Type of School

	public	for-profit	nonprofit
language score	-0.20	0.04	0.29
math score	-0.29	0.09	0.37
father's years of education	9.9	11.5	11.6
mother's years of education	10.0	11.5	11.7
household monthly income: less than 200,000 (%)[b]	37.0	19.4	19.0
household monthly income: 200,001–300,000 (%)[b]	26.3	21.5	21.5
household monthly income: 300,001–400,000 (%)[b]	13.3	14.4	14.8
household monthly income: more than 400,000 (%)[b]	20.1	41.7	41.9

Notes: Calculated using administrative data from SIMCE 2013 and SIMCE 2013 responses to parents' questionnaire, for 10th graders. I normalize test scores to have an overall mean of zero and standard deviation of one, by subject. As of March 16th, 2015, one dollar exchanges for 640 Chilean pesos.

Summing up, a public secondary school is a school that faces stringent regulation regarding teachers' job contracts, has relatively small class-sizes, has low or no fees, has no particular religious orientation, is in general non-selective, is present in rural areas, and its students come from relatively poor backgrounds. A for-profit secondary school is a school that faces a flexible teachers' contract regulation, charges relatively high fees, has no particular religious orientation, is selective, has low presence in rural areas, and its students come from relatively wealthy environments. Finally, a nonprofit secondary school is a school that faces a flexible teachers' contract regulation, is eligible for tax exemptions, charges relatively high fees, is predominantly Catholic, is selective, has low presence in rural areas, and its students come from relatively wealthy environments.

3 Empirical Model

3.1 A Model of School-Type Choice and Academic Performance

Following the literature on structural choice models with factor components, I approximate the school-type selection process of Chilean students with a discrete-continuous econometric model of school-type choice and test scores.[11] I assume that there are S types of secondary schools, and that parents choose the optimal type, s^*, according to a utility-maximizing argument:

$$s^* = \underset{s\in\{1,\ldots,S\}}{\text{argmax}} \{I(s)\},$$

where I assume a linear-in-parameters form for $I(s)$:

$$I(s) = Z\gamma_s + \eta^D(s) \qquad \text{for each } s \in \{1,\ldots,S\}. \tag{1}$$

Z is a vector of observed variables relevant to the decision, and $\eta^D(s)$ is the error term that also contains unobserved (but relevant) characteristics. $I(s)$ should be interpreted as the value of the indirect utility function associated to the choice s. This indirect utility function is the result of a standard utility maximization problem, and consequently Z contains variables associated to the utility function and to the budget constraint. I allow $\eta^D(s)$ and $\eta^D(s')$ to be correlated for any $s \neq s'$. I impose a factor structure to the model. Specifically,

$$\eta^D(s) = \alpha_s^D f + \nu^D(s) \qquad \text{for each } s \in \{1,\ldots,S\}, \tag{2}$$

where f is one-dimensional and denotes the unobserved heterogeneity. $\nu^D(s)$ represents an idiosyncratic error term, and satisfies $\nu^D(s) \perp\!\!\!\perp \nu^D(s') \perp\!\!\!\perp f \perp\!\!\!\perp (Z,X)$ for any s and $s' \neq s$, where $\perp\!\!\!\perp$ denotes statistical independence.[12]

I also model academic performance for each school-type $s \in \{1,\ldots,S\}$ as test score equations. Let $T(s)$ denote a $J \times 1$ vector of test scores, given schooling choice s. I assume the following

[11] See Aakvik et al. (1999), Aakvik et al. (2005), Cameron and Heckman (2001), Carneiro et al. (2003), Hansen et al. (2004), Sarzosa and Urzúa (2021), Urzua (2008) for applications of similar models in other contexts.

[12] $X = (X^T, X^M)$ is a vector containing all the observable variables from the other parts of the model.

linear-in-parameters form for $T(s)$:

$$T(s) = X^T \beta_s^T + \alpha_s^T f + \nu^T(s) \qquad \text{for each } s \in \{1, \dots, S\}, \tag{3}$$

where X^T contains observed variables determining test scores, and $\nu^T(s) \perp\!\!\!\perp \nu^T(s') \perp\!\!\!\perp f \perp\!\!\!\perp (Z, X)$ for any s and $s' \neq s$.

Finally, I posit a linear measurement system to identify the distribution of the unobserved factor, f, that is independent of the observed optimal school-type s^*. I supplement the model described above with a vector of linear equations linking early taken test scores with observed characteristics and the unobserved heterogeneity. This allows me to interpret f as a combination of different latent abilities affecting measured ability.[13] I model each of the equations in the measurement system as:

$$M_l = X_l^M \beta_l^M + \alpha_l^M f + \nu_l^M \qquad \text{for each } l \in \{1, \dots, L\}, \tag{4}$$

where L is the total number of linear equations in the system. The error term ν_l^M is statistically independent of the factor, the observable variables, and of $\nu^D(s)$ and $\nu^T(s')$ for any school-types s and s'.

This model of school-type choice and test scores shares the structure of the model in Hansen et al. (2004), and consequently I can directly apply their argument to prove its non-parametric identification. Specifically, I can apply Theorem 1 in Hansen et al. (2004) and Kotlarski Theorem (Kotlarski, 1967) to prove the identification of the distribution of the latent factor as well as the identification of the parameters in the latent utilities and test scores equations.

3.2 Estimation Strategy

I am able to observe the optimal school-type decisions (s^*), as well as the associated observable characteristics (Z, X). I also observe test scores as outcomes (T), which combine counterfactual scores and decisions in the following fashion:

$$T_i = \sum_{s=1}^{S} T_i(s) \times D_i(s),$$

where $D_i(s) \equiv \mathbb{1}[s = s^*]$, and $\mathbb{1}[\cdot]$ is an indicator function that takes a value of one if the argument is true, and zero otherwise. Also, $\sum_{s=1}^{S} D_i(s) = 1$. Finally, I observe early taken test scores (M). The key insight of my approach is that, conditional on the unobserved heterogeneity (f), all error

[13] In this setting, f includes unobserved factors that directly determine test scores such as cognitive and non-cognitive abilities.

terms are mutually independent. Thus, the likelihood function can be written as:

$$\prod_{i=1}^{N}\int\left\{\begin{array}{c}\left[g(\mathbf{T}_i(1)|X_i,f,D_i(1)=1)Pr\left[D_i(1)=1|X_i,f\right]\right]^{D_i(1)}\\ \vdots\\ \left[g(\mathbf{T}_i(S)|X_i,f,D_i(S)=1)Pr\left[D_i(S)=1|X_i,f\right]\right]^{D_i(S)}\end{array}\right\}\Pi_{j=1}^{J}h(M_{ij}|X_i,f)dG(f).$$

I also assume that f is distributed according to a three-component mixture of normals. Formally,

$$f\sim p_1N(\mu_1,\sigma_1^2)+p_2N(\mu_2,\sigma_2^2)+p_3N(\mu_3,\sigma_3^2).$$

This assumption provides enough flexibility and doesn't impose normality a priori. I estimate the entire model using Markov Chain Monte Carlo methods, and I use the sampling proposed by Gibbs. My use of Bayesian methods is merely for computational reasons, and to avoid the computation of the integral in the likelihood function. I am interested primarily in the mean of the posterior distribution, and therefore my analysis follows the classical perspective and is interpreted as an estimator that has the same asymptotic sampling distribution as the maximum likelihood estimator. See Robert and Casella (1999) for more details. See also Appendix C in Hansen et al. (2004) for the estimation procedure.

3.3 Definition of the Treatment Parameter of Interest

In this multiple potential outcomes setting, I am interested in estimating the effects of attending a school of type s^*, where s^* is optimal in the choice set $\{1,\ldots,S\}$ relative to attending a school of type k^*, where k^* is optimal in the choice set $\{1,\ldots,S\}\setminus s^*$. That is, I want to estimate counterfactual gains for first-best vs. second-best pairs. To do so, I define the Average Treatment Effect on the Treated (TT) of attending a school of type s^* as follows:[14]

$$TT(s^*)\ =\ \sum_{k^*\in\{1,\ldots,S\}\setminus s^*}E\left[Y_i(s^*)-Y_i(k)|D_i(s^*)=1\right]\times Pr\left[D_i(k^*)=1|D_i(s^*)=1\right],$$

where $s^*=\text{argmax}_{s\in\{1,\ldots,S\}}\{I(s)\}$, and $k^*=\text{argmax}_{k\in\{1,\ldots,S\}\setminus s^*}\{I(k)\}$. That is, the TT parameter compares the first-best alternative with the second-best alternative for each individual, and takes the average over all individuals who's first-best is s^*. The TT parameter is of interest in any program where the treatment status is endogenously determined by the agents, as it informs about the effect of the program for those who choose to be treated.

