Understanding School Competition Under Voucher Regimes

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Abstract

I study how different voucher designs and policies affect school competition in education markets, and their consequences for students' school choices and welfare. To that end, I build a structural model of demand and supply for primary education in markets that allow the use of vouchers. Unlike previous studies, I not only model schools' pricing behavior, but also their program participation decisions, a discrete strategy that adds an additional layer of complexity to the solution of the supply side game. I fit my model to rich administrative data from Chile, and leverage its simultaneous implementation of universal (available to all students) and targeted (available only to low-income students) vouchers to estimate my model's parameters. Counterfactual simulations indicate that universal and targeted vouchers affect school competition differently. On the one hand, a higher targeted voucher attracts more schools to participate in the targeted program. However, high-quality schools join only if the subsidy is sufficiently high. On the other hand, a higher universal voucher induces schools to lower the top-up fees they charge to parents. Specifically, a \$1 increase in the subsidy translates into a \$0.58 decrease in the average fee. Finally, policies that favor the universal voucher are more mobility- and welfare-enhancing in the aggregate, but increase the welfare gap between low- and high-income students, relative to policies favoring the targeted voucher.

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1 Introduction

In the past two decades, the education literature has made significant progress in understanding how vouchers affect the demand side of education markets (i.e. students). We have learned, from both experience and research, that vouchers: 1) have at most small effects on students' test scores; 2) have positive effects on high school graduation and college enrollment, especially for minority students; and 3) tend to induce a nonrandom migration from the public to the private sector, where high-income and high-ability students are the most likely to transition from public to private schools (Epple et al., 2017). Now, what do we know about the effects on the supply side (i.e. schools)? Unfortunately, our knowledge on this matter is very limited.[1] Moreover, understanding how schools respond to vouchers is critical, as voucher programs are greatly determined by schools' program participation decisions, as well as by their choices regarding tuition, educational inputs, etc. This paper contributes to filling this gap in the literature by explicitly studying schools' responses to voucher policies. It does so by combining economic theory and empirical analysis of administrative data from Chile.

Chile is a particularly interesting scenario to study educational vouchers. It has more than thirty years of experience with a nationwide voucher agenda, in which students choose among public and private schools facing no residential restrictions, and schools (either fully or partially) fund their operations through voucher subsidies that they receive from the government. In addition, the system combines two different voucher designs to subsidize enrollment: a universal voucher, which is a per-student subsidy paid to all schools; and a targeted voucher, which is a per-disadvantaged student subsidy paid to schools that choose to participate in the targeted

[1] There is a small literature that has studied the competition effects that voucher policies have on public schools' performance (Hoxby, 2003; Sandström and Bergström, 2005; Hsieh and Urquiola, 2006; Figlio and Rouse, 2006; Chakrabarti, 2008; Chan and McMillan, 2009; Card et al., 2010; Chakrabarti, 2013a,b; Figlio and Hart, 2014). The consensus is that vouchers induce some pressure on public schools to improve (although, Hsieh and Urquiola, 2006 show that, for the case of Chile, public schools' performance worsened in municipalities that experienced greater private competition). However, Epple et al. (2017) argue that in many of these studies it proves hard to truly identify the effects of increased competition on productivity, and that competition is easily confounded with composition and accountability effects. In another vein, Neilson (2017) studies quality responses of schools to the introduction of a targeted voucher program in Chile, while in Sánchez (2018) I focus on educational inputs and other strategic responses to the same targeted voucher policy.

voucher program. Thus, the Chilean case represents a one-of-a-kind implementation of a large scale voucher program, that allows the study of policies that differentially affect the universal and targeted voucher subsidies.

This paper develops an equilibrium model of school choice and competition under a voucher regime, which I solve using a new concept of equilibrium, and estimate using detailed and novel administrative data for elementary students and schools in Chile. In the demand side of the model, families choose schools by taking into account a number of schools' characteristics, such as proximity, after-voucher tuition, whether the school is public or private, religious affiliation, and other observable and unobservable characteristics. In the supply side, schools are vertically and horizontally differentiated, and compete as in an oligopoly. Private schools simultaneously decide whether they participate in a targeted voucher program, and choose the tuition they charge to students. The inherent characteristics of urban education markets, where a large number of schools compete for attracting students, coupled with the fact that I explicitly model demand, makes solving the supply side game particularly challenging.[2] The difficulty arises in that, depending on the size of the market, schools' program participation decisions may lead to a very large number of different possible market configurations, each of which has (at least) an equilibrium set of tuitions associated to it.[3] For instance, a market with ten schools has 1,024 different possible market configurations. A market with twenty schools has 1,048,576 different possible market configurations. Considering that Chilean educational markets are typically comprised by tens, and sometimes hundreds, of schools, the task of solving for an equilibrium quickly becomes computationally intractable. To overcome such difficulties, I adapt the concept of oblivious equilibrium, that was initially introduced by Weintraub et al. (2008) to facilitate the computation of dynamic games of imperfect competition in industries with many firms. In my setting, oblivious

[2]Since demand is modeled explicitly, schools' payoffs are nonlinear functions of schools' program participation decisions. This adds an extra layer of difficulty and tractability, relative to models where discrete choices in supply enter linearly in firms's payoffs (see, for example, Bresnahan and Reiss, 1991, Berry, 1992, Seim, 2006, Ciliberto and Tamer, 2009, Sweeting, 2009).

[3]A market configuration in this context is a realization of schools' program participation decisions. For instance, for a market with two schools, let $\tau_1 \in \{0,1\}$ and $\tau_2 \in \{0,1\}$ be school 1's and school 2's participation decisions, respectively. Then, the market configuration $T = (\tau_1, \tau_2) = (1, 0)$ is different from the market configuration $T' = (0, 1)$.

equilibrium assumes that each school makes decisions based only on its own type (i.e. realization of its cost structure) and a belief of the expected equilibrium in the market. I further define a sufficient statistic that summarizes the market's expected equilibrium, and that schools use to base their decisions on. This assumption considerably reduces the computational burden, while still allowing the model to accurately predict the choices and outcomes observed in the data.

I estimate the model using detailed and novel administrative data for elementary students and schools in Chile. I use the model and its estimated parameters to study the economic consequences of a variety of counterfactual policy scenarios. I perform two series of counterfactual exercises. First, I study schools' program participation response to different targeted voucher amounts, that range from 30% to 200% the actual subsidy amount. Second, I study the consequences on schools' and students' choices of a 20% increase in government spending in vouchers, that is entirely allocated to either increasing the universal voucher or increasing the targeted voucher. Both counterfactual exercises are motivated by actual policy changes that are currently under implementation, and that increase government spending in vouchers by approximately 20%.

From the first counterfactual exercise, I find that a higher targeted voucher attracts more schools to join the targeted voucher program. More important, such response is heterogeneous with respect to schools' quality. The first schools that decide to join the program are low-quality schools, while high quality schools join only if the subsidy is sufficiently high. These results speaks directly to the evidence shown in Abdulkadiroglu et al. (2018), and highlight the importance of understanding schools' responses to voucher policies. Abdulkadiroglu et al. (2018) present striking evidence that a recently introduced targeted voucher program, the Louisiana Scholarship Program, lowers students' math scores by 0.4 standard deviations, and also lowers achievement in three other subjects. When trying to explain why these negative achievement impacts emerge, the authors show evidence suggesting that selection of low-quality schools into the program may greatly explain the results.

From the second counterfactual exercise, I find that allocating all the extra funds into increasing the universal voucher induces some schools to leave the targeted program. Moreover, these leaving schools tend to be of higher quality than the typical school that stays in the program. The increase in the universal voucher also makes schools respond by lowering tuition. I find that a $1 rise in the universal voucher translates into a $0.58 fall in average tuition. On the contrary, allocating all the extra funds into the targeted voucher induces more schools to join the targeted program. Once again, the marginal schools (i.e. those that change their participation decision following a policy change) are of higher quality than the typical school that participates in the program before and after the policy change. The price response of schools is not as steep as in the increase-in-the-universal-voucher scenario. In the demand side of the markets, some students respond to the policies by changing their school choices. Specifically, 7% of disadvantaged and 11% of non-disadvantaged students switch schools when the universal voucher is increased.[4] Likewise, 4% of disadvantaged and 2% of non-disadvantaged students switch schools when the targeted voucher is increased. In both cases, most of the switching students switch to a school of higher quality. Lastly, the rise in a measure of students' welfare is higher in the aggregate when the universal voucher is increased than when the targeted voucher is increased. However, the welfare gap between disadvantaged and non-disadvantaged students increases under the universal voucher policy, and it shrinks under the targeted voucher policy.

This paper contributes to the literature along several fronts. First, I move beyond analyzing the question of whether an education system with school vouchers is superior to a system without vouchers, but rather focus on studying the economic implications of specific voucher designs and policies. Though the former question is of great importance, and has attracted the attention of many studies (Rouse, 1998; McEwan and Carnoy, 2000; Angrist et al., 2002, 2006; Hsieh and Urquiola, 2006; Rouse and Barrow, 2009; Bravo et al., 2010), I choose to investigate a narrower, but arguably more policy relevant question. Voucher programs come in all shapes and sizes, and their effects on outcomes directly depend on their design and the institutional setting in which they are introduced. Hence the importance of understanding the economic consequences associated

[4] Disadvantaged (non-disadvantaged) students are students that are (not) eligible to receive the targeted voucher. A student is classified by the Ministry of Education as being disadvantaged according to an income-based index, that was initially set to capture approximately the poorest 40% of the population. In practice, 52% of the student population is classified as disadvantaged.

to specific voucher plans. Recent studies that analyze similar questions include Gazmuri (2015), Ferreyra and Kosenok (2017), Neilson (2017), and Singleton (2017). To my knowledge, this is the first paper that empirically studies the implications of both universal and targeted voucher policies.

Second, this paper also contributes to the existing literature on the industrial organization of education markets. Studies such as Manski (1992), Epple and Romano (1998, 2008), and Nechyba (1999, 2000, 2003a,b) develop theoretical and computational general equilibrium models of education markets in which competition between public and private schools is introduced through tuition vouchers. These papers are motivated by early implementations of school choice programs in the U.S., as well as by the ideas for market-based educational vouchers originally laid out by Friedman (1962). A second and more empirical set of studies in this literature use actual data from existing school systems to learn about the economic implications of increased school choice.[5] Along this front, this paper most closely relates to Gazmuri (2015) and Neilson (2017), that estimate demand models of school choice for Chile's elementary education. Both studies use the results from their demand models to draw conclusions on the sorting and competition effects related to the introduction of a targeted voucher program. This paper improves on those studies by adding the explicit modeling of schools' decisions, which allows me to quantify schools' responses to voucher policies. Thus, I am able to answer a broader set of questions than if I estimated schools' demand in an isolated fashion. Furthermore, I show that supply responses play an important role in determining markets' equilibria. This paper also relates to Ferreyra and Kosenok (2017), and Singleton (2017), that estimate demand and supply models for charters schools in Washington, D.C. and Florida, respectively. I advance those studies by allowing schools to respond to policies along two dimensions: participation in the targeted voucher program, and tuition setting. The above-mentioned studies assume that schools respond via one channel only (i.e. entry).

[5] See e.g. Rouse (1998), Angrist et al. (2002, 2006), Hsieh and Urquiola (2006), Ferreyra (2007), Rouse and Barrow (2009), Bravo et al. (2010), Lara et al. (2011), Correa et al. (2014), Dinerstein and Smith (2014), Gazmuri (2015), Barrera-Osorio et al. (2017), Bau (2017), Ferreyra and Kosenok (2017), Neilson (2017), Singleton (2017), Walters (2017), Abdulkadiroglu et al. (2018).

Finally, this study adds to the entry and location choice literature in industrial organization (reviewed by Berry and Reiss, 2007, and Draganska et al., 2008). This literature typically uses reduced-form specifications for firms' profit functions, whereas I estimate structural models of school choice and price competition that determine schools' program participation decisions. In that respect, this paper closely relates to Draganska et al. (2009), Sullivan (2017), and Wollmann (2017), that specify sequential two-stage games, with oligopolistic firms making discrete choices on product assortment followed by continuous choices on prices. This paper differs from these studies by allowing an unusual large number of players (i.e schools) making sequential decisions in an also static discrete-continuous oligopolistic setting.

The remainder of the paper is organized as follows. Next section presents the institutional details of the Chilean school system. Section 3 describes the data used in the empirical analysis, defines the educational markets, and presents descriptive statistics and stylized facts. Section 4 presents an empirical model of school choice and school competition that approximates Chile's elementary education market. It also describes the identification and estimation strategy. Section 5 presents the estimation results. Section 6 presents the policy and counterfactual analysis, where I study the economic consequences of a series of counterfactual voucher policy scenarios. Finally, section 7 concludes.

2 School Vouchers in Chile

Chile's educational system operates under a nationwide school choice voucher agenda. It combines families' preferences with (public and private) schools competition for attracting students. Funding comes from the government, that pays voucher subsidies directly to the schools. Residential restrictions are nonexistent, therefore students can attend any school that they are willing to travel to (and are able to afford).

There exist three broad types of schools in Chile. *Public* schools, that are publicly managed, receive vouchers, and are tuition-free. *Private-voucher* schools, that are privately managed, receive vouchers, and are allowed to charge tuition (i.e. copayment) on top of the voucher subsidies. *Private-non-voucher* schools, that are privately managed, do not receive vouchers, and charge relatively high levels of tuition. In addition, private (voucher and non-voucher) schools operate under more lenient regulations regarding teachers hiring. They follow the Labor Code, as any other firm in the country, whereas public schools are subject to a Teacher Statute, that makes teachers hiring and firing harder.

The government combines two different voucher designs to subsidize enrollment:

- *Universal voucher:* per-student subsidy paid to all public and private-voucher schools.
- *Targeted voucher:* per-disadvantaged student subsidy paid to public and private-voucher schools that choose to participate in the targeted voucher program.[6]

Participation in the universal voucher program is mandatory for all public and private-voucher schools. In contrast, participation in the targeted voucher program is voluntary.[7] Private-non-voucher schools are not eligible to participate in any voucher program.[8] Schools that decide to participate in the targeted voucher program receive an additional subsidy per every disadvantaged student that they enroll, that supplements the subsidy received from the universal voucher. They are also required to charge no tuition to disadvantaged students, but they can charge any amount to non-disadvantaged. Table 1 summarizes the above-mentioned voucher regulations, distinguishing between schools' administrative type, and by whether they participate in the targeted voucher program. It also displays the corresponding enrollment shares for 1st graders for the year 2013. Notice that the vast majority (92%) of students attend a subsidized school, either public or private-voucher, which highlights the wide reach of any voucher policy within the

[6] From 1981 to 2007, the Chilean system operated under a universal voucher program only. In 2008, the government added the targeted voucher program to the universal program, in an effort to increase the access to private schools for low-income students. Since my data covers a period post-2007, I perform my analysis under the universal-and-targeted voucher setting.

[7] While, in principle, public schools have the choice to participate in the targeted voucher program, in practice, virtually all of them opt in. On the other hand, there is a considerable number of private-voucher schools that decide not to participate in the program.

[8] It is important to note that, despite the fact that private schools are allowed to switch their voucher status (e.g. from private-voucher to private-non-voucher, and viceversa) from one year to another, such transitions are very rare.

student population.

Table 1: Voucher Policies, by School-type (year 2013)

school-type:	public	private-voucher		private-non-voucher
in targeted voucher program:	yes	yes	no	no
receive universal voucher	✓	✓	✓	✗
receive targeted voucher	✓	✓	✗	✗
can charge tuition	✗	to non-disadv.	✓	✓
enrollment (%)	40	35	17	8

Notes: This table summarizes the regulations that apply to schools, depending on whether the school is public, private-voucher, or private-non-voucher, and on whether it participates in the targeted voucher program. Enrollment shares correspond to 1st grade for the year 2013.

3 Data, Educational Markets, and Descriptive Statistics

3.1 Data

I combine various administrative data sets for Chilean students and schools for the year 2013. First, I use the registry of all operating schools, in which I observe schools' management type, tuition, decision to participate in the targeted voucher program, address, and other characteristics such as religious orientation and urban status. Second, I use the registry of all students attending elementary education in the country. In these data I observe students' grade and school of attendance, whether the student is disadvantaged or non-disadvantaged, residential address, and other characteristics such as gender and date of birth.[9] Third, I use records on students' performance in mandatory national standardized tests taken by all 4th graders in the country. Finally, I use responses to a questionnaire sent to parents and tutors during the days 4th grade students take the national standardized tests. These responses provide additional demographic characteristics

[9]Students' addresses represent confidential data that I obtained from the Ministry of Education after signing a non-disclosure agreement. I store and analyze these records in a secure machine.

for students, such as parents' level of education, household income, and house amenities (e.g. computer and internet availability). Appendix A provides a more detailed description of the administrative data sets I use in this paper.

I use the address information contained in the administrative data to calculate students' geographical proximity to schools. The Ministry of Education already provides geocoded addresses in the form of latitude and longitude coordinates for all schools in the country. It does not, however, provide coordinates for students' residential addresses. I then use a combination of GIS tools to obtain geographic coordinates from these data. This process is key in order to specify a sensitive demand and supply model, because, as I show below, geographical proximity is a strong determinant of school choice and competition.