[14]See Heckman et al. (2006) and Heckman and Vytlacil (2007).

4 Data and Empirical Implementation

I use data from the SIMCE 2013 for 10th graders. SIMCE is a mandatory national standardized battery of tests aimed at measuring the degree of students' learning in a number of subjects at various educational levels. Specifically, SIMCE is taken by all students in 4th grade every year, and since 2005 it rotates between 8th and 10th grades in a yearly fashion. The subjects evaluated in 10th grade are verbal and mathematics. SIMCE data contain information on test scores, school characteristics, and student and family characteristics. I merge these data with tax records for school providers, so I can identify the for-/nonprofit status of the schools, and with CASEN 2011 and SIMCE 2012 for 10th graders data sets to construct the exclusion restrictions that I use in the choice equations. CASEN is the national socioeconomic characterization household survey, and is representative at the national, regional, and municipal level. I use the year 2011 for CASEN as this is the year in which 10th graders in 2013 were in 8th grade, and were therefore deciding the school-type for their secondary education. Ideally, I would also use SIMCE data for 10th graders in 2011 to construct the instruments, but since SIMCE wasn't administered to 10th graders in 2011, I use the 2012 version instead.

As outcome variables I use test scores for the two subjects evaluated in the SIMCE 2013 exams. The exogenous variables that I use in both the choice and the outcomes equations are: gender, mother's highest grade completed, father's highest grade completed, and region indicators. In addition, I include the following variables in the choice equations: the difference between the average test scores of 10th grade students in for-profit schools in a municipality and the average test scores of 10th grade students in public schools in that municipality in 2012, the difference between the average test scores of 10th grade students in nonprofit schools in a municipality and the average test scores of 10th grade students in public schools in that municipality in 2012, the percentage of secondary schools that are for-profit in a municipality in 2012, the percentage of secondary schools that are nonprofit in a municipality in 2012, municipality's log population in 2011, and municipality's urbanization rate in 2011.

Additionally, I use 8th grade test scores from SIMCE 2011 to form the measurement system. Students in this grade take exams in verbal, mathematics, social sciences, and natural sciences, and I use the scores from all four exams to identify the distribution of the unobserved factor. Exogenous variables in the measurement system include the same variables as in the outcome equations plus household composition indicators. Table 9 displays the variables inclusion rules for the measurement system, choice, and outcomes equations.

Table 9: Variables Used in the Empirical Analysis

variable	measurement system	choice	outcomes
gender	✓	✓	✓
mother's education	✓	✓	✓
father's education	✓	✓	✓
household composition	✓		
region	✓	✓	✓
avg. scores for-profit schools - avg. scores public schools[a]		✓	
avg. scores nonprofit schools - avg. scores public schools[a]		✓	
% for-profit schools[a]		✓	
% nonprofit schools[a]		✓	
log population[a]		✓	
urbanization rate[a]		✓	
factor	✓	✓	✓

Notes: I exclude household composition indicators from the 10th grade choice and outcomes equations because SIMCE 2013 data does not provide that information. [a] Calculated at the municipality level.

Table 10 shows the school-type transitions between primary and secondary levels for the sample I use in the empirical analysis. It presents both the total number and the percentage (in parentheses) of individuals transitioning from each school-type in primary to any other one in secondary[15]. Most of the students stay in the same school-type; however, there is still a considerable number of students changing school-types. Specifically, 67.7% of students in public schools, 69.6% of students in for-profit schools, and 74.3% of students in nonprofit schools remain in the same school-type when transitioning to secondary education. Also, 18.4% of students in public primary schools switch to a for-profit secondary school, and 13.9% of the same pool of students switch to a nonprofit secondary schools. Similarly, of all students in for-profit primary schools, 18.4% switch to public secondary schools, and 12% switch to nonprofit secondary schools. Lastly, 13.9% and 11.9% of students in nonprofit primary schools switch to public and to for-profit schools, respectively.

[15]Note that this is a simplification of the actual school transitions between primary and secondary levels. Specifically, I am not distinguishing between students that remain in the same school (and school-type) from students that change schools but remain in the same school-type. This is most interesting for students that attend primary schools that also offer secondary level (since students in primary schools that do not offer secondary level are forced to change schools). In my sample data, 46% of students in 8th grade in 2011 are enrolled in primary schools that also offer secondary level. Of those, 86% remain in the same school-type. And, only 14% of the students in that group switch schools between primary and secondary.

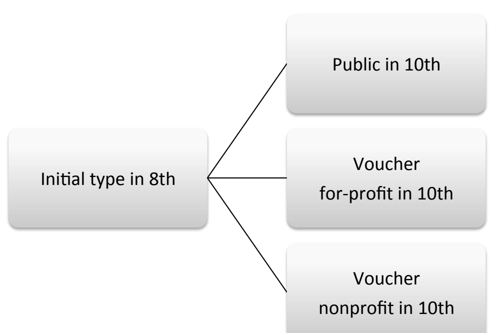
Table 10: School-Type Transition Matrix

school-type 8th grade	school-type 10th grade			
	public	voucher for-profit	voucher nonprofit	total
public	50,433	13,678	10,345	74,456
	(67.7)	(18.4)	(13.9)	(100.0)
voucher for-profit	9,795	37,029	6,373	53,197
	(18.4)	(69.6)	(12.0)	(100.0)
voucher nonprofit	4,994	4,294	26,810	36,098
	(13.8)	(11.9)	(74.3)	(100.0)
total	65,222	55,001	43,528	163,751
	(39.8)	(33.6)	(26.6)	(100.0)

Notes: Calculated using 8th grade SIMCE 2011 and 10th grade SIMCE 2013 data. Row percentages in parentheses.

I estimate the model outlined in section 3 separately for each type of school attended in primary education. That is, I estimate one separate model for students that attended public schools in primary, another one for students that attended for-profit schools in primary, and a third one for students that attended nonprofit schools in primary. My argument for doing so is that the decision of the school-type to attend in primary is endogenous by nature, and therefore it is reasonable to expect that the three samples are formed by different groups of individuals, and that the effect of attending a particular type of secondary school varies from group to group. Figure 1 illustrates the scheme of decisions associated to the models that I estimate.[16]

Figure 1: Scheme of Decisions



Notes: This figure displays the school-type decision that students face for their secondary education. Given a particular school-type chosen in primary, they choose to attend one of three types of secondary school: public, for-profit, nonprofit.

I construct the final data set I use in the empirical analysis in the following way. I begin with

[16]See, also, figure B.1 in appendix B.

a balanced panel of 163,751 students that take at least one of the 8th grade and one of the 10th grade SIMCE exams. I keep only students that take all four exams in 8th grade. I lose 6,937 observations for this reason. Next, I drop all individuals with a least one missing covariate. In order to avoid dropping observations with missing parental education information and differences in schools' test scores, I impute all missing observations in these variables with a value of zero, and include dummy variables that take a value of one if the respective covariate is non-missing and zero otherwise.[17] I lose 11,533 additional observations. I end up with a final data set consisting of 145,281 individuals, of whom 66,388 attended a public school in primary, 46,671 attended a for-profit school in primary, and 32,222 attended a nonprofit school in primary.

Tables 11 and 12 show summary statistics for the variables used in the empirical analysis. Table 11 describes the variables used in the measurement system. Almost half of the sample are men. Both parents have on average a little less than 11 years of formal education. The majority of the individuals in the sample live with both parents and with siblings, while 28% live with other relatives or non-relatives. The vast majority (71%) of students reside in the central region.

Table 11: Summary Statistics - Variables Used in the Estimation of the Measurement System

	mean	std. dev.	min	max
male	0.48	0.50	0	1
father's years of education	10.88	3.29	0	22
mother's years of education	10.88	3.15	0	22
living with both parents	0.59	0.49	0	1
living with siblings	0.67	0.47	0	1
living with others	0.28	0.45	0	1
region: north	0.13	0.34	0	1
region: center	0.71	0.45	0	1
region: south	0.16	0.36	0	1

Notes: Test scores are normalized to have an overall mean of zero and a standard deviation of one. The total number of observations is 145,281. All variables were constructed using SIMCE 2011 data sets.

Table 12 describes the variables that I include in the choice and outcomes equations. The figures follow closely what we observe in Table 11. We additionally observe that there is an average share of 32% of for-profit secondary schools and 28% of nonprofit secondary schools in the municipalities. Both for-profit and nonprofit schools outperform public schools in verbal and

[17] More specifically, a variable x that is imputed is transformed in the following way,

$$x' = x \times \mathbb{1}\left[x = \text{ non-missing}\right].$$

I include both x' and $\mathbb{1}\left[x = \text{ non-missing}\right]$ variables in the equations to be estimated.

mathematics exam scores. Finally, the average log population in a municipality is 11.57, and the urbanization rate is 86%.

Table 12: Summary Statistics - Variables Used in the Estimation of School-Type Choices and Test Scores in 10th Grade

	mean	std. dev.	min	max
male	0.48	0.50	0	1
father's years of education	10.91	3.33	0	22
mother's years of education	10.98	3.16	0	22
region: north	0.13	0.34	0	1
region: center	0.71	0.45	0	1
region: south	0.16	0.36	0	1
% for-profit schools[a]	0.32	0.21	0	0.94
% nonprofit schools[a]	0.28	0.16	0	1
avg. scores for-profit schools - avg. scores public schools: verbal[a]	0.33	0.53	-1.21	2.02
avg. scores nonprofit schools - avg. scores public schools: verbal[a]	0.52	0.47	-0.79	1.69
avg. scores for-profit schools - avg. scores public schools: math[a]	0.43	0.57	-1.36	1.84
avg. scores nonprofit schools - avg. scores public schools: math[a]	0.64	0.51	-0.83	2.05
log population[a]	11.57	1.09	6.83	13.67
urbanization rate[a]	0.86	0.18	0	1

Notes: Test scores are normalized to have an overall mean of zero and a standard deviation of one. The total number of observations is 145,281. All variables were constructed using CASEN 2011, SIMCE 2012, and SIMCE 2013 data sets.
[a] Calculated at the municipality level.

5 Results

5.1 Estimates

The measurement system in each of the models comprises four linear equations, one for each test taken in 8th grade (verbal, mathematics, social sciences, and natural sciences). Tables A.1-A.3 in appendix A present the estimates for these equations. Table A.1 does so for students that attended public schools in primary, Table A.2 for students that attended for-profit schools in primary, and Table A.3 for students that attended nonprofit schools in primary. In all three models females outperform males in verbal exams, and the opposite is true for all other tests. This pattern has already been documented for the case of Chile.[18] Both parents' education are significant determinants of test scores, with mother's education being somewhat more important than father's. The indicators for household composition are not always statistically different from

[18]See, for instance, Rodríguez et al. (2015).

zero, and an interesting pattern is found for the dummy for living with siblings. It increases math scores, but decreases social sciences. Geographical variables are also important, and their effects vary across models. For students in public primary schools, living in the South is associated with higher scores. Finally, the unobserved component of the model (ability) is a strong predictor of academic performance. It has a positive and significant effect in all equations. Note that to secure identification, I normalize the factor's loading to being equal to one in all three math scores equations.

Tables A.4–A.6 in appendix A present the estimates for the secondary school-type choice equations for the models for students in public schools in primary, students in for-profit schools in primary, and students in nonprofit schools in primary, respectively. The omitted choice is the public type. In general, being a male decreases the probability of choosing both a for-profit school and a nonprofit school, in all models. Parents' schooling increases such probabilities. Geographical variables are also important. Students from the South are more likely to choose schools of the public type in the public-in-primary model. This pattern reverses for other two models. The availability of for-profit and nonprofit schools in the municipality is possibly the most important predictor of choice. Their associated coefficients are large and statistically significant in all models. It is likely that this effect is operating through distance to school; for instance, a higher share of for-profit schools in an individual's municipality might very well imply that there is a better chance that schools of such type are close to the individual's residence.[19] Average differences in school test scores are also shown to be strong determinants of the choice. Large cities are usually associated to choosing a private school, and high urbanization rates increase the probability of choosing a for-profit school, but reduces the probability of choosing a nonprofit school. Finally, high-ability students choose private schools more frequently, especially nonprofits.

Tables A.7-A.9 in appendix A present the estimates for the outcome equations—i.e. verbal and math scores in 10th grade. Table A.7 shows estimates for the public-in-primary model, Table A.8 for the for-profit-in-primary model, and Table A.9 for the nonprofit-in-primary model. The results are in line with what I find for the measurement system. That is, females perform better than males in verbal exams but not in math, and parental and geographic variables are important determinants of academic performance. Once again, the factor determines strongly test scores, with its loadings being all positive and statistically different from zero.

[19]Hastings and Weinstein (2008), Allende et al. (2019), Neilson (2021), and Sanchez (2023) document an important role of proximity to school when choosing schools.

5.2 Goodness of Fit

To validate the models, I simulate one million observations using the estimates for the covariates and the distributions of the factor and the error terms, and the sample data, for each of the three models. The exercise is as follows. I randomly select an observation from the data, and draw a value for the factor and the error term from their estimated distribution functions. With that in hand, I compute the predicted value of the indirect utility, $I(s)$, for each of the three school-type choices. Thus, I get I(public), I(for-profit), and I(nonprofit), and can compute the optimal choice, s^*, by selecting the school-type associated with the highest indirect utility level. I also predict counterfactual outcomes for each of the three school-type choices. I repeat this process one million times.

Tables A.10-A.12 in appendix A present the goodness of fit of the simulated models. Table A.10 compares the actual school type choices with the ones predicted by the models. All three models do an excellent job in reproducing the actual choices. Similar is the conclusion for the measurement systems and the outcomes, as shown in Tables A.11 and A.12. The models predict well the first two moments of the actual distributions.

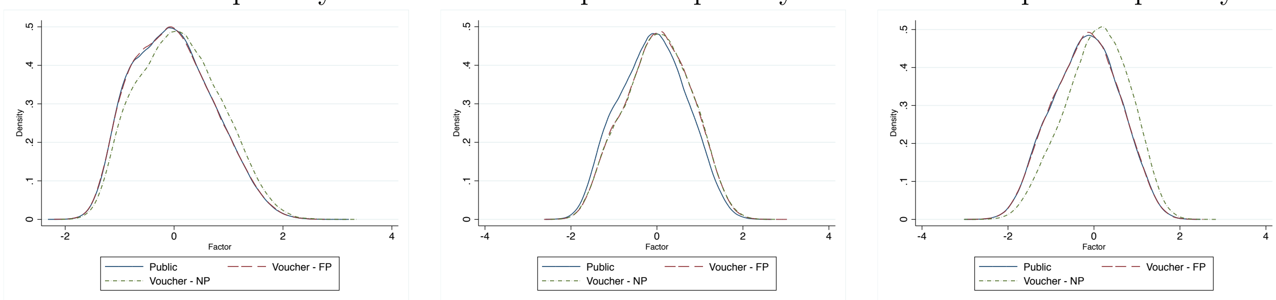
5.3 Distribution of the Unobserved Ability

Figures B.2-B.4 in appendix B present the estimated distributions of the unobserved ability, shown separately for each of the three models. The estimated parameters are presented at the bottom of the figures. The shapes of all three densities confirm my approach of not assuming normality a priori, and the estimated probabilities show that all mixture components are needed to well approximate the distributions.

Figure 2 presents the distributions of the unobserved ability by secondary school-type choice, shown separately for each of the three models. In the public-in-primary model (panel i), nonprofit schools seem to attract more high-ability students than both public and for-profit schools. Similar is the case for the nonprofit-in-primary model (panel iii). In the for-profit-in-primary model (panel ii), both types of private schools are shown to be equally successful in attracting high-ability students. Note that the patterns found in these figures are in line with the estimated loadings in the multinomial models presented in Tables A.4-A.6. They also confirm the results of theoretical models of competition between public and private schools under voucher regimes, such as Epple and Romano (1998) and MacLeod and Urquiola (2015), that predict a concentration of high-ability students in private schools.

Figure 2: Distribution of Factor by School-Type in 10th Grade

i. Public in primary | ii. For-profit in primary | iii. Nonprofit in primary



Notes: The factor is simulated using the estimates of the model. The simulated data contain one million observations.

5.4 Treatment Effects

I use the simulated models to compute the average treatment on the treated effect parameter defined in section 3.3. Each estimated TT parameter should be interpreted as the average gain of attending a particular school-type relative to the second-best alternative, for individuals choosing to attend that particular school-type. The second-best alternative varies across individuals, and the TT parameter weighs each of the margins accordingly. Table 13 presents the estimated TT effects for all three models. The outcomes are scores in verbal and mathematics exams. In the public-in-primary model (panel i), attending a public secondary school has a negative effect on test scores, reducing verbal scores by 0.112σ, and math scores by 0.18σ. For-profit secondary enrollment is associated with positive effects on test scores—0.034σ in verbal, and 0.061σ in math. Attending a secondary nonprofit school improves verbal and math scores—the estimated treatment parameters are 0.122σ in verbal and 0.202σ in math. A similar pattern is observed in the for-profit-in-primary model (panel ii), both in sign and magnitude. In the nonprofit-in-primary sample of students (panel iii), attending either a public or a for-profit secondary school is associated with negative effects on performance in both verbal and math exams. Attending a nonprofit secondary school increases verbal scores in 0.127σ, and math scores in 0.205σ.