Finally, I collect data on private-non-voucher schools' tuition. Such information is not included in the administrative data that the Ministry of Education provides. I perform this process by manually collecting tuition amounts from either schools' websites or telephone conversations. I successfully retrieve tuition values for all private-non-voucher schools in the country.

3.2 Educational Markets

In this setting, there is no clear definition of geographic educational markets, because students face no geographical constraints when choosing schools, and there is no administrative boundaries that define and separate the markets. Gazmuri (2015) and Neilson (2017) face the same empirical challenge, and they both provide reasonable guides to define and form geographic educational markets for Chile. I follow their approaches, and use data on students' travelled distance to define the markets. Specifically, I join all contiguous municipalities where 5% or more of the students attending schools in those municipalities reside in.[10] This creates a network of municipalities that constitutes a market. Finally, and in an effort to select only predominantly urban markets, I drop all markets with less than 10,000 elementary education students. I end up with 29 non-

[10]Following Neilson (2017), I assume that two municipalities are contiguous if and only if they are 5 km. or less apart from each other, when measured by their two closest points.

overlapping markets across the country. However, in this version of the paper, I use data from 28 of the 29 markets. For computational reasons, I leave out the market corresponding to the capital city, Santiago.

Table 2 presents summary statistics for the the 28 educational markets used in the empirical analysis. Three important markets' characteristics are worth mentioning. First, the educational markets in the sample are large, with an average of 23,651 students and 86 schools. The smallest market is comprised by 35 schools, whereas the largest market has 240 schools competing for attracting students. Second, 52% of the students in the average market are disadvantaged. And this number ranges from 30% to 69% in the entire sample, which highlights the broad impact that any policy change in the targeted voucher can have on students' school choices. Third, on average markets have 42 private-voucher schools competing with each other, and this number goes up to 138 in the largest market. Again, this markets' feature underscores the importance of any policy change in the voucher subisidies. On the other hand, a large number of private-voucher schools in a market represents an empirical challenge when trying to model and estimate schools' behavior in an oligopolistic context, as I show in section 4.

Table 2: Educational Markets' Characterization

	mean	std. dev.	min	max
no. of students	23,651	13,810	10,082	59,316
% disadvantaged students	52	10	30	69
no. of schools	86	52	35	240
no. of public schools	38	19	14	87
no. of private-voucher schools	42	33	12	138
no. of private-non-voucher schools	6	7	0	35
% private-voucher schools in targeted program	62	17	21	86

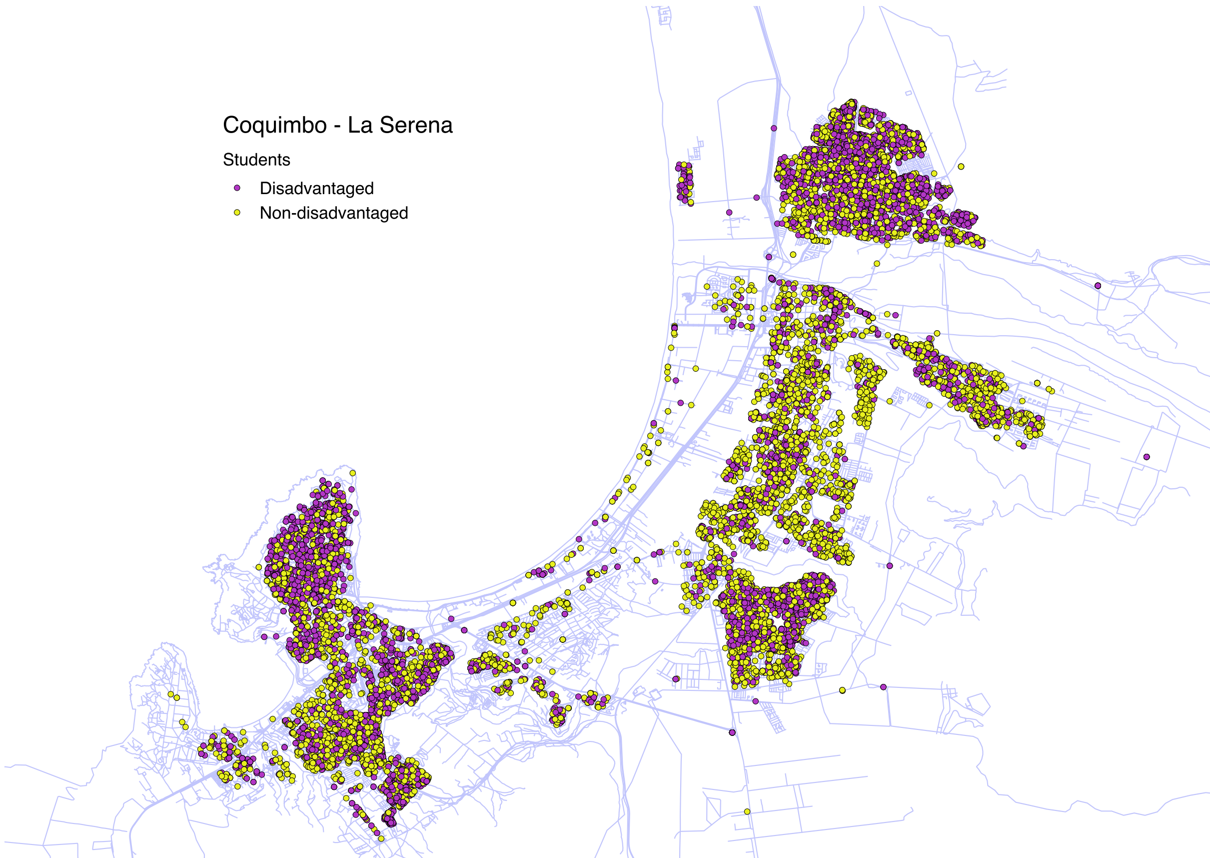
Notes: Summary statistics for all 28 geographic educational markets included in the empirical analysis. The data from the market corresponding to the capital city, Santiago, is not included.

Figures 1-4 present an example of an educational market created with the geocoded data. The market is formed by the municipalities of Coquimbo and La Serena, in Northern Chile. Figure 1 displays the streets and roads layout for the market. Figure 2 displays the spatial distribution of students' homes within the market. It distinguishes between disadvantaged (in purple) and non-disadvantaged (in yellow) students. Notice that it is possible to identify neighborhoods with high and low concentrations of disadvantaged students. Figure 3 displays the spatial distribution of schools within the market, distinguishing between public (in yellow), private-voucher (in blue), and private-non-voucher (in red) schools. Here, we can also identify areas with different concentrations of privately managed schools. Finally, Figure 4 displays the spatial distribution of private-voucher schools, distinguishing between schools that do (in blue) and do not (in light blue) participate in the targeted voucher program. Not surprisingly, neighborhoods with high concentrations of disadvantaged students (in Figure 2) also present high concentrations of schools that opted to participate in the targeted voucher program. Nonetheless, both types of schools are found in all of the neighborhoods.

Figure 1: Educational Market: Coquimbo-La Serena

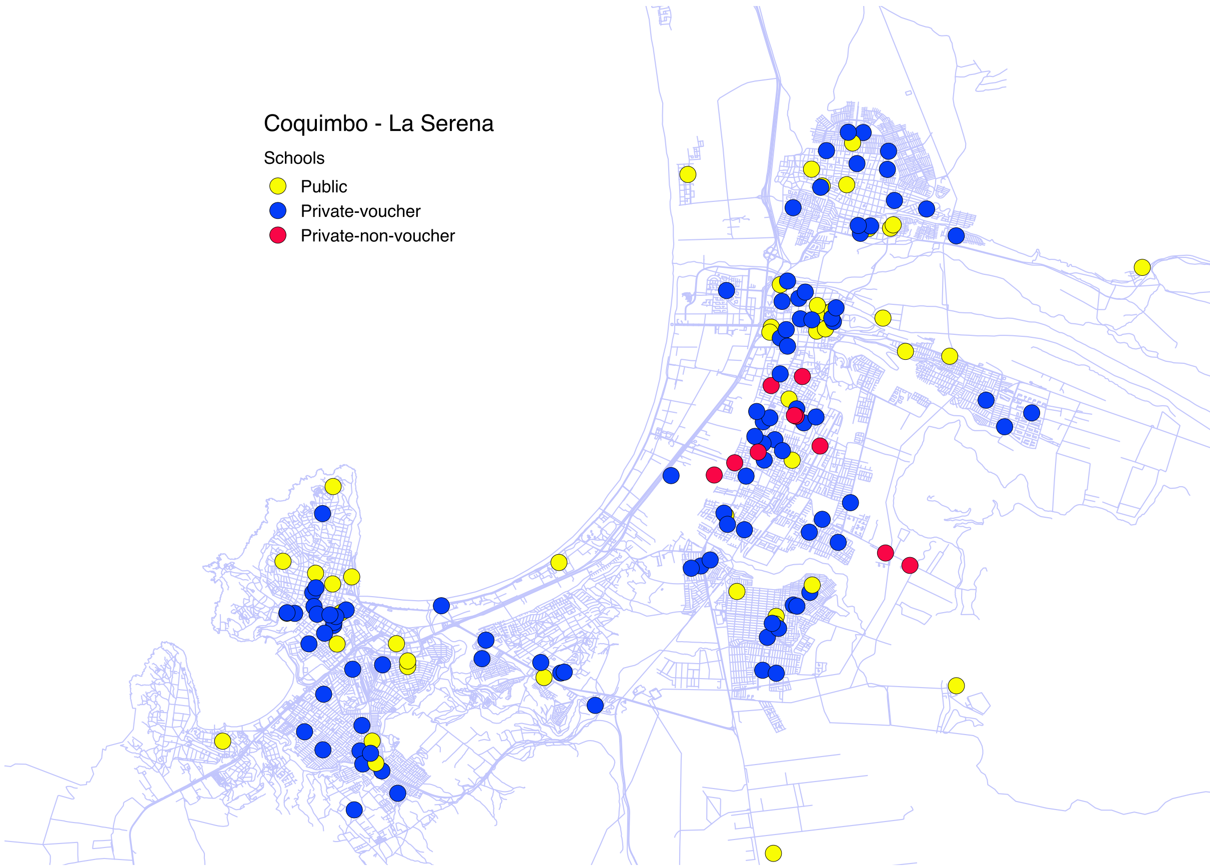
Notes: This figure shows the streets and roads layout for the educational market formed by the municipalities of Coquimbo and La Serena, in Northern Chile.

Figure 2: Educational Market: Coquimbo-La Serena - Students



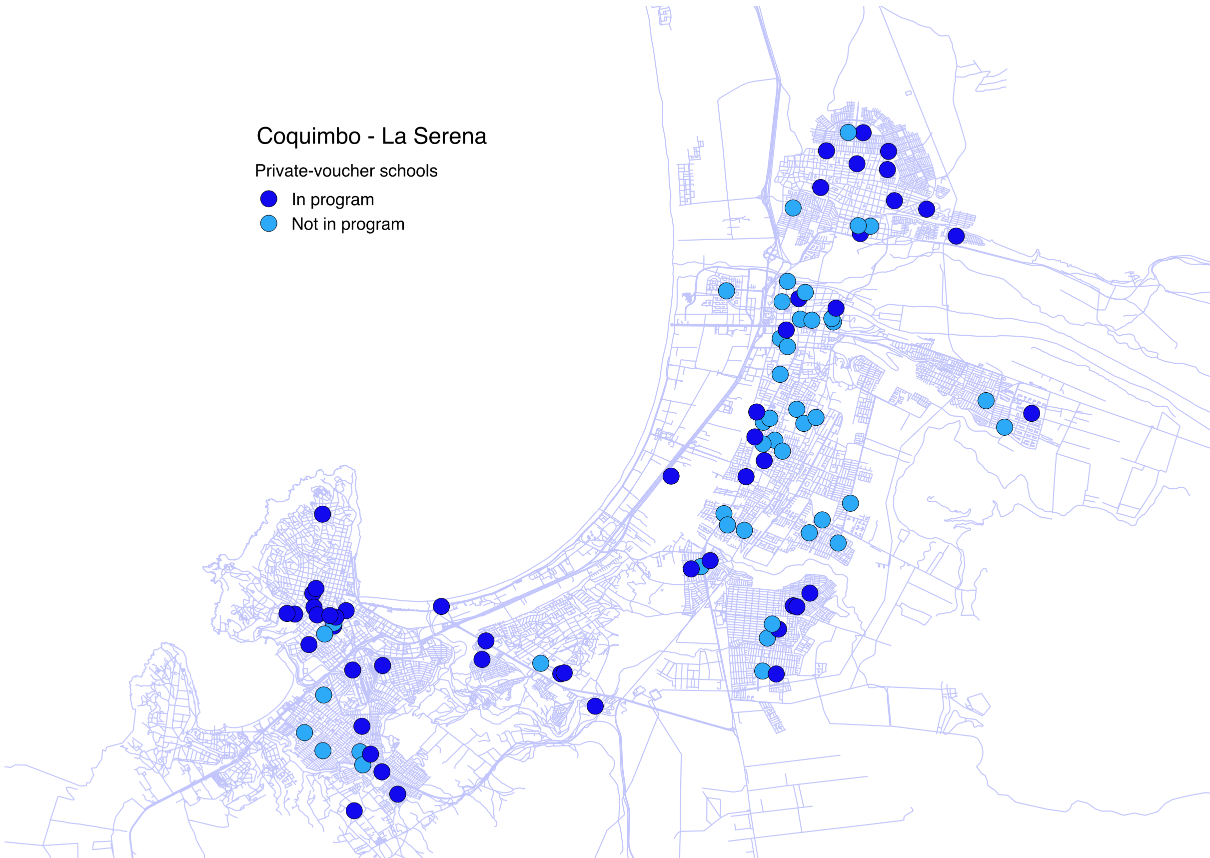
Notes: This figure shows the spatial distribution of students in the educational market formed by the municipalities of Coquimbo and La Serena, in Northern Chile. It distinguishes between disadvantaged (in purple) and non-disadvantaged (in yellow) students.

Figure 3: Educational Market: Coquimbo-La Serena - Schools



Notes: This figure shows the spatial distribution of schools in the educational market formed by the municipalities of Coquimbo and La Serena, in Northern Chile. It distinguishes between public (in yellow), private-voucher (in blue), and private-non-voucher (in red) schools.

Figure 4: Educational Market: Coquimbo-La Serena - Private-voucher Schools



Notes: This figure shows the spatial distribution of schools in the educational market formed by the municipalities of Coquimbo and La Serena, in Northern Chile. It distinguishes between schools that participate (in blue) and do not participate (in light blue) in the targeted voucher program.

3.3 Descriptive Statistics

Table 3 displays the size of the annual voucher subsidies for the years 2008–2014. Figure 5 complements this analysis graphically. We observe that both the universal voucher and the targeted voucher have been slowly and steadily increasing over the years, with averages for the period of $1,114 and $604 for the universal and targeted vouchers, respectively. The targeted voucher amount is considerable, relative to the universal voucher, representing about 50%–60%

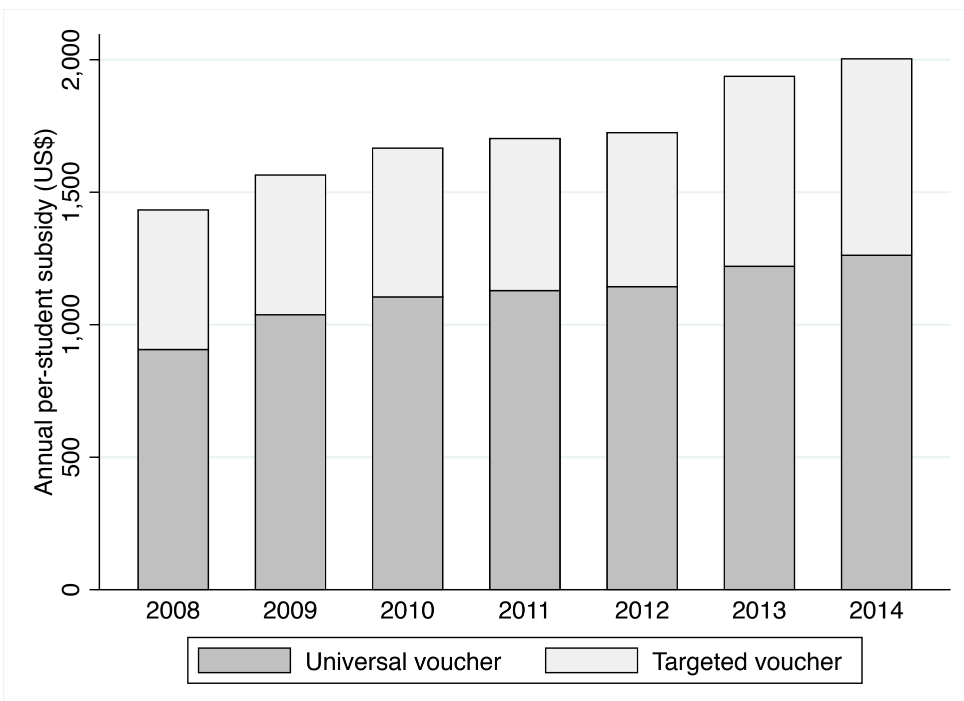
the size of the universal voucher.

Table 3: Size of Annual Voucher Subsidies, by Category and Year

year	universal voucher	targeted voucher
2008	906	527
2009	1,037	527
2010	1,105	562
2011	1,129	574
2012	1,143	581
2013	1,220	717
2014	1,262	741

Notes: Voucher levels are in real prices using 2013 as the base year, and were transformed from Ch$ to US$ according to the exchange rate as of March 1, 2013 (472.96 Ch$/US$). The universal voucher values correspond to those for students at schools with full school shifts.

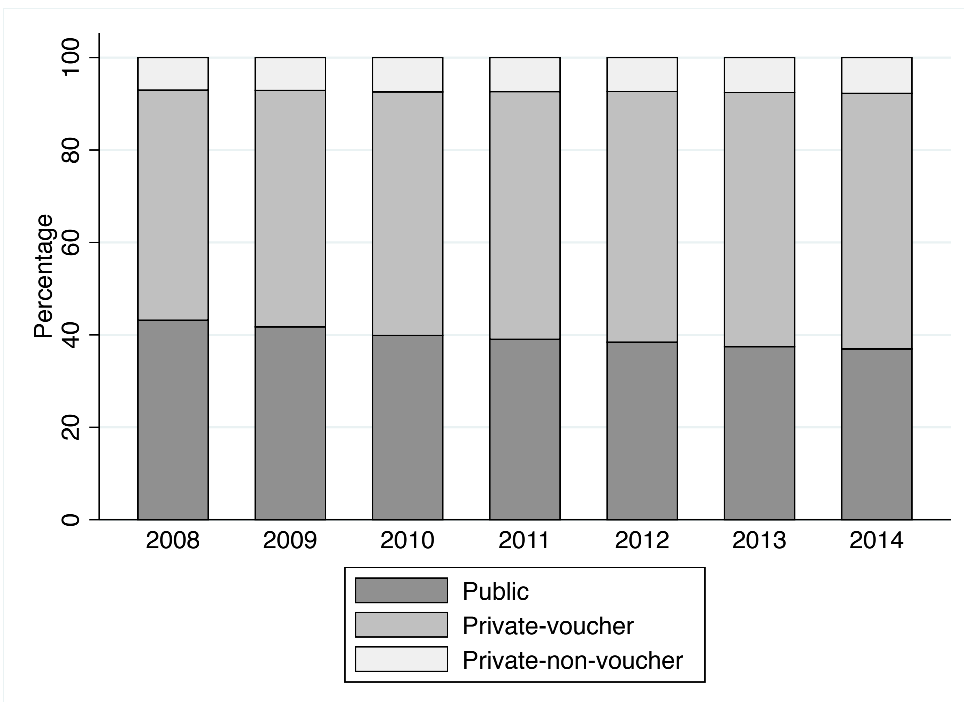
Figure 5: Size of the Voucher Subsidies by Category and Year



Notes: Voucher levels are in real prices using 2013 as the base year, and were transformed from Ch$ to US$ according to the exchange rate as of March 1, 2013 (472.96 Ch$/US$). The universal voucher values correspond to those for students at schools with full school shifts.

Figure 6 displays the enrollment share distribution for first graders among the three broad types of schools for the years 2008–2014. Three important patterns emerge. First, public and private-voucher schools together enroll more than 90% of students. Second, the share of students in public schools has been slightly decreasing over time, going from a little more than 40% in 2008 to somewhat less than 40% in 2014. Third, such decline in public schools enrollment has translated in an almost one-to-one increase in the share of students attending private-voucher schools, while the private-non-voucher enrollment share has remained fairly constant over the period.

Figure 6: First Grade Enrollment Distribution Over Time



Notes: Calculated using administrative data from the Ministry of Education.

Table 4 summarizes the characteristics of elementary schools, distinguishing by whether the school is public, private-voucher, or private-non-voucher, and by whether the school participates in the targeted voucher program. Consistent with Figure 6, 92% of students attend subsidized schools, either public (40%) or private-voucher (52%).[11] Also, schools that participate in the targeted voucher program enroll about three quarters of the student population. When we disaggregate the student population into disadvantaged and non-disadvantaged groups, we observe that 90% of disadvantaged students attend schools that participate in the targeted voucher program (52% public, 38% private-voucher), which means that they forcefully pay zero tuition. For non-disadvantaged students, the enrollment distribution is somewhat different, with almost three quarters of students attending privately managed schools (57% private-voucher, 16% private-non-voucher). A fifth of public schools are located in rural areas, while less than 7% of private-voucher and none of private-non-voucher schools are considered to be rural. Public schools are mandated to be tuition-free. Private-voucher schools that participate in the targeted voucher program must charge zero tuition to disadvantaged students, and charge on average $121 per year to non-disadvantaged. Private-voucher schools that do not participate in the targeted voucher program charge on average $711 for annual tuition. Private-non-voucher schools charge much higher tuition than the rest of schools, with an average of almost $5,000 per year. The performance in standardized math tests of students in public schools is the lowest among the groups of schools. Students in private-voucher schools that participate in the targeted voucher program come in second. Students in private-voucher schools not participating in the targeted voucher program outperform students in the former two groups of schools, and students in private-non-voucher schools obtain the highest scores. The same order is observed for the percentage of teachers with some kind of specialization, and the percentage of teachers with long-term work contracts, with public schools having the lowest concentrations, and private-non-voucher schools the highest ones.

[11]These numbers correspond to first grade enrollment in 2013.

Table 4: Schools' Characteristics, by School-type

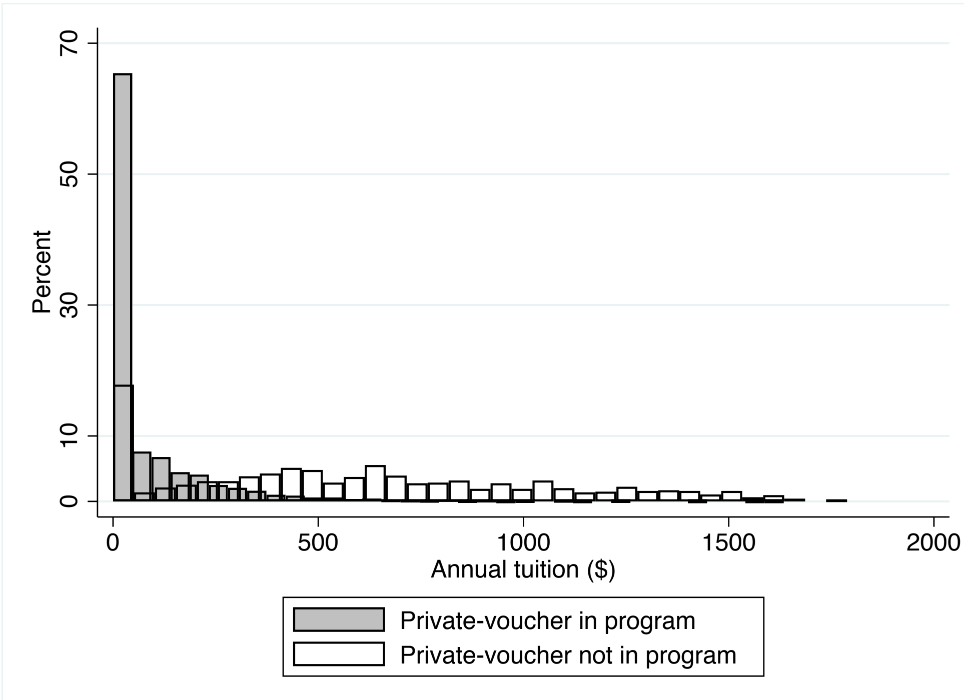
school-type:	public	private-voucher		private-non-voucher
in targeted voucher program:	yes	yes	no	no
enrollment (%)	40	35	17	8
enrollment - disadv. (%)	52	38	10	1
enrollment - non-disadv. (%)	27	31	26	16
rural (%)	21	7	1	0
avg. annual tuition (US$)	0	0/121	711	4,960
avg. math scores	-0.25	-0.01	0.28	0.75
teachers with specialization (%)	41	46	55	57
teachers with long-term contracts (%)	44	59	64	81

Notes: This table summarizes the characteristics of elementary schools, depending on whether the school is public, private-voucher, or private-non-voucher, and on whether it participates in the targeted voucher program. Tuition levels are in real prices using 2013 as the base year, and were transformed from Ch$ to US$ according to the exchange rate as of March 1, 2013 (472.96 Ch$/US$). Test scores are standardized to have mean zero and standard deviation one at the student level. Enrollment shares correspond to 1st grade for the year 2013.

Figure 7 presents a more detailed picture of the heterogeneity in the tuition charged by private-voucher schools. It plots the distribution of annual full tuition charged by private-voucher schools, depending on whether the school participates in the targeted voucher program.[12] The tuition distribution for private-voucher schools participating in the targeted voucher program is highly right-skewed, with almost 70% of schools charging zero tuition (to non-disadvantaged students), and virtually no schools charging more than $500. In contrast, the tuition distribution for private-voucher schools not participating in the targeted voucher program is much more disperse. Only about 20% of schools don't charge tuition, and there is a high proportion of schools charging relatively high amounts.

[12]Full tuition refers to the tuition paid by non-disadvantaged students.

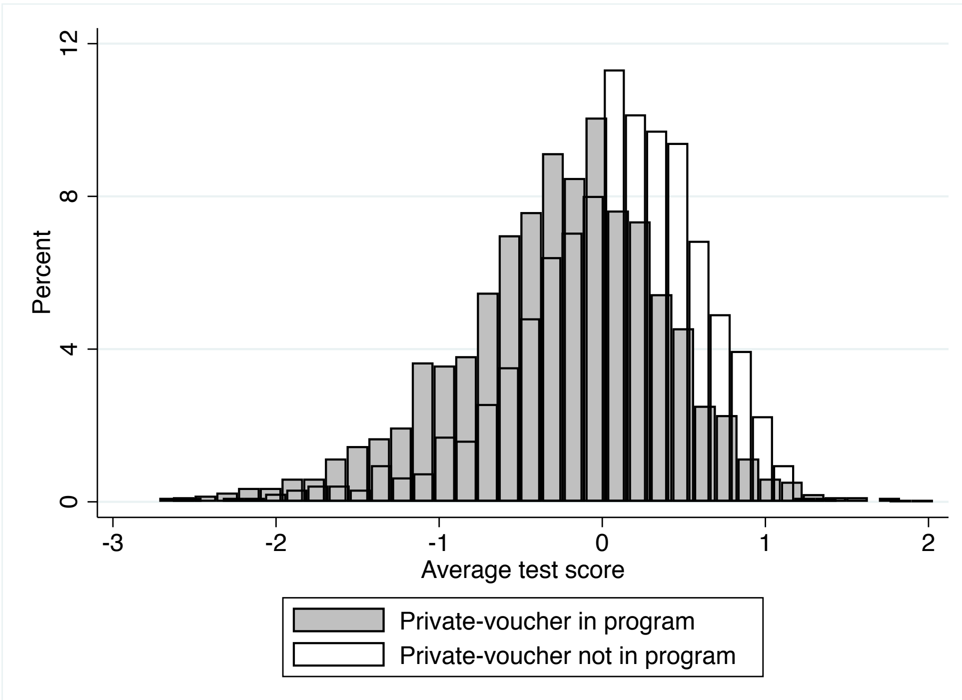
Figure 7: Annual (Full) Tuition Distribution for Private-voucher Schools



Notes: Full tuition refers to the tuition paid by non-disadvantaged students. Tuition levels are in real prices using 2013 as the base year, and were transformed from Ch$ to US$ according to the exchange rate as of March 1, 2013 (472.96 Ch$/US$).

Figure 8 presents the distribution of private-voucher schools' average test scores in the 4th grade mathematics standardized exam, disaggregated by whether schools participate in the targeted voucher program or not. We observe three important patterns. First, there is high heterogeneity in average test scores among schools. This is true for the group of schools that participate in the targeted voucher program, as well as for the group of schools that opted out. Second, the distribution for schools that don't participate in the targeted voucher program is more left-skewed than the distribution for schools participating in the program, which translates into a higher proportion of schools with high test scores in the former group. Finally, there is a good amount of overlapping between the two distributions, suggesting that, even though, on average, students in schools not participating in the targeted voucher program achieve higher test scores than students in the other group of schools, this is not necessarily the case on a school-by-school basis.

Figure 8: Average Test Score Distribution for Private-voucher Schools



Notes: School's average test score is the average score in the mathematics standardized test for 4th grade students enrolled in the school. Test scores are standardized to have mean zero and standard deviation one at the student level.

4 A Demand and Supply Model of Elementary Schools

I develop and estimate a structural model of demand and supply of schools for Chile's elementary education. There exist several education markets that are geographically separated one from another. Each market is populated by households that live in different locations within the market, and that have children who are eligible for attending elementary school. Given its budget constraint, each household chooses among the schools available in the market.

There are three different types of schools: public, private-voucher, and private-non-voucher. In each market, schools are located in different geographic areas within the market. Location decisions are assumed to be exogenous. Public schools are mandated to be tuition free, private-voucher schools are allowed to charge tuition, and private-non-voucher schools charge relatively high levels of tuition. Public and private-voucher schools receive a flat per-student subsidy voucher (i.e. universal voucher). In addition, a complementary subsidy program is available for public and private-voucher schools: a targeted voucher to disadvantaged students. This targeted program is mandatory for public schools, and is optional for private-voucher schools. The targeted voucher program adds extra per-pupil funds of about 50% over the universal voucher for every disadvantaged student that the school enrolls, with the requirement of charging zero tuition to those students. Thus, each private-voucher school that chooses to participate in the targeted voucher program must charge zero tuition to disadvantaged students, but can charge any amount to non-disadvantaged. In contrast, private-voucher schools that opt out charge a unique level of tuition to all students, regardless of whether the student is disadvantaged or non-disadvantaged. Private-non-voucher schools do not receive any subsidy.

4.1 Demand

I assume that students have heterogeneous preferences over schools' tuition, geographical proximity (i.e. distance from home to school), a set of schools' fixed characteristics, such as whether the school is public or private, its religious orientation, etc., and a measure of schools' quality. I capture heterogeneity in preferences with a set of random coefficients that vary over students' observed demographic characteristics. Formally, in each market, student $i \in \{1, \ldots, I\}$ chooses the school $j \in \{1, \ldots, J\}$ that maximizes her utility. I specify the student's conditional indirect utility by:[13]

$$U_{ij} \quad = \quad \beta_{1i}^{\zeta} p_j^{\zeta} + \beta_2^{\zeta} d_{ij} + \beta_3^{\zeta'} X_j + \beta_4^{\zeta} q_j + \xi_j^{\zeta} + \varepsilon_{ij} \tag{1}$$

[13] My model's demand specification follows the standard assumptions in the education literature, and in particular those in Gallego and Hernando (2009), Gazmuri (2015), Arcidiacono et al. (2016), Cuesta et al. (2017), Ferreyra and Kosenok (2017), and Neilson (2017).

where p_j^ζ is school j's tuition charged to student i, d_{ij} is distance from student i's home to school j, X_j is a vector of school j's characteristics, q_j is school j's quality, and ε_{ij} is an i.i.d. preference shock. The superscript ζ refers to the type of the student, i.e. disadvantaged or non-disadvantaged. Also, for any $\beta^\zeta \in \{\beta_2^\zeta, \beta_3^\zeta, \beta_4^\zeta, \xi_j^\zeta\}$, we have $\beta^\zeta = D_i\beta^D + (1-D_i)\beta^{nonD}$, where $D_i = \mathbb{1}[i \text{ is disadvantaged}]$. Similarly, $\beta_{1i}^\zeta = D_i\beta_{1i}^D + (1-D_i)\beta_{1i}^{nonD}$, where $\beta_{1i}^D = \beta_1^D + \sum_r z_{ir}\beta_{1r}^D$ and $\beta_{1i}^{nonD} = \beta_1^{nonD} + \sum_r z_{ir}\beta_{1r}^{nonD}$, with z_{ir} a demographic characteristic.

Note that the tuition that school j charges to student i, p_j^ζ, depends on whether the student is disadvantaged, and on whether the school participates in the targeted voucher program. Specifically,

$$p_j^\zeta = (1 - D_i\tau_j)p_j,$$

where $\tau_j = \mathbb{1}[j \text{ participates in targeted program}]$, and p_j is school j's full tuition level.

Let $V_{ij} = \beta_{1i}^\zeta p_j^\zeta + \beta_2^\zeta d_{ij} + \beta_3^{\zeta'} X_j + \beta_4^\zeta q_j + \xi_j^\zeta$. Then, $U_{ij} = V_{ij} + \varepsilon_{ij}$. Assuming $\varepsilon_{ij} \sim$ Type I Extreme Value, the probability that student i chooses school j is logistic:

$$P_{ij} \quad = \quad \frac{e^{V_{ij}}}{\sum_k e^{V_{ik}}}.$$

4.2 Supply

Public, private-voucher, and private-non-voucher schools are differentially affected by the institutional aspects of the voucher subsidies. I am interested in the effect that voucher policies have on schools' decisions to participate in the targeted voucher program, and on their tuition levels. Therefore, I focus only on private-voucher schools' decisions, given that all public schools participate in the targeted voucher program and are not allowed to charge tuition, and private-non-voucher schools are not directly affected by the vouchers.