Table 13: Estimated Treatment on the Treated Effects

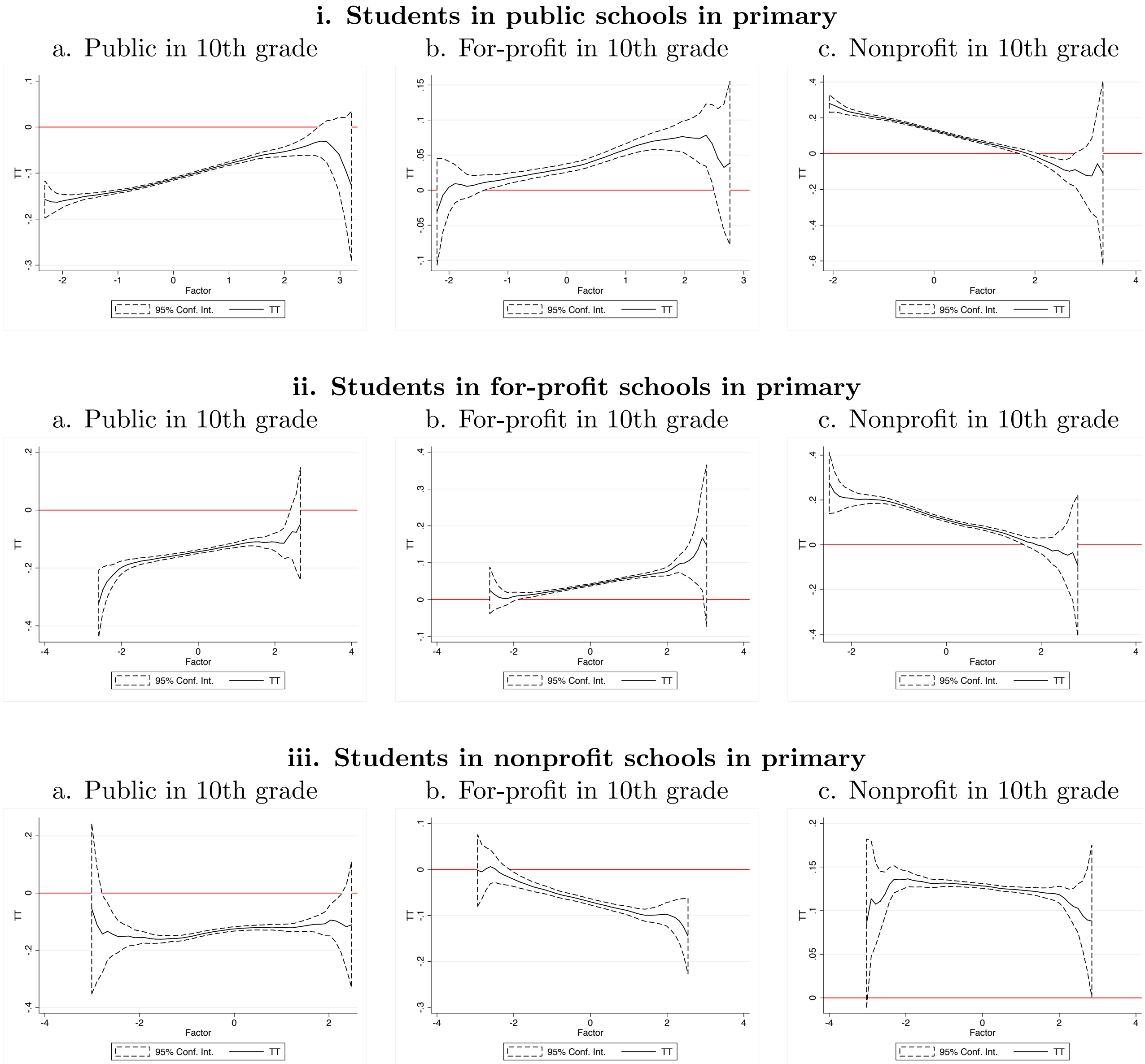
	verbal	mathematics
i. public in primary		
public 10th grade	-0.112***	-0.180***
for-profit 10th grade	0.034***	0.061***
nonprofit 10th grade	0.122***	0.202***
ii. for-profit in primary		
public 10th grade	-0.146***	-0.244***
for-profit 10th grade	0.041***	0.108***
nonprofit 10th grade	0.114***	0.132***
iii. nonprofit in primary		
public 10th grade	-0.134***	-0.218***
for-profit 10th grade	-0.066***	-0.090***
nonprofit 10th grade	0.127***	0.205***

Notes: All treatment on the treated parameters estimates were computed using the simulated model. *** denotes statistically significance at 99% level. Mean tests on the simulated expressions for the treatment on the treated parameter are performed to test for statistical significance. The null hypothesis is the treatment parameter being equal to zero.

In order to interpret the magnitude of the estimated effects, note that a standard deviation is the distance between the median student in the class and the 84th percentile. According to Allan and Fryer (2011), a student typically improves by about one standard deviation over the course of 1.4 academic school years, or 12.5 months. Therefore, an effect of 0.1σ translates into 1.25 months of schooling, and an effect of 0.2σ into 2.5 additional months.

I now turn to study the heterogeneity of the treatment on the effects along an important dimension: the unobserved ability. Figures 3 and 4 show how the estimated effects 10th grade test scores vary as a function of the unobserved ability, for verbal and math exams, respectively. The treatment of public school in secondary yields no positive effect on verbal and math scores, in the entire distribution of unobserved ability. The treatment of for-profit school in secondary has an increasing, and almost always positive, TT effect on test scores along the ability distribution, for students that attended public and for-profit schools in primary. The corresponding TT parameter of for-profit secondary school is non-positive in the entire ability distribution for students that attended nonprofit schools in primary. Lastly, nonprofit secondary schools increase—at least, weakly—verbal scores for all students, especially for those with low levels of ability.

Figure 3: Treatment on the Treated as a Function of Unobserved Ability - Verbal

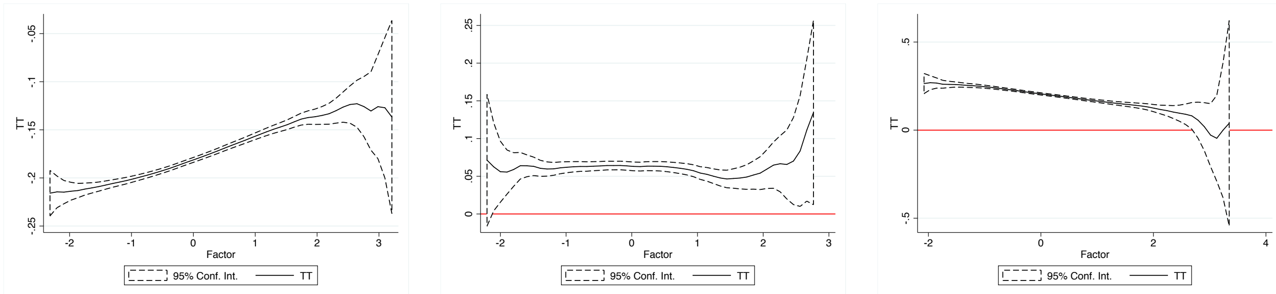


Notes: Each panel plots the Treatment on the Treated (TT) parameter of attending a particular type of secondary school on verbal scores, as a function of the unobserved ability (factor). 95% confidence intervals in dashed lines.

Figure 4: Treatment on the Treated as a Function of Unobserved Ability - Math

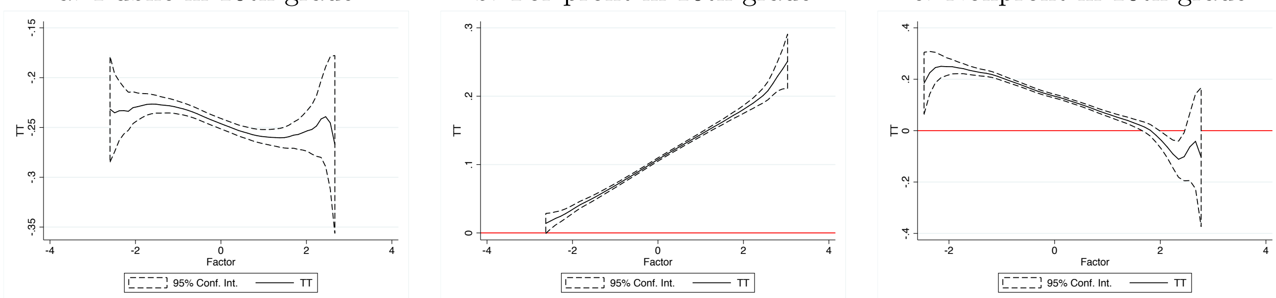
i. Students in public schools in primary