I assume that private-voucher schools make decisions on whether to participate in the targeted voucher program, and on their tuition level, given their expectations of other schools' decisions, demand, and the realization of a cost structure, that consists of a marginal cost of educating a student and a fixed cost of participating in the targeted voucher program. I further assume that private-voucher schools are profit seekers, a reasonable assumption for the context, and common in the literature (Urquiola and Verhoogen, 2009; Barrera-Osorio et al., 2017; Neilson, 2017).

More formally, school j incurs in a marginal cost of c_j for delivering education to a student, which may vary depending on whether the student is disadvantaged or non-disadvantaged.[14] This marginal cost includes extra spending in teaching hours, staff remuneration, utilities' bills, etc., that are associated to the education of an additional student. I assume that schools observe each other's marginal costs when they make their choices, i.e. marginal costs are public information. In addition, school j incurs in a fixed cost of κ_j for participating in the targeted voucher program. This fixed cost includes administrative efforts related to dealing with an additional source of subsidy (i.e. bureaucracy), perceived costs associated to increased monitoring by the government, as well as school's own preference for serving (or not) disadvantaged students. Further, I assume that the fixed cost is observed only by the school itself, but not by its competitors, i.e. it is private information. In contrast to marginal costs, which are primarily driven by observable costs for homogeneous inputs, fixed costs may depend on the intrinsic efficiency of each school's processes, the strategic decisions it makes, as well as its own preference for participating in the program, all of which are generally unobserved to the other schools.

Thus, private-voucher school j chooses its program participation and tuition level to maximize expected profits:

$$\begin{aligned}\max_{\tau_j \in \{0,1\}, p_j \geq 0} \quad E\left[\Pi_j\right] \quad = \quad & E_{\tau_{-j}} \Bigg[(p_j + v^u - c_j^{nonD}) \sum_i (1 - D_i) P_{ij}(\cdot) \\ & + \tau_j (v^u + v^t - c_j^D) \sum_i D_i P_{ij}(\cdot) - \tau_j \kappa_j \\ & + (1 - \tau_j)(p_j + v^u - c_j^D) \sum_i D_i P_{ij}(\cdot) \Bigg]\end{aligned}$$

[14]It is reasonable to believe that educating a disadvantaged student, that is highly likely to come from a vulnerable and at-risk family, may involve more educational efforts than educating a non-disadvantaged student, who presumably enjoys of a richer and more stimulating environment at home.

where τ_j is school j's decision to join the targeted voucher program, and v^u and v^t are the universal and targeted voucher subsidies, respectively. To simplify notation, I suppress $(p_1, \ldots, p_J; \tau_1 \ldots, \tau_J)$ as arguments of P_{ij}. Note, too, that the expectation is taken with respect to the other schools' program participation decisions, τ_{-j}.

The expression for school j's expected profits consists of three parts. The first part is the profits obtained for educating non-disadvantaged students, where for each of those students the school perceives the tuition they charge, p_j, the universal voucher, v^u, and incurs in a marginal cost c_j^{nonD}. The second part is the profits obtained for educating disadvantaged students in the case that the school joins the targeted program, where for each disadvantaged student the school perceives the universal and targeted vouchers, $v^u + v^t$, and incurs in a marginal cost c_j^D. Notice that c_j^D is generally different from c_j^{nonD}. The school also pays the fixed cost τ_j for participating in the targeted program. Finally, the third part is the profits obtained for educating disadvantaged students in the case that the school opts out of the targeted program, where for each disadvantaged student the school perceives the tuition it charges, p_j, the universal voucher, v^u, and incurs in a marginal cost c_j^D.

Implicit in my description of schools' objective function is the fact that schools do not present different marginal costs across regimes. That is, they do not become more or less efficient in the delivery of education by joining the program. The reason for making this assumption is that, if we assume that disadvantaged and non-disadvantaged students involve different education costs, then different marginal costs across regimes are not longer identifiable from the data, as I show below. On the contrary, if we assume that disadvantaged and non-disadvantaged students involve the same marginal costs, then different marginal costs across regimes can be identified. I find the former interpretation more plausible for the Chilean context, where there is a perceived higher cost of educating students from more vulnerable backgrounds (Fontaine and Urzúa, 2018); however, I do not rule out the latter.

The solution to schools' optimization problem is not trivial for several reasons. First, it involves both a discrete variable and a continuous variable to maximize over. Second, the continuous variable, p_j, is constrained to be non-negative, and therefore may result in a corner solution in the optimum. Third, the objective function depends on other schools' decisions through the $P_{ij}(\cdot)$ terms (i.e. it is a game).

Consider the optimality conditions for p_j, and ignore the expectation over other schools' participation decisions for a moment. If the school participates in the targeted program (i.e. $\tau_j = 1$), the Kuhn-Tucker first-order conditions for tuition are:

$$p_{j|\tau_j=1}(\tau_{-j}, p_{-j}) \quad \leq \quad c_j^{nonD} - v^u - \frac{\sum_i (1-D_i) P_{ij}(\cdot)}{\sum_i (1-D_i) \frac{\partial P_{ij}(\cdot)}{\partial p_j}},$$

$$p_{j|\tau_j=1}(\tau_{-j}, p_{-j}) \frac{\partial \Pi_{j|\tau_j=1}}{\partial p_j} = 0, \text{ and } p_{j|\tau_j=1}(\tau_{-j}, p_{-j}) \geq 0,$$

where the first equation is the profits' derivative with respect to tuition being less than or equal to zero, the second equation is the complementary slackness, and the last equation is the non-negativity constraint. Also, (τ_{-j}, p_{-j}) is the vector containing all other schools' program participation and tuition decisions. From the first equation, we observe that the universal voucher drives down the tuition charged by the school. In other words, the larger the universal voucher, the lower the level of tuition set by the school, all else equal. The last term on the right-hand side in the first equation represents the markup relative to the marginal cost and the universal voucher that schools can charge because of their market power. This markup is smaller the more price-sensitive the demand is. Notice that the markup term depends only on the demand of non-disadvantaged students. This is so because the school is required not to charge tuition to disadvantaged students in the case the school joins the targeted voucher program. This institutional feature allows the identification of school j's marginal cost for educating non-disadvantaged students, c_j^{nonD}.[15]

The Kuhn-Tucker first-order conditions for tuition, in the case that the school opts out of the

[15]Strictly speaking, c_j^{nonD} is identified only for schools charging positive tuition. In the empirical implementation of the model, I make functional assumptions that allow me to infer costs for schools with a binding non-negativity constraint. Same rationale applies to the identification of $c_j^{D\&nonD}$ below.

targeted voucher program (i.e. $\tau_j = 0$) are:

$$p_{j|\tau_j=0}(\tau_{-j}, p_{-j}) \quad \leq \quad c_j^{D\&nonD} - v^u - \frac{\sum_i P_{ij}(\cdot)}{\sum_i \frac{\partial P_{ij}(\cdot)}{\partial p_j}},$$

$$p_{j|\tau_j=0}(\tau_{-j}, p_{-j}) \frac{\partial \Pi_{j|\tau_j=0}}{\partial p_j} = 0, \text{ and } p_{j|\tau_j=0}(\tau_{-j}, p_{-j}) \geq 0.$$

Here, the markup term in the first equation depends on the demand of all students, because school j's tuition is charged to everybody, regardless of whether the student is disadvantaged or non-disadvantaged. For this reason, I can identify school j's marginal cost of educating both disadvantaged and non-disadvantaged students, $c_j^{D\&nonD}$.

Notice that I emphasize the dependency of the optimal tuition on the program participation decisions of all schools in the market, $\tau = (\tau_1, \ldots, \tau_J)$. This implies that there is potentially a different set of optimal tuition levels for every different market configuration.

Now, consider the optimality conditions for school j's program participation decision, τ_j:

$$\tau_j \quad = \quad \mathbb{1}\left\{E_{\tau_{-j}}\left[\Pi_{j|\tau_j=1}(\tau_{-j}, p(\tau_{-j})) - \Pi_{j|\tau_j=0}(\tau_{-j}, p(\tau_{-j}))\right] - \kappa_j > 0\right\},$$

which simply states that school j joins the targeted program if and only if the expected profits of joining the program net of the program participation costs are greater than the expected profits of not joining the program.

As it is, this problem is theoretically solvable. However, in practice, it proves to be computationally intractable. The main reason for this intractability comes from the need of computing a different equilibrium set of tuitions for each possible market configuration. And, considering that urban education markets in Chile include tens, and sometimes hundreds of private-voucher schools, the problem quickly becomes computationally expensive as the number of schools grows. For instance, in a market with 10 private-voucher schools, there are 1,024 different market configurations. In a market with 20 private-voucher schools, there are 1,048,576 different market configurations.[16]

To overcome such practical difficulties, I adapt the concept of *Oblivious Equilibrium* (Weintraub et al., 2008) to my setting.

4.2.1 Oblivious Equilibrium

Oblivious equilibrium (OE) was initially introduced by Weintraub et al. (2008) to facilitate the computation of equilibria in dynamic games of imperfect competition in industries with a large number of firms. It constitutes an approximation to full-solution equilibria (i.e. Markov perfect equilibria), but it has been shown to accurately mimic the full-solution results, with approximation errors that quickly decay as the number of firms in the industry grows (Weintraub et al., 2008, 2010; Xu, 2008; Qi, 2013). OE in dynamic settings assumes that firms make their decisions by taking into account the long-run equilibrium of the game, in lieu of the period-by-period equilibrium. Thus, firms ignore the contemporaneous effect of their own actions on their competitors' actions, as well as the contemporaneous effect of their competitors' actions on the firms' own actions.

I adapt the concept of OE to my setting as follows. I assume that each school makes decisions based only on its own type (i.e. realization of its fixed cost) and a belief of the expected equilibrium in the market. This is different from a full-solution equilibrium, in this context a Bayesian Nash equilibrium, in that the assumption implies that schools' competitors actions do not directly affect schools' own actions, but only through the expected equilibrium's belief, and likewise schools' own actions only affect their competitors' actions through their competitors' belief about the expected equilibrium.

I further define a sufficient statistic that summarizes the market's expected equilibrium, which I assume schools use to base their decisions on. I denote this sufficient statistic as γ_{ij}, where γ_{ij}

[16] More generally, in a market with J private-voucher schools, there is a total of 2^J different possible market configurations.

is such that,

$$\tilde{P}_{ij} = \frac{e^{V_{ij}}}{e^{V_{ij}} + E_{\tau_{-j}}\left[\sum_{k\neq j} e^{V_{ik}(\tau_k)}\right]} = \frac{e^{V_{ij}}}{e^{V_{ij}} + \gamma_{ij}}.$$

Thus, school j's belief of the expected equilibrium consists in the vector $\gamma_j = (\gamma_{1j}, \ldots, \gamma_{Ij})$.

A vital criterion for an OE is that schools' beliefs be *consistent*. In other words, when schools have consistent beliefs about the expected equilibrium, the choices they make result in an equilibrium that is consistent with those beliefs. More formally,

$$\bar{\gamma}_{ij} = \sum_{k\neq j} \left\{ u_k(\bar{\gamma}) e^{V_{ik}(\tau_k=1)} + (1 - u_k(\bar{\gamma}))\, e^{V_{ik}(\tau_k=0)} \right\}, \tag{2}$$

where $\bar{\gamma} = (\bar{\gamma}_1, \ldots, \bar{\gamma}_J)$ is the set of schools' consistent beliefs, and $u_j(\bar{\gamma}) = Pr(\tau_j = 1; \bar{\gamma})$ is school j's oblivious program participation probability when it has consistent beliefs $\bar{\gamma}$.

Equation (2) defines a fixed-point for $\bar{\gamma}$, i.e. $\bar{\gamma} = \Gamma(\bar{\gamma})$. I solve for this fixed-point by using the following iterative algorithm:

1. Start with an initial value, $\bar{\gamma}^0$.
2. Compute the optimal tuition levels and profits for both the cases when the school joins the program and when the school opts out, given the school's beliefs.
3. Compute the probability that the school joins the program, using the calculated profits and the realization of the fixed cost.
4. Compute a new value for the schools' beliefs, $\bar{\gamma}^1$, following equation (2).
5. Compare $\bar{\gamma}^1$ with $\bar{\gamma}^0$. If $\bar{\gamma}^1$ is sufficiently close to $\bar{\gamma}^0$, stop. Otherwise, update $\bar{\gamma}^0 = \bar{\gamma}^1$, and go back to step 2.

Alogirthm 1 below describes the algorithm in more detail.

Algorithm 1 Oblivious Equilibrium Solver

$\gamma_{ij}^0 = 0$; $\gamma_j^0 = (\gamma_{1j}^0, \ldots, \gamma_{Ij}^0)$
$\Delta = 100$
$tol = 1e-6$
while $\Delta > tol$ **do**
  $p^*_{j|\tau_j=1} = \text{argmax}_p \, \Pi_{j|\tau_j=1}(p, \gamma_j^0)$; $\quad p^*_{j|\tau_j=0} = \text{argmax}_p \, \Pi_{j|\tau_j=0}(p, \gamma_j^0)$
  $u_j(\gamma_j^0) = Prob\left(\Pi_{j|\tau_j=1}(p^*_{j|\tau_j=1}, \gamma_j^0) - \Pi_{j|\tau_j=0}(p^*_{j|\tau_j=0}, \gamma_j^0) > \kappa_j\right)$
  $\gamma_{ij}^1 = \sum_{k \neq j} \left\{u_k(\gamma_k^0) e^{V_{ik}(\tau_k=1)} + (1 - u_k(\gamma_k^0))\, e^{V_{ik}(\tau_k=0)}\right\}$; $\quad \gamma_j^1 = \left(\gamma_{1j}^1, \ldots, \gamma_{Ij}^0\right)$
  $\Delta = \max_{(ij)} |\gamma_{ij}^1 - \gamma_{ij}^0|$
  $\gamma_j^0 = \gamma_j^1$
end while

Note that uniqueness of equilibrium in this game is not guaranteed. However, I investigate the prevalence of multiple equilibria numerically, by computing the number of oblivious equilibria that arise from a large grid of starting values for $\bar{\gamma}$. At the estimated parameters, I find that there is always a unique equilibrium.

With all this in hand, I define an *Oblivious Equilibrium* for this static game as a set of oblivious participation probabilities, $(u_1(\bar{\gamma}), \ldots, u_J(\bar{\gamma}))$, and tuitions, $(p_1(\bar{\gamma}), \ldots, p_J(\bar{\gamma}))$, such that schools' profits are maximal given their beliefs about the expected equilibrium, and that schools' beliefs are consistent.[17]

4.3 Estimation and Identification

I estimate the model's parameters sequentially. First, I obtain the demand parameters. Then, given the demand parameters, I estimate the parameters that enter the marginal cost and the fixed cost of participating in the targeted voucher program.

4.3.1 Demand

A key school characteristic in the demand model is school's quality. This variable is essentially unobservable, and is usually captured by the school fixed effects, ξ_j, in standard models. However,

[17] Notice that, despite the desirable properties of OE, this application of the concept of OE consists in one of the very few in the literature (see, e.g., Xu, 2008; Qi, 2013).

in an effort to be able to say something about students' preferences for quality, I follow Arcidiacono et al. (2016), and use test scores data to recover a proxy measure of schools' quality (or schools' test scores productivity). Specifically, I estimate the following regression model:

$$y_{ij} = \alpha_1' x_i + \alpha_2' X_j + q_j + \upsilon_{ij}, \tag{3}$$

where y_{ij} is the test score of student i in school j, x_i is a vector of student's observed characteristics, X_j is a vector of school's observed characteristics, q_j is school j's unobserved quality, and υ_{ij} is an idiosyncratic error term. I proceed in two steps for estimation. In the first step, I estimate

$$y_{ij} = \alpha_1' x_i + \rho_j + \upsilon_{ij}.$$

In the second step, I use the estimated $\hat{\rho}_j$ to recover α_2 and q_j, by estimating

$$\hat{\rho}_j = \alpha_2' X_j + q_j.$$

The residual of this second step equation is my estimated measure for the unobserved quality of the school, $\hat{q}_j = \hat{\rho}_j - \hat{\alpha}_2' X_j$. I additionally use a measure of school's "teachers quality", which I define by the cross product of the subset of school's observed characteristics that relate to teachers (e.g. teachers' experience, % teachers with specialization, % female teachers, etc.) and the corresponding subset of $\hat{\alpha}_2$ estimated coefficients.

With the estimated measures of schools' quality in hand, I proceed to estimate demand parameters following Goolsbee and Petrin (2004) and Hackmann (2015). The estimation is done in two steps. First, I use Maximum Likelihood to estimate distance and preference parameters capturing taste heterogeneity in mother's education. In the second step, I recover the remaining "average" preference parameters by two stages least squares (2SLS).

First Step.

I use Maximum Likelihood to estimate preference for proximity, taste heterogeneity in mother's education level, and mean utilities, δ_j^ζ. Note that mean utilities vary at the school-student type level, and absorb the remaining preference components from the indirect utility function:

$$\delta_j^\zeta = \beta_1^\zeta p_j^\zeta + \beta_3^{\zeta'} X_j + \beta_4^\zeta q_j + \xi_j^\zeta$$

The corresponding log-likelihood function is:

$$LL(\beta) = \sum_i \sum_j e_{ij} \ln \left(\frac{\exp\left(\beta_{1i}^\zeta p_j^\zeta + \beta_2^\zeta d_{ij} + \delta_j^\zeta\right)}{\sum_k \exp\left(\beta_{1i}^\zeta p_k^\zeta + \beta_2^\zeta d_{ik} + \delta_k^\zeta\right)} \right),$$

where e_{ij} is the choice indicator.

Second Step.

I use the estimated $\hat{\delta}_j^\zeta$ terms from the first step to estimate the remaining mean preference parameters in a linear regression of the form:

$$\hat{\delta}_j^\zeta = \beta_1^\zeta p_j^\zeta + \beta_3^{\zeta'} X_j + \beta_4^\zeta q_j + \xi_j^\zeta. \tag{4}$$

As is usual in demand models, I assume that X_j is uncorrelated with ξ_j. However, p_j^ζ is potentially endogenous. Thus, I estimate equation (4) by 2SLS, using BLP-type of instruments for tuition (Berry et al., 1995).

Identification is ensured as long as the variables used to instrument for tuition are valid instruments (i.e. are correlated with the endogenous variable, but not with the preference shock). I follow Berry et al. (1995) and use non-price attributes of all other schools in the market. The intuition behind these instruments is that we believe (and according to the supply side of the model) that schools make their program participation and tuition decisions by taking into account their competitors' characteristics, but that the utility that a student gets from attending a given school does not depend on the other schools' characteristics. In practice, I use the sum of other schools' pupil-teacher ratio, the sum of other schools' quality measures, and the percentage of public schools in the market to create the instruments.[18]

4.3.2 Supply

I use the demand estimates and schools' optimality conditions to estimate the marginal and fixed costs parameters. I parameterize the marginal cost c_j as follows:

$$c_j = X_j\omega_1 + \epsilon_j,$$

where ϵ_j is an idiosyncratic shock . I can then write down the latent tuition function to be estimated as:

$$p_j^* \quad = \quad c_j(\omega) - v^u - m_j(\hat{\beta}; d_j) + \epsilon_j,$$

where $m_j(\hat{\beta}; d_j)$ corresponds to the (estimated) markup term in the first-order conditions.[19] Observed tuition is,

$$p_j = \begin{cases} p_j^* & \text{if } p_j^* > 0 \\ 0 & \text{if } p_j^* \leq 0. \end{cases}$$

I assume $\epsilon_j \sim N(0, \sigma_\epsilon^2)$, which implies the model is a Type 1 Tobit (Tobin, 1958; Amemiya, 1985).

Similarly, I parameterize $\kappa_j = W_j\lambda + \nu_j$, where W_j is a vector of variables affecting the fixed cost, and $\nu_j \sim N(0, \sigma_\nu^2)$. This allows me to specify a probit model for the decision to participate in the targeted voucher program.

I estimate the costs parameters using a GMM procedure coupled with a nested fixed-point (NFXP) algorithm that solves for markets' equilibria at every iteration of the parameters in the optimization routine. The moments I use are the difference between schools' predicted and actual

[18] Results using means instead of sums for the instruments are similar to the ones I report below. Conceptually, instruments using sums incorporate variation coming from both other schools' characteristics and markets' size, whereas instruments using means incorporate variation coming only from other schools' characteristics.

[19] Specifically, $m_j(\hat{\beta}; \tau_j) = \tau_j \frac{\sum_i (1-D_i) P_{ij}(\cdot; \hat{\beta})}{\sum_i (1-D_i) \frac{\partial P_{ij}(\cdot; \hat{\beta})}{\partial p_j}} + (1-\tau_j) \frac{\sum_i P_{ij}(\cdot; \hat{\beta})}{\sum_i \frac{\partial P_{ij}(\cdot; \hat{\beta})}{\partial p_j}}$.

program participation and tuition decisions.[20]

5 Results

I present evidence for 28 geographic markets from Chile for the year 2013, which consists in data for 662,327 elementary school students and 2,224 schools (959 public, 1,110 private-voucher, 155 private-non-voucher).[21]

Tables 5 and 6 present summary statistics for the variables used in estimation. Table 5 describes variables at the student level. On average, a student travels 3.05 km. to her school of choice. 53% of students are disadvantaged, and 51% are male. Almost two thirds of students have a computer at home, while half of them have internet connection. More than a quarter of students have less than 9 books at home, while only 15% of them have more than 51 books at home. The majority of students attended some form of preschool education. More than a quarter of students' mothers don't have a secondary education degree, and only 16% of students' mothers have a college degree. A similar pattern is observed for fathers' education. Finally, more than half of students live in households with a total monthly income below $740.02, and only 7% of students live in households with a total monthly income of $1,902.91 or higher.

[20] A proper correction for standard errors should be used to account for the fact that demand estimates are used as inputs in the supply estimation procedure. Bootstrap is an option. The results I show below do not include corrected standard errors.

[21] For the moment, I am not using data from the market that corresponds to Santiago, the nation's capital city.

Table 5: Summary Statistics - Student Level

	mean	std. dev.	median
distance to school of choice (km.)	3.05	9.49	1.39
disadvantaged	0.53	0.50	1.00
male	0.51	0.50	1.00
computer at home	0.64	0.48	1.00
internet at home	0.49	0.50	0.00
no. of books at home: 0	0.03	0.17	0.00
no. of books at home: 1–9	0.25	0.43	0.00
no. of books at home: 10–50	0.39	0.49	0.00
no. of books at home: 51–100	0.10	0.30	0.00
no. of books at home: 100 or more	0.05	0.21	0.00
no. of books at home: missing	0.18	0.39	0.00
attended day care	0.13	0.34	0.00
attended pre-kindergarten level 1	0.53	0.50	1.00
attended pre-kindergarten level 2	0.73	0.44	1.00
attended kindergarten	0.82	0.39	1.00
mother's education: none	0.08	0.26	0.00
mother's education: primary	0.20	0.40	0.00
mother's education: secondary	0.39	0.49	0.00
mother's education: college	0.16	0.36	0.00
mother's education: missing	0.18	0.38	0.00
father's education: none	0.07	0.26	0.00
father's education: primary	0.20	0.40	0.00
father's education: secondary	0.36	0.48	0.00
father's education: college	0.15	0.35	0.00
father's education: missing	0.22	0.41	0.00
household's monthly income: $317.15 or less	0.23	0.42	0.00
household's monthly income: $317.15–$740.02	0.31	0.46	0.00
household's monthly income: $740.02–$1,902.91	0.22	0.41	0.00
household's monthly income: $1,902.91 or more	0.07	0.25	0.00
household's monthly income: missing	0.18	0.38	0.00

Notes: All variables are at the student level, for the sample used in estimation. Income levels are in real prices using 2013 as the base year, and were transformed from Ch$ to US$ according to the exchange rate as of March 1, 2013 (472.96 Ch$/US$).

Table 6 presents summary statistics for variables at the elementary school level. On average, private (voucher and non-voucher) schools charge $943.15 per year. Two thirds of private-voucher schools participate in the targeted voucher program. 43% of schools are public, half of schools are private-voucher, and only 7% of schools are private-non-voucher. Also, a fifth of schools are located in a rural area, and half of schools are considered to follow a secular orientation. The average years of experience of teachers in schools is, on average, 12.69 years. Schools tend to hire teachers with both a degree in education and a college degree. Teachers with specialization or with a 10 or more semesters degree are relatively scarce in schools. Finally, schools hire mainly female teachers.

Table 6: Summary Statistics - School Level

	mean	std. dev.	median
annual tuition (private schools)	943.15	1805.32	182.24
participates in targeted voucher program (private-voucher schools)	0.66	0.47	1.00
public	0.43	0.50	0.00
private-voucher	0.50	0.50	0.00
private-non-voucher	0.07	0.25	0.00
rural	0.20	0.40	0.00
secular	0.50	0.50	0.00
average teachers' experience	12.69	5.67	12.35
% teachers with a degree not in education	0.03	0.06	0.00
% teachers with a college degree	0.92	0.11	0.94
% teachers with a long-term contract	0.51	0.25	0.50
% teachers with specialization	0.48	0.20	0.47
% teachers with a 10+ semesters degree	0.38	0.29	0.33
% female teachers	0.75	0.16	0.76

Notes: All variables are at the school level, for the sample used in estimation. Tuition levels are in real prices using 2013 as the base year, and were transformed from Ch$ to US$ according to the exchange rate as of March 1, 2013 (472.96 Ch$/US$).

5.1 Demand Estimates

Tables 7 and 8 present the results of estimating the test scores equation (3). Table 7 shows the estimated coefficients for the first step, in which the student level test scores are regressed on a set of student characteristics and school fixed-effects.[22] The results are in line with the existing related evidence (see, for example, Neilson, 2017, and Rau et al., 2018). In particular,

[22]The test score variable used as dependent variable in this regression corresponds to the average of student's math and verbal scores. As I mentioned above, this variable is normalized to have mean zero and standard deviation one.

male students perform worse than females.[23] Disadvantaged students score lower than non-disadvantaged. More resources at home (e.g. computer, internet, books) generally increases students' test scores. Surprisingly, attending preschool lowers students' test scores. The higher the level of parents' education, the higher the test score of the student. Similarly, more financial resources in the household increase students' academic performance.

[23] Rau et al. (2018) show that the gender effect varies depending on the subject tested. More precisely, 8th grade Chilean females outperform males in verbal, but the opposite occurs in math, social sciences, and natural sciences. They also show that the female effect in verbal is significantly stronger than the male effect in any of the other three subjects, which may explain the negative effects for males that Neilson (2017) and this paper find when averaging math and verbal scores.

Table 7: Test Scores Regressions - Step 1

variable	coef.	std. err.
male	-0.057***	0.005
disadvantaged	-0.053***	0.005
computer at home	0.024***	0.008
computer at home: missing	-0.052***	0.017
internet at home	-0.006	0.007
internet at home: missing	-0.076***	0.011
no. books at home: 0	0.044***	0.014
no. books at home: 10–50	0.111***	0.014
no. books at home: 51–100	0.180***	0.016
no. books at home: more than 100	0.253***	0.017
no. books at home: missing	0.160***	0.027
attended day care	-0.018***	0.007
attended day care: missing	-0.007	0.023
attended prekindergarten level 1	-0.049***	0.005
attended prekindergarten level 1: missing	-0.107***	0.026
attended prekindergarten level 2	0.002	0.008
attended prekindergarten level 2: missing	-0.017	0.031
attended kindergarten	0.047*	0.026
attended kindergarten: missing	0.047	0.043
mother's education: primary	0.029***	0.010
mother's education: secondary	0.129***	0.010
mother's education: college	0.151***	0.012
father's education: missing	0.040*	0.021
father's education: primary	0.039***	0.010
father's education: secondary	0.098***	0.010
father's education: college	0.145***	0.012
father's education: missing	0.091***	0.014
household's monthly income: \$317–\$740	0.025***	0.007
household's monthly income: \$740–\$1,903	0.051***	0.008
household's monthly income: \$1,903 or more	0.082***	0.012
household's monthly income: missing	0.097***	0.023
constant	-0.305***	0.030
R-squared	0.272	

Notes: Estimated coefficients from test scores regressions at the student level. School fixed-effects are included. * denotes significance at the 90% level, ** denotes significance at the 95% level, *** denotes significance at the 99% level.

Table 8 shows the results for the second step of the estimation procedure of the test scores equation (3), which uses the school fixed-effects estimated in the first step, and regresses them on a set of schools' observed characteristics. Public and private-voucher schools are associated with a low contribution to test scores, relative to private-non-voucher schools. The coefficients for rural and secular are positive and negative, respectively, but they are both statistically insignificant. Finally, the results for the set of variables that relate to schools' teacher resources suggest that having a staff of teachers that are more qualified, have better work contracts, and are majority female, increases schools' contribution to test scores.

Table 8: Test Scores Regressions - Step 2

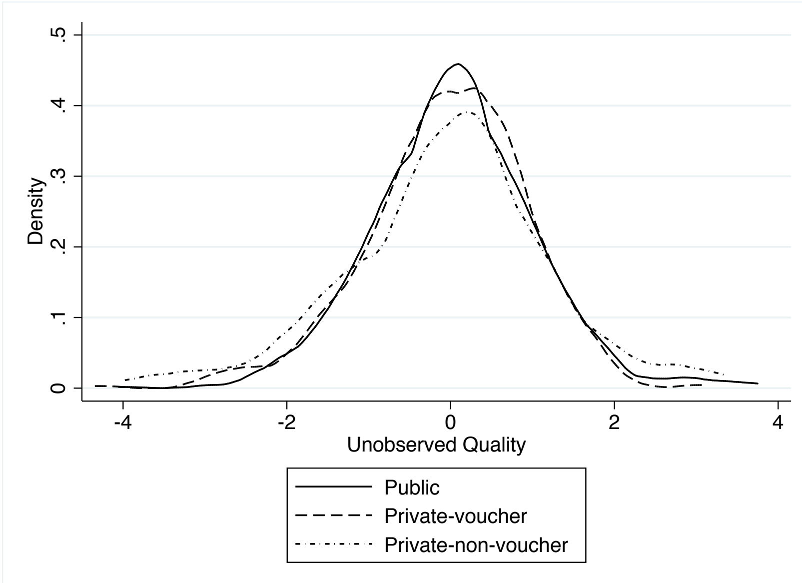
variable	coef.	std. err.
rural	0.014	0.025
public	-0.551***	0.032
private-voucher	-0.437***	0.027
secular	-0.023	0.015
average teachers' experience	-0.003*	0.002
% teachers with a degree not in education	-0.264*	0.145
% teachers with a college degree	0.218***	0.076
% teachers with a long-term contract	0.338***	0.041
% teachers with specialization	0.192***	0.041
% teachers with a 10+ semesters degree	0.182***	0.029
% female teachers	0.253***	0.049
constant	-0.430***	0.107
R-squared	0.245	

Notes: Estimated coefficients from second step of test scores regressions (at the school level). Market fixed-effects are included. * denotes significance at the 90% level, ** denotes significance at the 95% level, *** denotes significance at the 99% level.

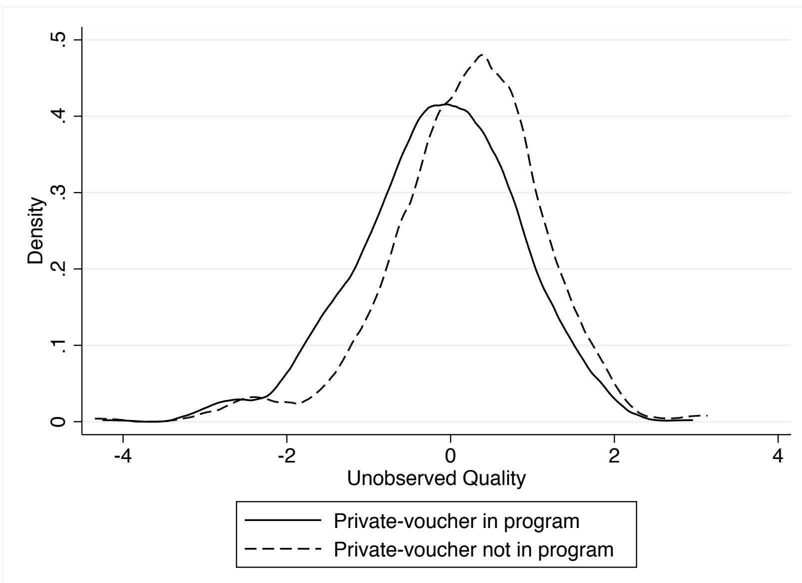
Following the analysis from section 4.3.1, I use the estimates from the test scores regressions to construct a measure of schools' unobserved quality. In addition, I construct a measure of schools' teachers quality, which is simply the cross-product of schools' teacher resources and the corresponding estimated coefficients. Figures 9 and 10 display the distributions of the estimated schools' unobserved and teacher quality, respectively. Panel A in Figure 9 presents schools' unobserved quality distribution by schools' administrative type. Unsurprisingly, given the way the unobserved quality was constructed, all school-types present the same distribution mean. This is expected, given that the unobserved quality is the residual of a regression that has the school-types as regressors. A considerable level of heterogeneity is also observed. Panel B supplements this information by showing schools' unobserved quality distribution for private-voucher schools only, distinguishing between schools that do and do not participate in the targeted voucher program. The quality distributions differ one from another, with schools participating in the targeted voucher program presenting a more right-skewed distribution than schools that are not in the program. Figure 10 presents schools' estimated teachers quality distributions. Panel A shows the distributions by schools' administrative type. Private-non-voucher schools present the distribution associated to the highest levels of teachers quality, which is followed by private-voucher schools' distribution, and lastly by public schools' distribution. Panel B presents schools' teacher quality distributions for private-voucher schools only, distinguishing between schools that do and do not participate in the targeted voucher program. Consistent with what was observed in Figure 9, schools that participate in the program have a teacher quality distribution that is more right-skewed than schools that do not participate in the program.