a. Public in 10th grade b. For-profit in 10th grade c. Nonprofit in 10th grade



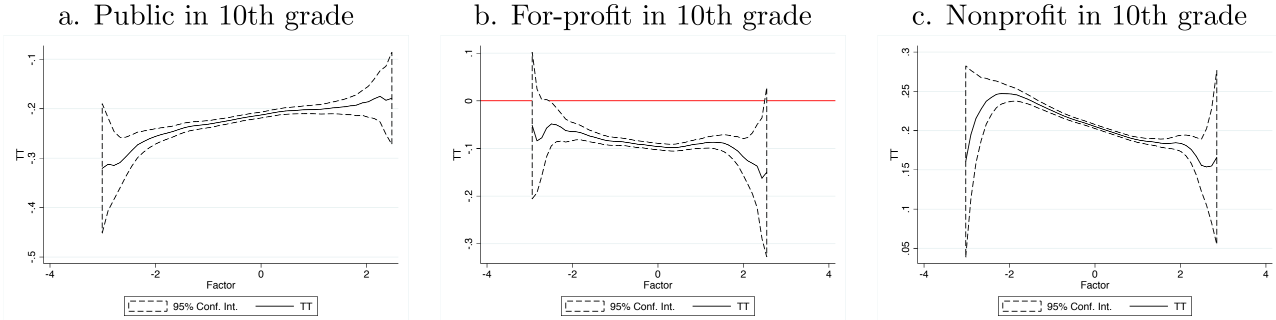
ii. Students in for-profit schools in primary

a. Public in 10th grade b. For-profit in 10th grade c. Nonprofit in 10th grade



iii. Students in nonprofit schools in primary

a. Public in 10th grade b. For-profit in 10th grade c. Nonprofit in 10th grade



Notes: Each panel plots the Treatment on the Treated (TT) parameter of attending a particular type of secondary school on mathematics scores, as a function of the unobserved ability (factor). 95% confidence intervals in dashed lines.

In sum, my evidence shows that public secondary schools reduce academic achievement, when compared to private options. The evidence is strong, and shows that no student benefits from attending public schools. Next, students that attended either public or for-profit schools in primary, and that have low levels of (unobserved) ability benefit most from attending nonprofit schools than any other alternative. High ability students in this subsample, on the other hand, are better off attending a for-profit school. Finally, students that were educated in nonprofit schools in primary only perceive positive treatment effects from staying in nonprofit schools for their secondary education.

6 Conclusions

In this paper, I study the private sector of education in Chile, a middle-income country with more than forty years of experience with subsidized private schools, to draw conclusions on whether private schools are effective in providing quality education. I do so by estimating a structural model of secondary school-type choice and academic performance, that allows me to control for endogenous outcomes and unobserved heterogeneity, which I interpret as a combination of students' inherent abilities. My results show that private schools are more effective than public schools in increasing learning outcomes. I also show that the effect that private schools have on test scores varies according to the profit motive of the school (i.e. for-profit, nonprofit). Heterogeneity of the estimated effects with respect to the unobserved ability and family background is also documented, with interesting findings. In general, low ability students perceive greater test scores gains by attending nonprofit private schools, while high ability students experience greater returns from for-profit private schools.

School choice systems with private school vouchers, such as the Chilean one, are found to have the potential to raise both equity and efficiency, and to provide an effective means of improving learning outcomes of students (Barrera-Osorio, 2009; Bettinger, 2009; Wossmann, 2009; Bravo et al., 2010). However, it is important to note that the effects of a program depend crucially on the conditions under which it is implemented, as well as on the design of the specific policy. In this respect, the case of Chile provides an excellent opportunity to learn about the effects that a large scale voucher program have on schools and students. According to my results, the majority of secondary students benefit from attending subsidized private schools. These schools, in turn, tend to choose to locate in urban areas and to serve students from low socioeconomic backgrounds. All these factors need to be taken into account when considering adopting and designing this type of school system.

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A Additional Tables

Table A.1: Estimates: Measurement System - Students in Public Schools in Primary

	verbal	mathematics	social sciences	natural sciences
male	-0.218	0.173	0.172	0.098
	(0.007)	(0.007)	(0.007)	(0.007)
father's years of education[a]	0.011	0.011	0.013	0.012
	(0.001)	(0.001)	(0.001)	(0.001)
mother's years of education[a]	0.017	0.020	0.024	0.019
	(0.001)	(0.001)	(0.001)	(0.001)
living with both parents	0.006	0.003	0.022	0.019
	(0.007)	(0.007)	(0.007)	(0.006)
living with siblings	0.009	0.040	-0.024	0.011
	(0.007)	(0.006)	(0.006)	(0.006)
living with others	0.011	-0.004	0.000	-0.002
	(0.006)	(0.006)	(0.006)	(0.006)
region: north	-0.190	-0.151	-0.205	-0.176
	(0.013)	(0.012)	(0.012)	(0.013)
region: center	-0.150	-0.038	-0.094	-0.099
	(0.010)	(0.009)	(0.009)	(0.010)
non-missing: father's years of education[b]	-0.110	-0.118	-0.149	-0.117
	(0.016)	(0.016)	(0.017)	(0.015)
non-missing: mother's years of education[b]	-0.108	-0.137	-0.204	-0.149
	(0.020)	(0.020)	(0.021)	(0.020)
intercept	-0.027	-0.368	-0.261	-0.277
	(0.020)	(0.019)	(0.020)	(0.019)
factor	1.063	1.000	0.943	1.053
	(0.005)		(0.005)	(0.004)

Notes: Estimates from the measurement system part of the model, where coefficients for a linear-in-parameters equation are estimated. All explanatory variables come from SIMCE 2011 for 8th graders database. Standard errors in parentheses. The total number of observations is 66,388. [a] Missing values replaced with a zero. [b] Dummy variable being equal to one if the corresponding variable is non-missing, and zero otherwise.

Table A.2: Estimates: Measurement System - Students in For-Profit Schools in Primary

	verbal	mathematics	social sciences	natural sciences
male	-0.180	0.190	0.223	0.116
	(0.009)	(0.008)	(0.008)	(0.009)
father's years of education[a]	0.013	0.021	0.022	0.018
	(0.001)	(0.001)	(0.001)	(0.001)
mother's years of education[a]	0.024	0.028	0.034	0.028
	(0.001)	(0.002)	(0.002)	(0.001)
living with both parents	-0.008	-0.007	0.000	0.000
	(0.008)	(0.008)	(0.008)	(0.007)
living with siblings	0.008	0.049	-0.023	0.016
	(0.008)	(0.008)	(0.008)	(0.007)
living with others	0.018	-0.005	-0.010	-0.004
	(0.007)	(0.008)	(0.008)	(0.007)
region: north	-0.066	0.080	-0.049	0.019
	(0.017)	(0.017)	(0.017)	(0.017)
region: center	-0.131	0.002	-0.043	-0.058
	(0.014)	(0.013)	(0.014)	(0.014)
non-missing: father's years of education[b]	-0.139	-0.220	-0.259	-0.184
	(0.023)	(0.023)	(0.024)	(0.022)
non-missing: mother's years of education[b]	-0.251	-0.301	-0.379	-0.309
	(0.027)	(0.028)	(0.028)	(0.026)
intercept	0.244	-0.055	0.089	0.077
	(0.027)	(0.025)	(0.026)	(0.025)
factor	1.013	1.000	0.961	1.056
	(0.005)		(0.005)	(0.005)

Notes: Estimates from the measurement system part of the model, where coefficients for a linear-in-parameters equation are estimated. All explanatory variables come from SIMCE 2011 for 8th graders database. Standard errors in parentheses. The total number of observations is 46,671. [a] Missing values replaced with a zero. [b] Dummy variable being equal to one if the corresponding variable is non-missing, and zero otherwise.

Table A.3: Estimates: Measurement System - Students in Nonprofit Schools in Primary

	verbal	mathematics	social sciences	natural sciences
male	-0.202	0.174	0.219	0.124
	(0.010)	(0.010)	(0.010)	(0.010)
father's years of education[a]	0.014	0.022	0.022	0.018
	(0.002)	(0.002)	(0.002)	(0.002)
mother's years of education[a]	0.024	0.028	0.034	0.032
	(0.002)	(0.002)	(0.002)	(0.002)
living with both parents	-0.012	0.006	0.017	0.010
	(0.009)	(0.009)	(0.009)	(0.008)
living with siblings	0.010	0.049	-0.020	0.013
	(0.009)	(0.009)	(0.010)	(0.009)
living with others	0.019	-0.009	0.024	0.002
	(0.009)	(0.009)	(0.010)	(0.009)
region: north	-0.042	0.035	-0.024	-0.016
	(0.019)	(0.019)	(0.020)	(0.020)
region: center	-0.022	0.108	0.084	0.029
	(0.013)	(0.013)	(0.013)	(0.013)
non-missing: father's years of education[b]	-0.135	-0.197	-0.254	-0.210
	(0.028)	(0.028)	(0.029)	(0.027)
non-missing: mother's years of education[b]	-0.307	-0.402	-0.427	-0.390
	(0.034)	(0.034)	(0.034)	(0.033)
intercept	0.372	0.147	0.166	0.238
	(0.030)	(0.030)	(0.031)	(0.029)
factor	0.987	1.000	0.953	1.030
	(0.006)		(0.006)	(0.006)

Notes: Estimates from the measurement system part of the model, where coefficients for a linear-in-parameters equation are estimated. All explanatory variables come from SIMCE 2011 for 8th graders database. Standard errors in parentheses. The total number of observations is 32,222. [a] Missing values replaced with a zero. [b] Dummy variable being equal to one if the corresponding variable is non-missing, and zero otherwise.

Table A.4: Estimates: Secondary School-Type Choice - Students in Public Schools in Primary

	choice:	
	voucher for-profit	voucher nonprofit
male	-0.145	-0.016
	(0.018)	(0.018)
father's years of education[a]	0.015	0.010
	(0.004)	(0.004)
mother's years of education[a]	0.025	0.029
	(0.004)	(0.004)
region: north	-0.475	-0.237
	(0.036)	(0.036)
region: center	-0.143	-0.288
	(0.026)	(0.025)
% for-profit schools[b]	3.772	
	(0.050)	
% nonprofit schools[b]		2.953
		(0.060)
avg. scores for-profit schools - avg. scores public schools: verbal[a,b]	-0.125	
	(0.056)	
avg. scores nonprofit schools - avg. scores public schools: verbal[a,b]		0.719
		(0.054)
avg. scores for-profit schools - avg. scores public schools: math[a,b]	-0.072	
	(0.051)	
avg. scores nonprofit schools - avg. scores public schools: math[a,b]		-0.805
		(0.050)
log population[b]	-0.105	0.133
	(0.013)	(0.014)
urbanization rate[b]	0.928	-0.327
	(0.083)	(0.079)
non-missing: father's years of education[c]	-0.151	0.052
	(0.055)	(0.059)
non-missing: mother's years of education[c]	-0.028	-0.115
	(0.057)	(0.059)
non-missing: avg. score difference for-profit vs. public (verbal and math)[c]	1.825	
	(0.101)	
non-missing: avg. score difference for-profit vs. public (verbal)[c]		1.203
		(0.340)
non-missing: avg. score difference for-profit vs. public (math)[c]		0.090
		(0.342)
intercept	-3.481	-4.501
	(0.136)	(0.127)
factor	-0.004	0.168
	(0.013)	(0.013)

Notes: Estimates from the multinomial choice part of the model, where the base school type choice is "public"—that is, all estimated coefficients are relative to the choice of choosing a public school in 10th grade. All variables were constructed using CASEN 2011, SIMCE 2012, and SIMCE 2013 data sets. Standard errors in parentheses. The total number of observations is 66,388. [a] Missing values replaced with a zero. [b] Calculated at the municipality level. [c] Dummy variable being equal to one if the corresponding variable is non-missing, and zero otherwise.

Table A.5: Estimates: Secondary School-Type Choice - Students in For-Profit Schools in Primary

	choice:	
	voucher for-profit	voucher nonprofit
male	-0.139	-0.085
	(0.020)	(0.025)
father's years of education[a]	0.073	0.044
	(0.005)	(0.006)
mother's years of education[a]	0.063	0.035
	(0.005)	(0.006)
region: north	0.128	0.024
	(0.044)	(0.053)
region: center	0.046	-0.171
	(0.036)	(0.041)
% for-profit schools[b]	2.952	
	(0.054)	
% nonprofit schools[b]		2.025
		(0.079)
avg. scores for-profit schools - avg. scores public schools: verbal[a,b]	0.670	
	(0.061)	
avg. scores nonprofit schools - avg. scores public schools: verbal[a,b]		1.377
		(0.072)
avg. scores for-profit schools - avg. scores public schools: math[a,b]	-0.200	
	(0.056)	
avg. scores nonprofit schools - avg. scores public schools: math[a,b]		-1.039
		(0.066)
log population[b]	0.090	0.208
	(0.015)	(0.018)
urbanization rate[b]	-0.594	-0.244
	(0.105)	(0.114)
non-missing: father's years of education[c]	-0.715	-0.444
	(0.073)	(0.087)
non-missing: mother's years of education[c]	-0.484	-0.11
	(0.078)	(0.090)
non-missing: avg. score difference for-profit vs. public (verbal and math)[c]	1.545	
	(0.078)	
non-missing: avg. score difference for-profit vs. public (verbal)[c]		-0.606
		(0.643)
non-missing: avg. score difference for-profit vs. public (math)[c]		1.191
		(0.641)
intercept	-2.434	-3.801
	(0.147)	(0.175)
factor	0.178	0.157
	(0.014)	(0.018)

Notes: Estimates from the multinomial choice part of the model, where the base school type choice is "public"—that is, all estimated coefficients are relative to the choice of choosing a public school in 10th grade. All variables were constructed using CASEN 2011, SIMCE 2012, and SIMCE 2013 data sets. Standard errors in parentheses. The total number of observations is 46,671. [a] Missing values replaced with a zero. [b] Calculated at the municipality level. [c] Dummy variable being equal to one if the corresponding variable is non-missing, and zero otherwise.

Table A.6: Estimates: Secondary School-Type Choice - Students in Nonprofit Schools in Primary

	choice:	
	voucher for-profit	voucher nonprofit
male	-0.150	-0.060
	(0.033)	(0.026)
father's years of education[a]	0.026	0.050
	(0.008)	(0.006)
mother's years of education[a]	0.023	0.077
	(0.007)	(0.006)
region: north	0.119	0.620
	(0.066)	(0.055)
region: center	0.178	0.459
	(0.044)	(0.036)
% for-profit schools[b]	2.404	
	(0.076)	
% nonprofit schools[b]		2.108
		(0.086)
avg. scores for-profit schools - avg. scores public schools: verbal[a,b]	0.023	
	(0.099)	
avg. scores nonprofit schools - avg. scores public schools: verbal[a,b]		0.876
		(0.073)
avg. scores for-profit schools - avg. scores public schools: math[a,b]	0.259	
	(0.092)	
avg. scores nonprofit schools - avg. scores public schools: math[a,b]		-0.169
		(0.067)
log population[b]	0.061	0.166
	(0.023)	(0.018)
urbanization rate[b]	0.097	-0.584
	(0.147)	(0.116)
non-missing: father's years of education[c]	-0.068	-0.394
	(0.113)	(0.090)
non-missing: mother's years of education[c]	-0.322	-0.637
	(0.113)	(0.092)
non-missing: avg. score difference for-profit vs. public (verbal and math)[c]	1.216	
	(0.125)	
non-missing: avg. score difference for-profit vs. public (verbal)[c]		1.305
		(0.378)
non-missing: avg. score difference for-profit vs. public (math)[c]		-0.116
		(0.382)
intercept	-3.166	-2.804
	(0.233)	(0.173)
factor	0.005	0.386
	(0.022)	(0.018)

Notes: Estimates from the multinomial choice part of the model, where the base school type choice is "public"—that is, all estimated coefficients are relative to the choice of choosing a public school in 10th grade. All variables were constructed using CASEN 2011, SIMCE 2012, and SIMCE 2013 data sets. Standard errors in parentheses. The total number of observations is 32,222. [a] Missing values replaced with a zero. [b] Calculated at the municipality level. [c] Dummy variable being equal to one if the corresponding variable is non-missing, and zero otherwise.