Figure 9: Schools' Unobserved Quality Distribution

A. All Schools



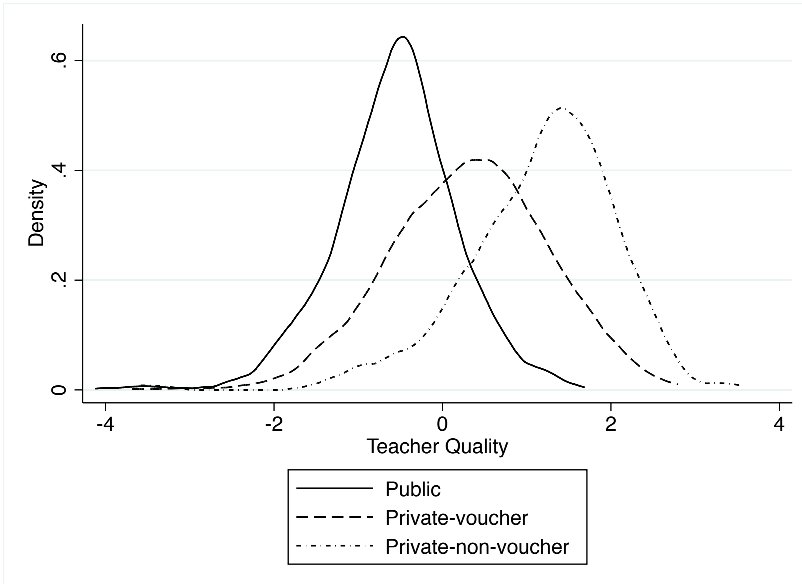
B. Private-voucher Schools



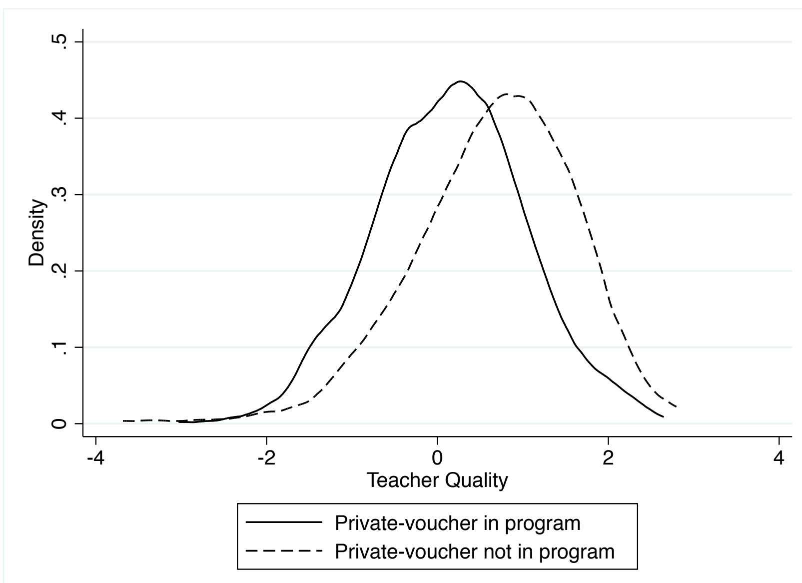
Notes: This figure plots kernel density estimates for the distribution of schools' estimated unobserved quality.

Figure 10: Schools' Teacher Quality Distribution

A. All Schools



B. Private-voucher Schools



Notes: This figure plots kernel density estimates for the distribution of schools' estimated teacher quality.

Table 9 displays the estimated parameters for the demand model. The table combines estimates from the first (maximum likelihood) and second (2SLS) steps. The omitted mother's level of education category is “not formal education”. My estimates are in line with the related literature (e.g. Gallego and Hernando, 2009, Gazmuri, 2015, Cuesta et al., 2017, Neilson, 2017). The estimated “average” parameters for tuition, that correspond to the omitted mother’s level of education category of “not formal education”, are negative and statistically significant. The preference heterogeneity parameters suggest that children with highly educated mothers are more likely to attend schools with high levels of tuition.[24] Also, disadvantaged students have in general more negative coefficients for tuition, suggesting a greater dislike for higher prices for this group of students.[25] The coefficients on the distance variables suggest an important dislike for long travels from home to school. They also show that preferences are convex with respect to distance. Public schools are less preferred than private schools in both groups of students, as is the case of rural schools relative to urban schools. The opposite is observed for secular schools, relative to religious schools. Finally, students prefer schools of higher quality, although non-disadvantaged students may have stronger preferences for quality than disadvantaged students.

[24]The correct reading of the tuition coefficients for each mother’s education group is obtained by adding the “average” coefficient to the coefficient that correspond to the group of interest. For instance, the tuition coefficient for non-disadvantaged students whose mothers have primary education is $-0.177 - 0.095 = -0.272$.

[25]Gazmuri (2015), unlike Gallego and Hernando (2009), Cuesta et al. (2017), Neilson (2017), and this paper, finds positive coefficients in tuition for some groups of students. Her results may be explained by the fact that she does not instrument for tuition, but rather assumes exogeneity of that variable after controlling for other schools’ characteristics.

Table 9: Estimates for Demand Model

	non-disadvantaged		disadvantaged	
	coef.	std. err.	coef.	std. err.
annual tuition/100	-0.177	0.004	-0.055	0.007
annual tuition/100 × mother's education: primary	-0.095	0.011	-0.196	0.008
annual tuition/100 × mother's education: secondary	0.083	0.010	-0.037	0.002
annual tuition/100 × mother's education: college	0.138	0.010	0.003	0.002
annual tuition/100 × mother's education: missing	0.164	0.010	-0.062	0.004
distance to school/10	-5.023	0.051	-5.267	0.048
distance to school squared/10	0.026	0.002	0.050	0.001
public	-0.631	0.055	-0.073	0.071
rural	-0.657	0.068	-0.988	0.124
secular	0.096	0.046	0.116	0.060
unobserved quality	0.790	0.059	0.336	0.075
teachers quality	3.529	0.285	1.544	0.331
constant	-2.102	0.212	-1.025	0.235

Notes: Results from maximum likelihood estimation of distance and preference heterogeneity by mother's education, and from 2SLS estimation of remaining mean preference parameters. Omitted mother's level of education category is "not formal education". Tuition is instrumented with non-price attributes of other schools in the market in the 2SLS estimation. Tuition amounts are in real prices for the year 2013, and were transformed from Ch$ to US$ according to the exchange rate as of March 1, 2013 (472.96 Ch$/US$).

5.2 Supply Estimates

Table 10 displays the estimated marginal cost and program participation fixed cost parameters. The results for the marginal cost parameters are the following. Higher quality schools present higher marginal costs. This is true for both measures of quality. More precisely, one standard deviation of higher unobserved quality translates into $27.9 of higher marginal costs. Likewise, one standard deviation of higher teachers quality increases marginal costs by $29.6. Secular schools have on average $12.8 higher marginal costs than religious schools, although the corresponding estimate is not statistically significant. Rural schools have on average $169.9 lower marginal schools than schools located in urban areas. This is an intuitive result if we believe that rural schools invest less in amenities per student, and that staff and teachers' wages are lower in rural areas than in the city.[26] Lastly, schools that participate in the targeted program have on average \$315.8 lower marginal costs. In other words, the marginal cost of educating non-disadvantaged students is about three hundred dollars lower than the marginal cost of educating both disadvantaged and non-disadvantaged students.[27]

The results for the program participation cost parameters are the following. Higher levels of unobserved and teachers quality are associated with higher levels of participation cost, suggesting that higher quality schools find it more costly to join the targeted voucher program. Specifically, an increase in one standard deviation in schools' unobserved quality increases the cost of participating in the program by \$9,271, although this difference is not statistically significant. Similarly, a one standard deviation increase in schools' teachers quality increases the program participation cost by \$40,578. Secular schools find it more costly to join the targeted voucher program than religious schools, by approximately \$36,337.[28]

[26]There is a long literature that documents the high wages advantage of cities relative to rural areas. See, for instance, Bryan et al. (2014) for a study that investigates the migration behavior of individuals in Bangladesh, motivated by the higher returns to labor found in the cities.

[27]Recall from section 4.2 that the marginal cost of educating non-disadvantaged students is identified from schools participating in the targeted program, whereas the marginal cost of educating both disadvantaged and non-disadvantaged students is identified from schools that do not participate in the program.

[28]These results correspond to the interpretation of the program participation cost representing perceived increase in bureaucracy associated to participation and/or school's own preference for participation described in section 4.2.

Table 10: Estimates for Supply Model

	coef.	std. err.
marginal cost ($100):		
unobserved quality	0.279	0.056
teachers quality	0.296	0.062
secular	0.128	0.103
rural	-1.699	0.284
participates in targeted program	-3.158	0.106
constant	6.123	0.225
σ^2	2.199	0.119
participation cost ($1,000):		
unobserved quality	9.271	6.980
teachers quality	40.578	7.089
secular	36.337	13.005
constant	-146.977	12.241
$\log(\sigma)$	1.650	0.144
no. of private-voucher schools	1,110	

Notes: The first panel reports estimates of marginal cost parameters of a Tobit model for tuition. The model includes market fixed-effects, but those estimates are not reported. The second panel reports estimates of fixed cost parameters of a probit model for participation in the targeted voucher program. The tuition function for the case the school participates in the targeted program differs from the tuition function for the case the school opts out of the program only by the intercept, which is equal to the coefficient for the participation in the program dummy plus the constant for the case the school participates in the program, and only to the constant for the case the school opts out. All marginal and fixed cost parameters were estimated using a GMM procedure coupled with a nested fixed-point algorithm. Costs are in real prices for the year 2013, and were transformed from Ch$ to US$ according to the exchange rate as of March 1, 2013 (472.96 Ch$/US$).

Table 11 presents the predicted mean and median marginal and program participation costs for schools, which were constructed using the estimates presented in Table 10. The average (median) marginal cost of educating a non-disadvantaged student is $237 ($279), about half as much as the average (median) marginal cost of educating both disadvantaged and non-disadvantaged students, $553 ($595). Also, the average (median) private-voucher school has negative program participation costs, of about $-\$158,000$ ($-\$156,000$), meaning that it finds it attractive to join the targeted program even if it incurs in some loss in profits by doing so. Negative participation costs may be interpreted as the result of the existence of non-monetary benefits associated to the participation in the program (e.g. preference for attracting disadvantaged students), or to efficiency gains associated to participation. Other interpretations may also be possible, and I remain agnostic about which interpretation is more plausible, as my model does not allow me to identify the sources and motivations that underlie the participation cost.

Table 11: Predicted Costs

	mean	median
marginal cost ($):		
c_j^{nonD}	237	279
$c_j^{D\&nonD}$	553	595
participation cost ($1,000):		
κ_j	-158	-156

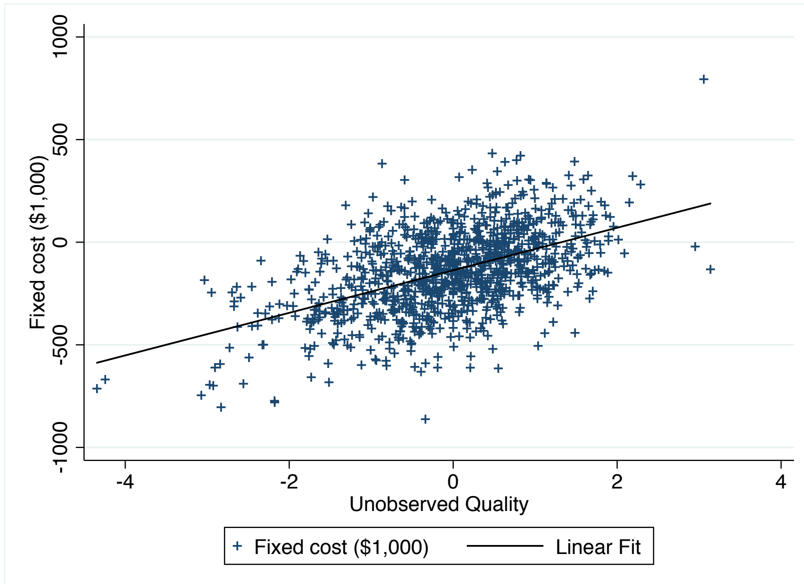
Notes: This tables presents the mean and median of predicted schools' marginal and program participation costs' distributions, which were constructed by using the estimated costs' parameters from the GMM-NFXP procedure. Costs are in real prices for the year 2013, and were transformed from Ch$ to US$ according to the exchange rate as of March 1, 2013 (472.96 Ch$/US$).

Figure 11 complements the results for the program participation cost from Table 11. Panel A plots the relationship between schools' predicted participation cost (y-axis) and unobserved quality (x-axis). Analogously, Panel B displays the relationship between schools' predicted participation cost (y-axis) and teachers quality (x-axis). There exists a positive correlation between schools' program participation cost and both measures of quality, suggesting that higher quality schools find it more costly to participate in the targeted program than lower quality schools, all else equal. Put differently, for the same gain in profits, a low-quality school is more likely to decide to join the targeted voucher program than a high-quality school. This is an important empirical result, that has not been documented in other studies, and that speaks directly to the evidence reported in Abdulkadiroglu et al. (2018) for the Louisiana Scholarship Program (LSP), a targeted voucher program currently in operation in the state of Louisiana. Abdulkadiroglu et al. (2018) document large negative effects of attending private-voucher schools on test scores (of about 0.4

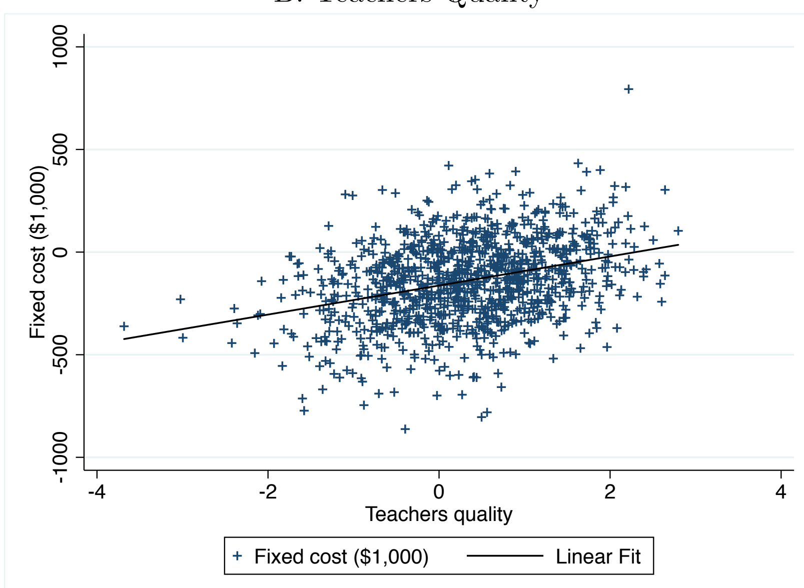
standard deviations for math), and suggest that such finding may be explained by the fact that the private schools that are part of the LSP are predominantly low-quality. In fact, they show that, among all the private schools that were invited to participate in the LSP, the ones that joined the program were schools that had been continuously failing and losing students in the years that preceded the program. This result is also important because it can help policymakers to have and idea of which are the schools that may choose to participate in a targeted voucher program given a particular design (e.g. amount of the subsidy).

Figure 11: Schools' Program Participation Cost vs. Quality

A. Unobserved Quality



B. Teachers Quality



Notes: This figure displays the relationship between schools' predicted program participation cost and two measures of schools' quality. Panel A plots the relationship between schools' participation cost (y-axis) and unobserved quality (x-axis), whereas Panel B plots the relationship between schools' participation cost (y-axis) and teachers quality (x-axis). Schools' predicted participation costs were constructed using the estimated costs' parameters from the GMM-NFXP procedure. Costs are in real prices for the year 2013, and were transformed from Ch$ to US$ according to the exchange rate as of March 1, 2013 (472.96 Ch$/US$).

6 Policy Analysis and Counterfactuals

I use the model and its estimated parameters to study the economic consequences of a variety of counterfactual policy scenarios. I am mostly interested in understanding whether and how schools respond to changes in the voucher subsidies. I focus on schools' program participation and tuition setting responses to policies. I also investigate whether and how such responses affect students' school choices.

My counterfactual policy analyses are motivated by actual policies that have recently been implemented in Chile. In 2016, and as part of a series of major reforms to all levels of the education system, the *Ley de Inclusión Escolar* law began to operate. This law introduced various changes to the regulations applicable to schools, including important increases to the voucher subsidies.[29] These increases include a rise in the universal subsidy, a new per-student voucher for schools that do not charge tuition, an increase in the targeted voucher, and a new per-disadvantaged student voucher to students in the third and fourth quintiles in the household income distribution (also for schools not charging tuition). The ultimate goal of these voucher increases is to end up with a system where no school charges top-up fees. The introduction of the reform has been gradual, both in terms of the voucher increases, and geographically, with smaller regions entering first to the new regime. When fully implemented, it is estimated that the reform will increase the total government spending by about 20–30%.

As is usual with important reforms in education, proponents and detractors abound. Proponents argue that the goal of no tuition in schools is key to transform the current system into a more equitable one, and that the changes are in line with that objective. Detractors, in turn, argue that the reform is is too complex, and that it involves too many changes and additions to the voucher system without paying attention to schools' responses, which could lead to undesirable and unintended consequences.[30]

[29] Overall, the law has three major pillars: 1) the end of copayment, implemented via increases in the vouchers; 2) the end of selection from the part of schools when oversubscribed, implemented via the introduction of lotteries to assign seats at schools; and 3) the end of the profit-seeking motive in private-voucher schools. In this paper, I focus on the increase-in-vouchers part of the law.

[30] These and other arguments can be found in the transcript of the 120th session of Chile's Chamber of Deputies,

My goal with the policy simulations is to study the consequences of particular changes in the vouchers, and the mechanisms through which those consequences occur, paying special attention to schools' responses to policies. I do not aim to predict the consequences of the reform that is actually being implemented, because it involves aspects other than the voucher changes, which my model is silent about. I instead intend to inform policymakers about whether and how schools respond to particular changes in the voucher policies, and how such responses affect students' school choices.

I perform two series of counterfactual exercises. First, I study schools' program participation response to a set of different targeted voucher amounts, that range between 30% and 200% the 2013 subsidy level. I examine whether higher subsidy amounts attract more schools to participate in the targeted program, and whether the response of low-quality schools is different from the response of high-quality schools. The targeted program constitutes an important policy tool to bring tuition costs to zero for disadvantaged students, and therefore the study of schools' participation decisions is central to understand the capabilities of governments to lower tuition costs through the targeted voucher.

Second, I study the economic consequences of a 20% increase in the total budget that the government spends in vouchers, and that is implemented either as an increase in the level of the universal voucher, or as an increase in the level of the targeted voucher. I investigate the responses of schools to these policies, and the corresponding effect on students' school choices. 20% is about the percentage increase in government's spending induced by the actual reform being implemented in Chile. As stated above, instead of mimicking the actual policy, I choose to analyze separate increases in each of the vouchers, which can help to disentangle the mechanisms through which each of the vouchers operate.

January 26, 2015.

6.1 Targeted Voucher Policies

I simulate the estimated model under seven different policy scenarios, where in each of them I keep the universal voucher fixed to its actual value ($1,220 for the year 2013), and set the level of the targeted voucher to either $200, $400, $600, $800, $1,000, $1,200, or $1,400.[31] I study schools' program participation decisions in each of the counterfactuals.

Table 12 presents schools' program participation behavior in each of the seven counterfactual scenarios. The first column presents the level of the targeted voucher with which the model was simulated and the results obtained. The second column presents the total number of private-voucher schools that participate in the targeted program at each level of the targeted voucher. The third column presents the total number of private-voucher schools that opt out of the targeted program at each level of the targeted voucher. The fourth column presents the number of additional private-voucher schools that join the program at each level of the targeted voucher, relative to the number of private-voucher schools that are part of the program when the level of the targeted voucher is $200 lower. For example, the number of additional schools that join the program when the targeted voucher level is $400 is equal to the total number of schools that participate in the program at the targeted voucher level of $400 minus the total number of schools that participate in the program at the targeted voucher level of $200. For the targeted voucher level of $200, the number of additional schools joining the program is set to be the same as the total number of schools that participate in the program.

At the lowest level of the targeted voucher analyzed, $200, there are 606 private-voucher schools that decide to participate in the targeted program. These schools represent about 55% of all private-voucher schools.[32] This high response of schools to the positive but relatively small targeted voucher amount of $200 is somewhat expected, considering that many private-voucher schools are predicted to have negative program participation costs (see Figure 11), meaning that they find it optimal to participate in the program even if that results in a reduction in profits

[31] The actual value of the targeted voucher for the year 2013 is $717 (see Table 3).
[32] The total number of private-voucher schools in the sample is 1,110.

(before accounting for the program participation cost). For higher levels of the targeted voucher, larger sets of schools choose to join the targeted program. For instance, 62 additional private-voucher schools join the program when the targeted voucher is increased from $200 to $400. Likewise, 60 additional schools join the targeted program when the targeted voucher is increased from $400 to $600. Even more schools join the program when the targeted voucher is further increased, although the number of new schools joining the program is smaller the higher the level of the targeted voucher.[33] At the targeted voucher level of $1,400, which is about twice as large as the actual level ($717), 875 private-voucher schools decide to participate in the targeted program, which represents about 79% of all private-voucher schools in the sample. This result shows that, even for relatively high levels of the targeted subsidy, there is still a non-negligible group of schools that find it unattractive to join the targeted voucher program. However, possibly more important than the number of schools that stay out of the program is the identity (i.e. characteristics) of those schools. Put differently, a policymaker is likely to be less concerned of a targeted voucher program not being able to attract a set of schools if those schools are predominantly low-quality than if they are high-quality.

[33]Note, too, that the percentage of new schools joining the program is always around 10-14% relative to the set of schools that do not participate in the program. For instance, of the 504 schools that are not part of the program at the targeted voucher level of $200, 62 of them (12.3%) decide to join the program when the targeted voucher level is increased to $400.

Table 12: Schools' Program Participation Responses to Targeted Voucher Policies

subsidy amount	schools in program	schools not in program	additional schools joining program
\$200	606	504	606
\$400	668	442	62
\$600	728	382	60
\$800	772	338	44
\$1,000	812	298	40
\$1,200	849	261	37
\$1,400	875	235	26

Notes: This table presents the program participation responses of private-voucher schools to seven different levels of the targeted voucher. The first column displays the targeted voucher level with which the model was simulated and the results obtained. The second column displays the total number of private-voucher schools that participate in the targeted program for each level of the targeted voucher. The third column displays the total number of private-voucher schools that do not participate in the targeted program for each level of the targeted voucher. The fourth column displays the number of additional schools that join the targeted program for each level of the targeted voucher, relative to the number of schools that participate in the targeted program when the targeted voucher level is \$200 lower. For instance, for the targeted voucher level of \$400, there are 668 private-voucher schools that participate in the program, which exceeds in 62 the number of private-voucher schools that are part of the program when the level of the targeted voucher is \$200 (606). Therefore, there are 62 additional schools that join the program at the targeted voucher level of \$400. For the targeted voucher level of \$200, the number of additional schools joining the program is the same as the total number of private-vouchers schools in the program. Voucher amounts are in real prices for the year 2013, and were transformed from Ch\$ to US\$ according to the exchange rate as of March 1, 2013 (472.96 Ch\$/US\$). The total number of private-voucher schools is 1,110.

Figure 12 complements the results from Table 12. It displays average quality measures for the set of additional schools that join the targeted program at each of the seven levels of the targeted voucher analyzed. Panel A plots additional schools' average unobserved quality, while panel B does analogously for schools' teachers quality. At the targeted voucher level of \$200, schools' average quality measures are calculated for all private-voucher schools that participate in the program, and serve as a reference to compare against schools' quality measures at higher levels of the targeted voucher. At higher levels of the targeted voucher, the average quality measures are calculated only for the additional schools joining the program.[34] Two important

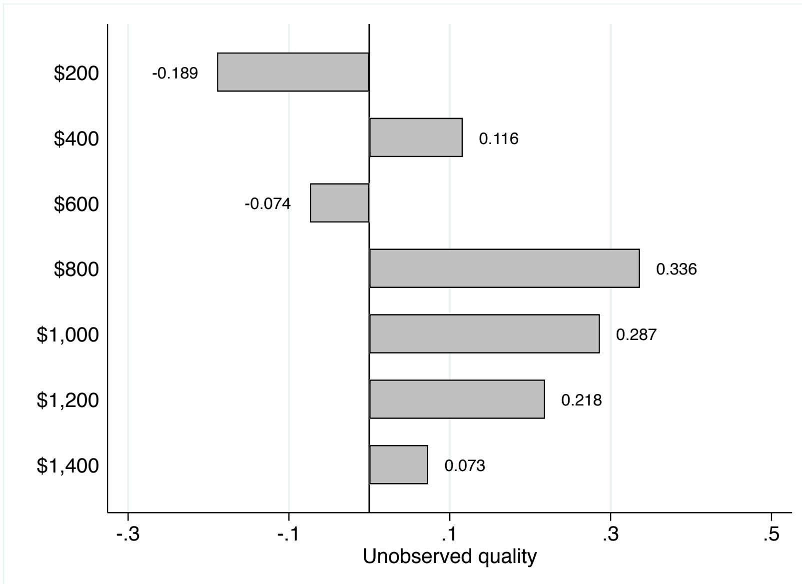
[34] For each targeted voucher level of \$400 and higher, additional schools are schools that participate in the program at the corresponding targeted voucher level, but that do not participate in the program at lower levels of the targeted voucher.

patterns emerge. First, the average quality of the schools that are part of the program when the targeted voucher is $200 is considerably lower than the average quality of every set of new schools joining the program at higher levels of the targeted voucher. This is true for both unobserved and teachers quality measures. Second, the average teachers quality of the new schools in the program is higher the higher the level of the targeted voucher. This observed pattern is not exactly the same for the unobserved quality measure, but every set of additional schools is of higher unobserved quality (on average) than the reference set of schools that participate in the program at the targeted voucher level of $200. This finding is consistent with the estimation results for schools' program participation costs (see Figure 11), and suggests that higher quality schools find it particularly costly to participate in the program, and are therefore less likely to be part of the program than lower quality schools. A policy implication of this finding is that policymakers need to be sufficiently generous if they want to attract high-quality schools to participate in a targeted voucher program. That is, they should set a relatively high targeted voucher amount.[35] Once again, this result is directly related to the evidence in Abdulkadiroglu et al. (2018), where one could argue that the negative effects of attending voucher schools may well be mitigated by increasing the subsidy offered to participating schools, thus making more attractive the option of participating in the program to higher quality schools.

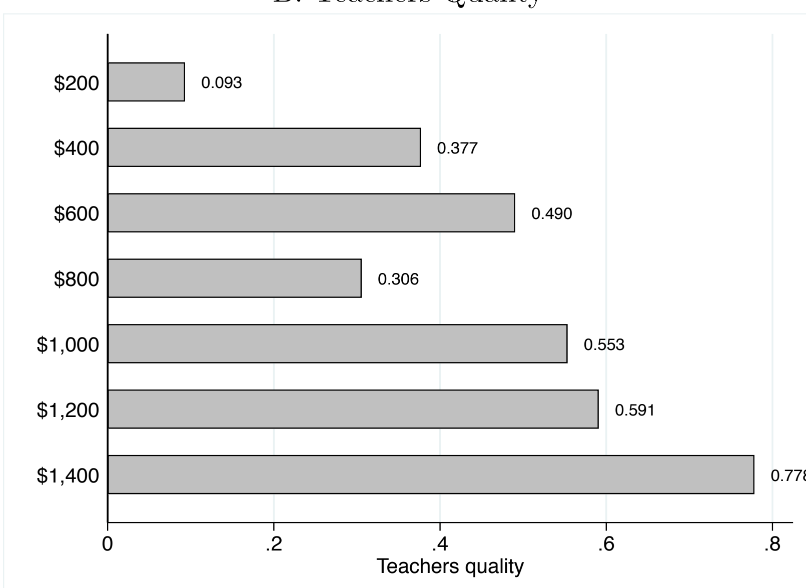
[35] Another policy implication is to somehow lower the costs of joining the program, especially for high-quality schools. This could be achieved by, for example, cutting down bureaucracies in the joining process.

Figure 12: Average Quality of the Additional Schools Joining the Targeted Voucher Program

A. Unobserved Quality



B. Teachers Quality



Notes: This figure plots the average unobserved and teachers quality of the additional private-voucher schools the join the targeted program at each level of the targeted voucher, relative to the private-voucher schools that are part of the program when the level of the targeted voucher is $200 lower. For the targeted voucher level of $200, the average quality of the additional private-voucher schools is the same as the average quality of all private-voucher schools that participate in the program. Voucher amounts are in real prices for the year 2013, and were transformed from Ch$ to US$ according to the exchange rate as of March 1, 2013 (472.96 Ch$/US$).

6.2 Expansion in Government Spending

I study the economic consequences of expanding the total budget that the government spends in vouchers by 20%. I am interested in studying schools' responses to and equilibrium effects of two specific policies, that represent different ways of allocating the extra funding and therefore of implementing the budget expansion. Specifically, I investigate schools and students' responses when all the extra funding is allocated to increase the universal voucher, as well as their responses when all the extra funding is allocated to increase the targeted voucher. For a reference, I also look at responses in a baseline scenario where both the universal and targeted vouchers remain unchanged at their actual levels (as of 2013). Table 13 displays the exact voucher amounts used in each of the counterfactual scenarios. In the baseline scenario, the universal and targeted vouchers are kept at their actual levels of $1,220 and $717, respectively. In the scenario where the universal voucher is increased, its amount is set to $1,562, and the amount of the targeted voucher is kept at $717. Finally, in the scenario where the targeted voucher is increased, the universal voucher is kept at $1,220, and the targeted voucher is set to $1,256. The increases in the voucher amounts are such that they effectively result in a 20% increase in government's spending, and were calibrated using simulations of the model.

Table 13: Voucher Amounts in Counterfactual Scenarios

	baseline	increase in universal voucher	increase in targeted voucher
universal voucher ($)	1,220	1,562	1,220
targeted voucher ($)	717	717	1,256

Notes: This table presents the exact voucher amounts used in each of the counterfactual scenarios. The increases in the voucher amounts are such that they approximately result in a 20% increase in government's spending, and were calibrated using several simulations of the model.

Table 14 presents schools' responses in program participation under each policy scenario. These responses are analyzed relative to the baseline scenario of no increase in the voucher amounts. The table reports the number of private-voucher schools that join the program after an increase in each of the vouchers, as well as the number of private-voucher schools that leave the program after the voucher changes. For a reference, it also presents the total number of private-voucher schools that are part of the program in the baseline scenario, as well as the total number of private-voucher schools that are not part of the program in the baseline scenario. An increase in the universal voucher induces some schools to leave the targeted voucher program. More precisely, 98 of the 752 private-voucher schools that participate in the program in the baseline decide to leave the program after an increase of \$342 in the universal voucher. These schools represent 13% of the group that participate in the program in the baseline. No new school is attracted to join the program. The response from schools is sizable, although it does not constitute a massive flight out of the program, as even after accounting for the leaving schools, more than half of all private-voucher schools still participate in the program. A simple rationale for explaining this result (some schools leaving, no school joining the program) comes from the fact that a rise in the universal voucher increases the importance of the universal voucher relative to the targeted voucher in schools' profits, and therefore the targeted program becomes less attractive for schools.

An increase of \$539 in the targeted voucher attracts an important number of additional schools to join the program. Specifically, 104 of the 358 private-voucher schools that do not participate in the program in the baseline decide to join the program after the rise in the targeted voucher. These schools represent 29% of the private-voucher schools that were not part of the program in the baseline. The response is sizable (as is the increase in the voucher), and its rationale is in that a higher targeted voucher makes the targeted program to be a more attractive option for many private-voucher schools, since it directly increases their profits for the case they join the program.

Table 14: Schools' Program Participation Responses in Counterfactual Scenarios

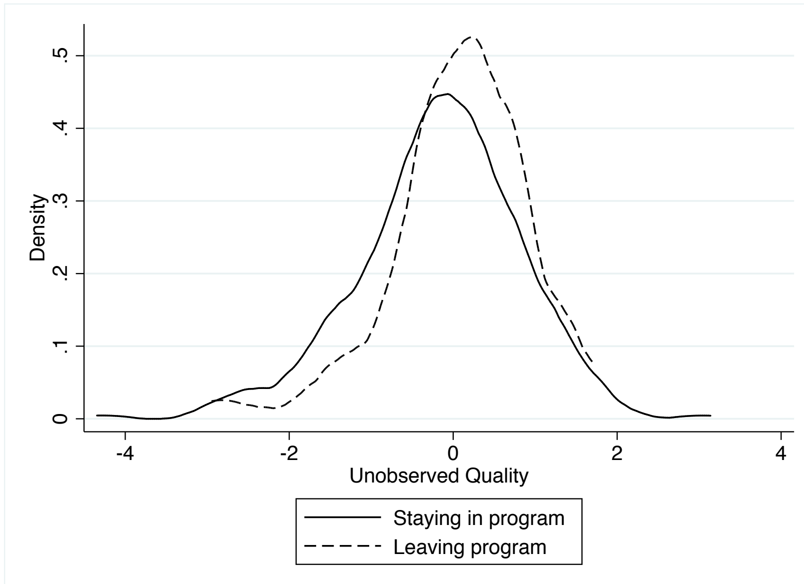
	increase in universal voucher	increase in targeted voucher
joining program	0	104
leaving program	98	0
in program (baseline)	752	
not in program (baseline)	358	

Notes: This table presents schools' program participation responses in the two counterfactual scenarios studied (increase in the universal voucher, and increase in the targeted voucher). The table reports the number of private-voucher schools that join the program, as well as the number of private-voucher schools that leave the program, in each policy scenario. It also presents the number of private-voucher schools that do and do not participate in the program in the baseline scenario.