Table A.7: Estimates: Test Scores in 10th Grade - Students in Public Schools in Primary

	verbal			mathematics		
school type in 10th grade:	public	for-profit	nonprofit	public	for-profit	nonprofit
male	-0.214	-0.211	-0.229	0.166	0.123	0.182
	(0.009)	(0.014)	(0.016)	(0.008)	(0.014)	(0.014)
father's years of education[a]	0.014	0.010	0.012	0.016	0.015	0.019
	(0.002)	(0.003)	(0.003)	(0.001)	(0.003)	(0.003)
mother's years of education[a]	0.019	0.012	0.020	0.027	0.023	0.023
	(0.002)	(0.003)	(0.003)	(0.002)	(0.003)	(0.003)
region: north	-0.118	-0.225	-0.146	-0.105	-0.108	-0.030
	(0.015)	(0.030)	(0.028)	(0.014)	(0.029)	(0.028)
region: center	-0.143	-0.204	-0.179	-0.014	-0.114	-0.077
	(0.012)	(0.022)	(0.020)	(0.011)	(0.022)	(0.018)
non-missing: father's years of education[b]	-0.109	-0.066	-0.171	-0.120	-0.131	-0.159
	(0.022)	(0.041)	(0.047)	(0.020)	(0.038)	(0.045)
non-missing: mother's years of education[b]	-0.096	-0.048	-0.118	-0.186	-0.148	-0.153
	(0.022)	(0.042)	(0.05)	(0.021)	(0.041)	(0.046)
intercept	-0.152	-0.010	0.097	-0.542	-0.317	-0.282
	(0.013)	(0.024)	(0.022)	(0.012)	(0.025)	(0.021)
factor	0.919	0.927	0.842	0.927	0.919	0.876
	(0.006)	(0.011)	(0.012)	(0.005)	(0.010)	(0.011)

Notes: Estimates from the outcomes part of the model, where coefficients for a linear-in-parameters equation are estimated. All variables were constructed using CASEN 2011, SIMCE 2012, and SIMCE 2013 data sets. Standard errors in parentheses. The total number of observations is 66,388. [a] Missing values replaced with a zero. [b]Dummy variable being equal to one if the corresponding variable is non-missing, and zero otherwise.

Table A.8: Estimates: Test Scores in 10th Grade - Students in For-profit Schools in Primary

	verbal			mathematics		
school type in 10th grade:	public	for-profit	nonprofit	public	for-profit	nonprofit
male	-0.188	-0.203	-0.208	0.168	0.136	0.180
	(0.019)	(0.010)	(0.021)	(0.016)	(0.010)	(0.019)
father's years of education[a]	0.022	0.020	0.011	0.025	0.029	0.022
	(0.004)	(0.002)	(0.005)	(0.004)	(0.002)	(0.004)
mother's years of education[a]	0.019	0.025	0.015	0.029	0.035	0.025
	(0.004)	(0.002)	(0.005)	(0.004)	(0.002)	(0.004)
region: north	-0.047	-0.034	-0.083	0.021	0.080	0.130
	(0.038)	(0.021)	(0.041)	(0.034)	(0.020)	(0.039)
region: center	-0.110	-0.108	-0.095	0.057	0.012	0.090
	(0.026)	(0.017)	(0.029)	(0.024)	(0.017)	(0.029)
non-missing: father's years of education[b]	-0.180	-0.232	-0.136	-0.177	-0.282	-0.265
	(0.059)	(0.030)	(0.065)	(0.054)	(0.028)	(0.062)
non-missing: mother's years of education[b]	-0.130	-0.237	-0.129	-0.229	-0.426	-0.170
	(0.061)	(0.033)	(0.072)	(0.056)	(0.030)	(0.065)
intercept	0.025	0.220	0.295	-0.352	0.035	-0.042
	(0.030)	(0.019)	(0.034)	(0.028)	(0.018)	(0.032)
factor	0.886	0.884	0.817	0.872	0.917	0.830
	(0.012)	(0.007)	(0.015)	(0.012)	(0.006)	(0.013)

Notes: Estimates from the outcomes part of the model, where coefficients for a linear-in-parameters equation are estimated. All variables were constructed using CASEN 2011, SIMCE 2012, and SIMCE 2013 data sets. tandard errors in parentheses. The total number of observations is 46,671. [a] Missing values replaced with a zero. [b]Dummy variable being equal to one if the corresponding variable is non-missing, and zero otherwise.

Table A.9: Estimates: Test Scores in 10th Grade - Students in Nonprofit Schools in Primary

	verbal			mathematics		
school type in 10th grade:	public	for-profit	nonprofit	public	for-profit	nonprofit
male	-0.193	-0.213	-0.211	0.169	0.094	0.138
	(0.026)	(0.028)	(0.012)	(0.024)	(0.025)	(0.010)
father's years of education[a]	0.020	0.027	0.020	0.033	0.028	0.028
	(0.005)	(0.006)	(0.002)	(0.005)	(0.005)	(0.002)
mother's years of education[a]	0.030	0.015	0.021	0.035	0.038	0.032
	(0.005)	(0.006)	(0.002)	(0.005)	(0.005)	(0.002)
region: north	0.032	-0.031	0.050	-0.022	0.035	0.121
	(0.049)	(0.057)	(0.022)	(0.045)	(0.047)	(0.020)
region: center	-0.0180	-0.007	0.066	0.053	0.051	0.154
	(0.028)	(0.036)	(0.015)	(0.026)	(0.031)	(0.014)
non-missing: father's years of education[b]	-0.302	-0.375	-0.212	-0.365	-0.410	-0.294
	(0.077)	(0.087)	(0.032)	(0.075)	(0.077)	(0.028)
non-missing: mother's years of education[b]	-0.108	-0.006	-0.258	-0.285	-0.233	-0.386
	(0.078)	(0.092)	(0.035)	(0.076)	(0.08)	(0.032)
intercept	0.120	0.206	0.337	-0.069	0.064	0.212
	(0.034)	(0.043)	(0.018)	(0.031)	(0.037)	(0.017)
factor	0.889	0.845	0.863	0.880	0.862	0.852
	(0.017)	(0.019)	(0.007)	(0.016)	(0.017)	(0.007)

Notes: Estimates from the outcomes part of the model, where coefficients for a linear-in-parameters equation are estimated. All variables were constructed using CASEN 2011, SIMCE 2012, and SIMCE 2013 data sets. Standard errors in parentheses. The total number of observations is 32,222. [a] Missing values replaced with a zero. [b]Dummy variable being equal to one if the corresponding variable is non-missing, and zero otherwise.

Table A.10: Goodness of Fit - School-Type Decisions

	school type 10th grade:					
	public		voucher for-profit		voucher nonprofit	
school-type primary:	actual	model	actual	model	actual	model
public	67.60	67.55	18.26	18.23	14.14	14.22
voucher for-profit	18.57	18.33	69.23	69.32	12.20	12.35
voucher nonprofit	13.81	13.62	11.61	11.67	74.58	74.71

Notes: The simulated data (model) contain one million observations generated using the model's estimates. The actual data (actual) contain 163,751 observations from SIMCE 2011 and SIMCE 2013 data sets. Each cell displays the percentage of individuals choosing a corresponding school type.

Table A.11: Goodness of Fit - Measurement System

		mean		std. dev.	
school-type primary	test	actual	model	actual	model
public					
	verbal	-0.198	-0.199	0.984	0.976
	mathematics	-0.252	-0.253	0.948	0.936
	social sc.	-0.258	-0.258	0.945	0.934
	natural sc.	-0.263	-0.264	0.957	0.946
voucher for-profit					
	verbal	0.091	0.090	0.990	0.978
	mathematics	0.125	0.124	0.994	0.975
	social sc.	0.148	0.148	0.995	0.975
	natural sc.	0.147	0.146	0.989	0.971
voucher nonprofit					
	verbal	0.275	0.274	0.963	0.951
	mathematics	0.338	0.337	0.979	0.963
	social sc.	0.316	0.315	0.982	0.966
	natural sc.	0.330	0.329	0.96	0.944

Notes: The simulated data (model) contain one million observations generated using the model's estimates. The actual data (actual) contain 163,751 observations from SIMCE 2011 and SIMCE 2013 data sets.

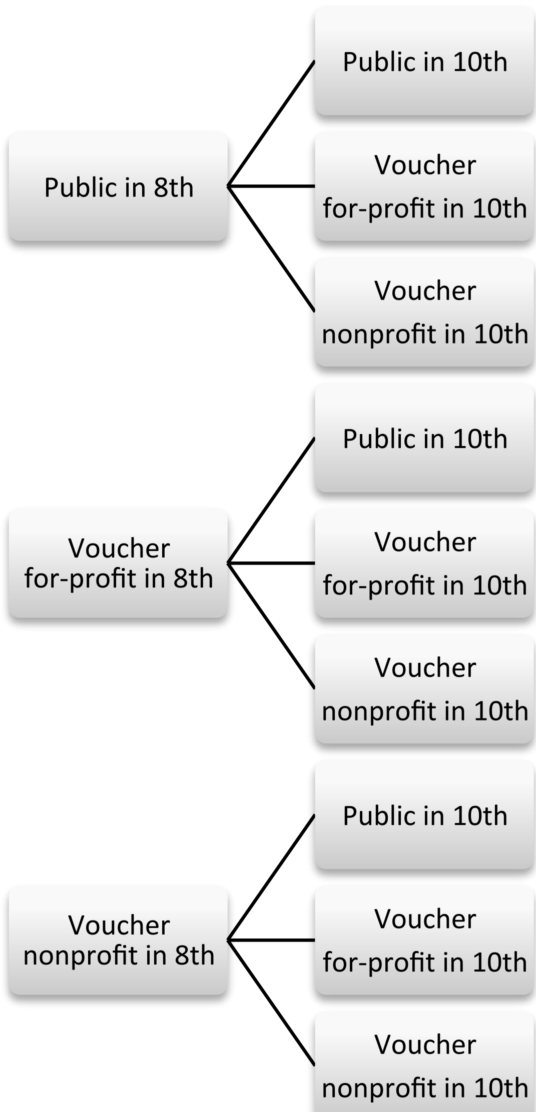
Table A.12: Goodness of Fit - Test Scores in 10th grade

school-type	test	mean actual	mean model	std. dev. actual	std. dev. model
i. public in primary					
public 10th grade					
	verbal	-0.267	-0.314	0.977	0.964
	mathematics	-0.384	-0.433	0.948	0.928
voucher for-profit 10th grade					
	verbal	-0.232	-0.234	0.959	0.966
	mathematics	-0.304	-0.305	0.929	0.932
voucher nonprofit 10th grade					
	verbal	0.006	-0.045	0.934	0.933
	mathematics	-0.017	-0.073	0.918	0.913
ii. for-profit in primary					
public 10th grade					
	verbal	-0.177	-0.172	1.001	1.006
	mathematics	-0.207	-0.207	0.945	0.944
voucher for-profit 10th grade					
	verbal	0.141	0.098	0.987	0.974
	mathematics	0.230	0.183	0.977	0.956
voucher nonprofit 10th grade					
	verbal	0.172	0.155	0.940	0.945
	mathematics	0.245	0.219	0.911	0.905
iii. nonprofit in primary					
public 10th grade					
	verbal	-0.074	-0.058	1.001	0.989
	mathematics	-0.083	-0.061	0.955	0.942
voucher for-profit 10th grade					
	verbal	0.019	0.030	0.993	0.981
	mathematics	0.058	0.074	0.945	0.929
voucher nonprofit 10th grade					
	verbal	0.409	0.373	0.931	0.929
	mathematics	0.526	0.489	0.889	0.878

Notes: The simulated data (model) contain one million observations generated using the model's estimates. The actual data (actual) contain 163,751 observations from SIMCE 2011 and SIMCE 2013 data sets.

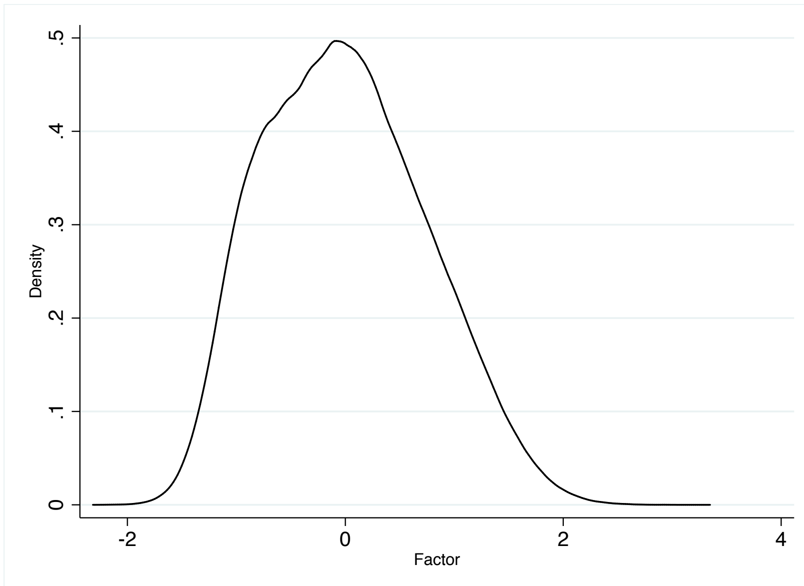
B Additional Figures

Figure B.1: Scheme of Decisions: Empirical Implementation



Notes: This figure displays the school-type decision that students face for their secondary education. Given a particular school-type chosen in primary, they choose to attend one of three types of secondary school: public, for-profit, nonprofit.

Figure B.2: Distribution of Factor - Students in Public in Primary



$$f \sim p_1 N(\mu_1, \sigma_1^2) + p_2 N(\mu_2, \sigma_2^2) + p_3 N(\mu_3, \sigma_3^2)$$

where

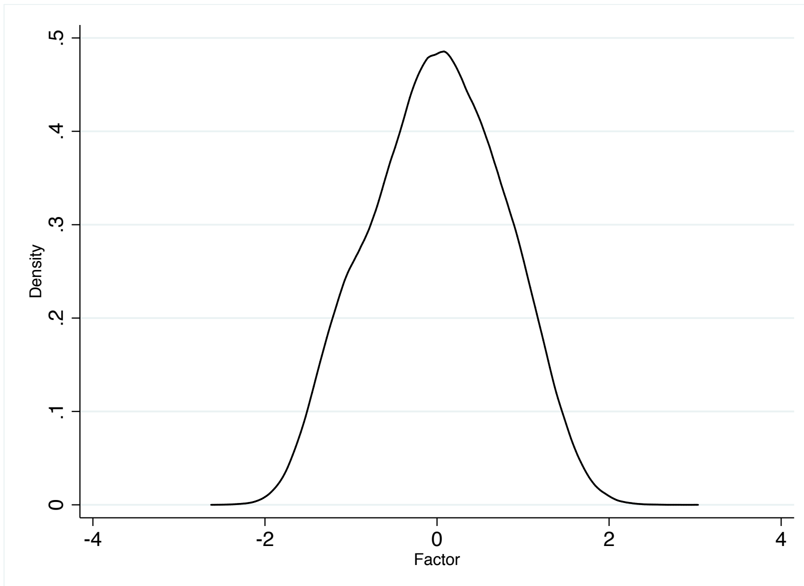
$$\mu = (-0.13, \quad -0.09, \quad 0.75)$$

$$\mathbf{1/\sigma^2} = (4.86, \quad 11.25, \quad 3.53)$$

$$\mathbf{p} = (0.48, \quad 0.20, \quad 0.33)$$

Notes: The factor is simulated using the estimates of the model. The simulated data contain one million observations.

Figure B.3: Distribution of Factor - Students in For-profit in Primary



$$f \sim p_1 N(\mu_1, \sigma_1^2) + p_2 N(\mu_2, \sigma_2^2) + p_3 N(\mu_3, \sigma_3^2)$$

where

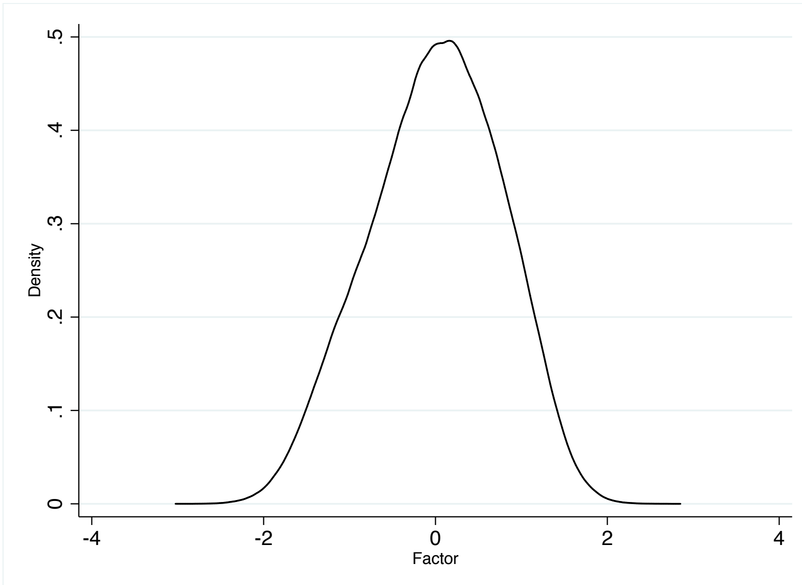
$$\mu = (-1.11, \quad -0.10, \quad 0.85)$$

$$\mathbf{1}/\sigma^{\mathbf{2}} = (8.28, \quad 3.82, \quad 5.35)$$

$$\mathbf{p} = (0.15, \quad 0.58, \quad 0.27)$$

Notes: The factor is simulated using the estimates of the model. The simulated data contain one million observations.

Figure B.4: Distribution of Factor - Students in Nonprofit in Primary



$$f \sim p_1 N(\mu_1, \sigma_1^2) + p_2 N(\mu_2, \sigma_2^2) + p_3 N(\mu_3, \sigma_3^2)$$

where

$$\mu = (-1.03, \quad -0.02, \quad 0.85)$$

$$\mathbf{1/\sigma^2} = (5.38, \quad 4.02, \quad 6.18)$$

$$\mathbf{p} = (0.20, \quad 0.55, \quad 0.25)$$

Notes: The factor is simulated using the estimates of the model. The simulated data contain one million observations.