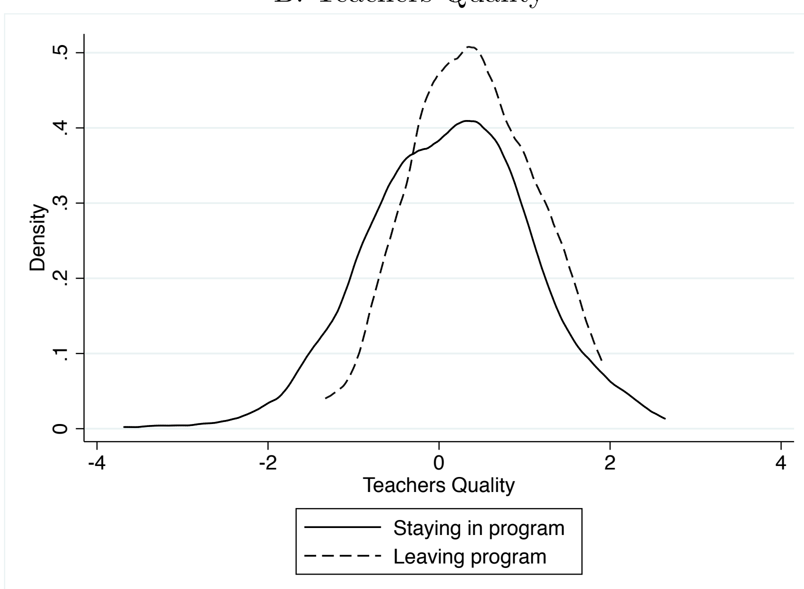
It is also important to look at the characteristics of the schools that either join or leave the program after increases in the vouchers. In a program evaluation language, these schools are the compliers; that is, they are the schools that respond to changes in exogenous parameters (i.e vouchers) by changing their program participation behavior. Figures 13 and 14 display the unobserved and teachers characteristics of the complier schools in each of the counterfactuals. Figure 13 plots the quality distributions of the private-voucher schools that leave the program after an increase in the universal voucher, and compare them with the quality distributions of the schools that remain in the program after the policy change. Panel A presents schools' unobserved quality distributions, while Panel B does analogously for schools' teachers quality. Though there is substantial overlap between compliers' and non-compliers' quality distributions, the schools leaving the program are in general of higher quality than the schools staying in the program. This is especially true for schools' teachers quality. Thus, an increase in the universal voucher not only results in a number of schools leaving the targeted program, but also in that the program loses some of its highest quality schools.

Figure 13: Increase in Universal Voucher - Quality Distribution of Schools Leaving Program

A. Unobserved Quality



B. Teachers Quality

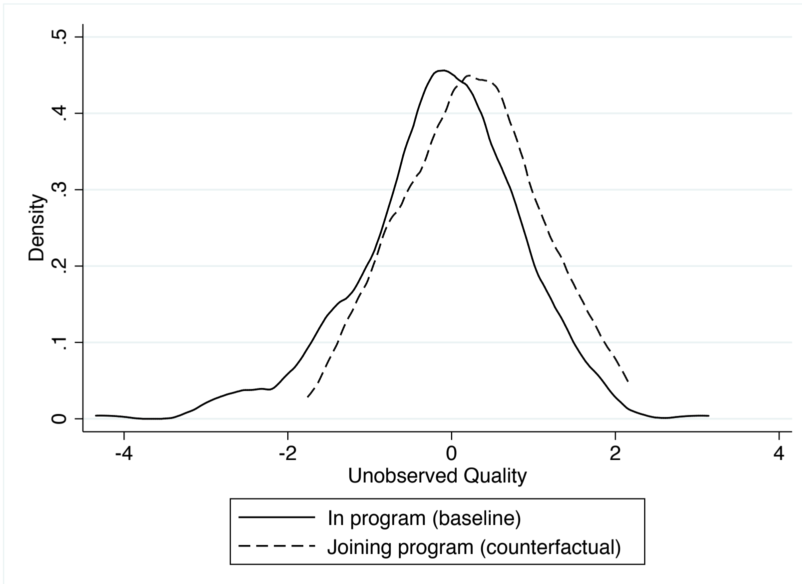


Notes: This figure plots the unobserved and teachers quality distributions of the private-voucher schools that decide to leave the targeted program after an increase of \$342 in the universal voucher, and compare them with the quality distributions of the private-voucher schools that choose to remain in the program after the same increase in the universal voucher. Panel A displays schools' unobserved quality distributions, while Panel B does analogously for schools' teachers quality distributions.

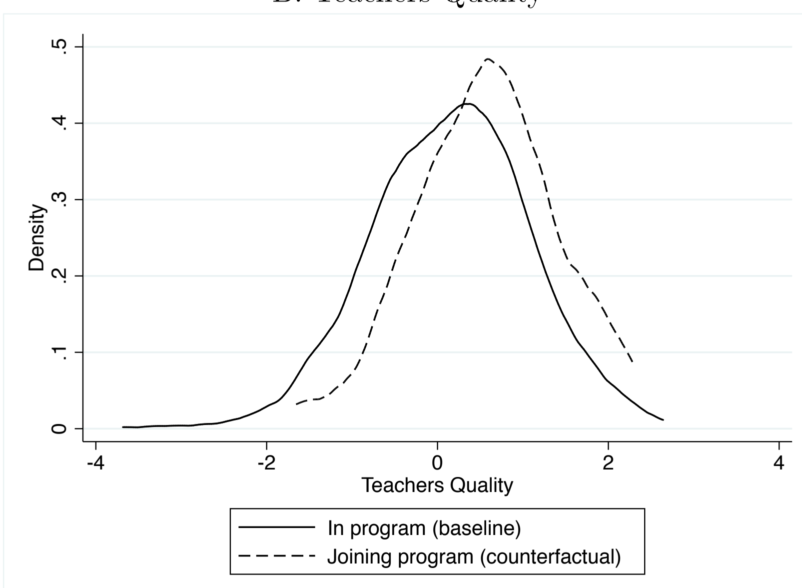
Figure 14 presents the unobserved and teachers quality distributions of the schools that decide to join the targeted program after an increase of \$539 in the targeted voucher (and that do not participate in the program absent the voucher increase), and compare them with the quality distributions of the schools that participate in the program absent the policy change. Panel A plots schools' unobserved quality distributions, while Panel B does analogously for schools' teachers quality distributions. There exists an important overlap between the distributions of the two groups of schools. Nonetheless, the schools joining the program after the increase in the targeted voucher are in general of higher quality than their counterparts in the program. Thus, an increase in the targeted voucher not only attracts more schools to participate in the targeted program, but it also tends to attract schools of higher quality than the ones that participate absent the voucher increase.

Figure 14: Increase in Targeted Voucher - Quality Distribution of Schools Joining Program

A. Unobserved Quality



B. Teachers Quality



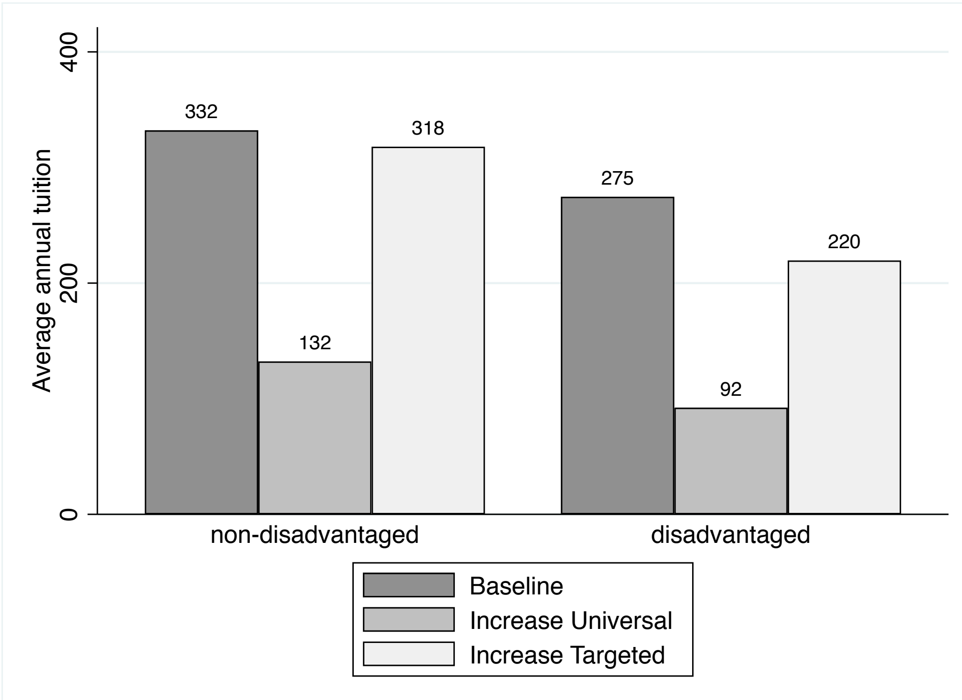
Notes: This figure plots the unobserved and teachers quality distributions of the private-voucher schools that decide to join the targeted program after an increase of $539 in the targeted voucher (and that do not participate in the program absent the policy change), and compare them with the quality distributions of schools that participate in the targeted program absent the increase in the targeted voucher. Panel A displays schools' unobserved quality distributions, while Panel B does analogously for schools' teachers quality distributions.

The results presented in Table 14 and Figures 13 and 14 describe two important supply responses to voucher policies. The implications of the changes in each of the vouchers are sizable and go in opposite direction. In particular, an increase in the universal voucher leaves the targeted program with less but also lower quality participating schools. Conversely, an increase in the targeted voucher increases the number of schools that participate in the program, but also the new participating schools are in general of higher quality than the rest of the participating schools.

Another channel through which schools respond to changes in the vouchers is via tuition. According to schools' optimality conditions (see Section 4.2), the universal voucher plays both a direct and an indirect role in determining tuition levels, whereas the targeted voucher's role in tuition setting is only indirect (through schools' demand). Therefore, it is reasonable to expect that schools' tuition levels be more sensitive to changes in the universal voucher than to changes in the targeted voucher. Figure 15 displays average tuition levels under each counterfactual scenario. It shows both average tuition charged to non-disadvantaged students (i.e. full tuition) and average tuition charged to disadvantaged students. An increase of \$342 in the universal voucher lowers the average tuition charged to non-disadvantaged students from \$332 to \$132. Put differently, a \$1 increase in the universal voucher translates into a \$0.58 decrease in average full tuition. The fall in average tuition charged to disadvantaged students is also important, going from \$275 to \$92. On the other hand, the targeted voucher has a much smaller effect in tuition. Specifically, a \$539 increase in the targeted voucher decreases the average tuition charged to non-disadvantaged students by only \$14, going from \$332 to \$318. Similarly, it decreases the tuition charged to disadvantaged students by \$55, going from \$275 to \$220.[36]

[36] All results account for the program participation response of schools to the voucher increases.

Figure 15: Schools' Tuition Setting Responses in Counterfactual Scenarios



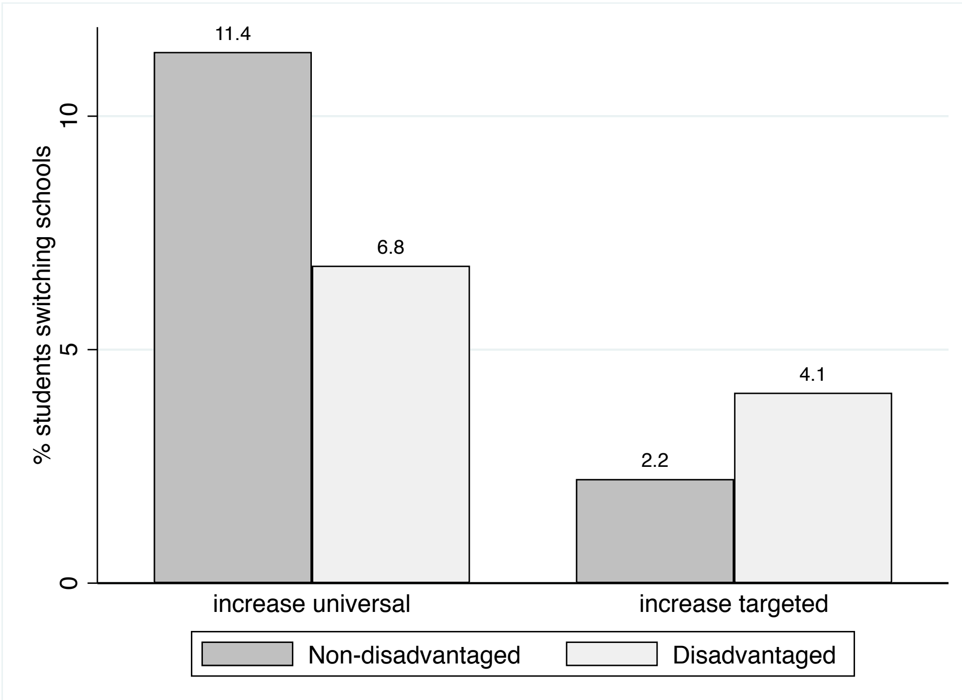
Notes: This figure presents average tuition levels of private-voucher schools under each of three counterfactual scenarios: baseline, increase of $342 in the universal voucher, increase of $539 in the targeted voucher. It distinguishes between tuition charged to non-disadvantaged students and tuition charged to disadvantaged students. Voucher amounts are in real prices for the year 2013, and were transformed from Ch$ to US$ according to the exchange rate as of March 1, 2013 (472.96 Ch$/US$).

Table 14 and Figures 13-15 have shown two different mechanisms through which schools respond to changes in the vouchers: program participation and tuition setting. A careful evaluation of a voucher policy needs to account for both types of responses. Failure to do so, may lead policymakers to make inaccurate conclusions. For instance, if a policymaker considers only the program participation response of schools, it may be led to prefer an increase in the targeted voucher over an increase in the universal voucher, because the former increases the quantity and quality of the schools that predominantly serve disadvantaged students. On the contrary, if the same policymaker considers only the tuition response of schools, it may prefer to increase the universal voucher over increasing the targeted voucher, as the former has a steeper effect in driving down tuition for all students.

More importantly, supply responses are of interest because they have consequences on students' choices and welfare. For example, more schools participating in the targeted voucher program may induce some disadvantaged students to switch to a new participating school. Similarly, lower tuitions may give some financially constrained students access to otherwise high-tuition schools. Figure 16 gives a picture of the school switches that occur under each counterfactual, relative to the baseline scenario of no voucher increase. It displays the percentage of students that switch to a different school than the one they attend in the baseline, and distinguishes between non-disadvantaged and disadvantaged students. 11.4% of non-disadvantaged and 6.8% of disadvantaged students choose a different school when the universal voucher is increased. Likewise, 2.2% of non-disadvantaged and 4.1% of disadvantaged students choose a different school when the targeted voucher is increased. These results can be interpreted as an increase in mobility for students, where supply responses in the form of lower prices allow some financially constrained individuals to choose schools that would otherwise be too expensive for them to attend.[37] Note also that the universal voucher policy produces a higher share of students switching schools than the targeted voucher policy. However, in relative terms, a higher share of non-disadvantaged students switch schools relative to disadvantaged students under the universal voucher policy, while the opposite occurs under the targeted voucher policy.

[37] Note that the two types of supply responses I study in this paper, i.e. program participation and tuition setting, are essentially two different mechanisms that schools use to price-respond to voucher policies. By choosing to participate in the targeted program, schools are actually choosing to (second degree) price discriminate among students, where they charge no tuition to disadvantaged students, and may charge a positive amount to non-disadvantaged. Tuition setting is, evidently, a price response as well.

Figure 16: Students Switching Schools in Counterfactual Scenarios

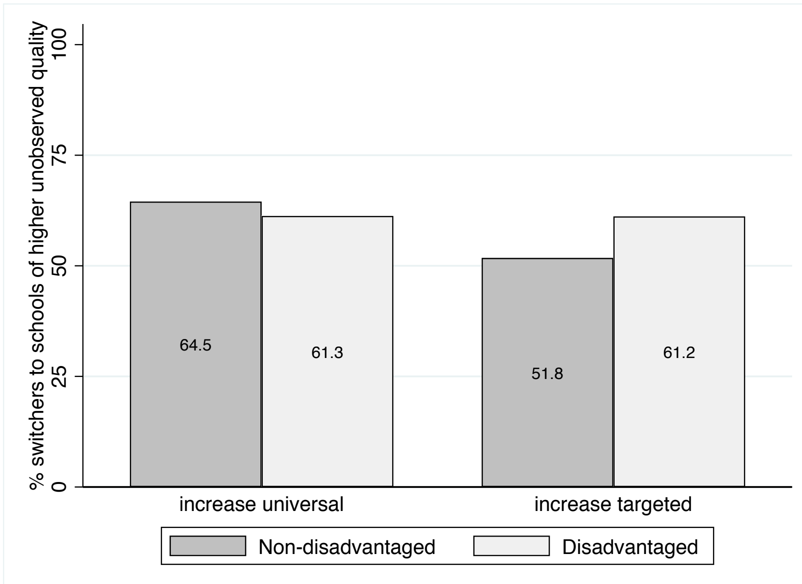


Notes: This figure displays the percentage of students that switch to a different school under each of the counterfactual scenarios, relative to the school they choose in the baseline. It distinguishes between non-disadvantaged and disadvantaged students.

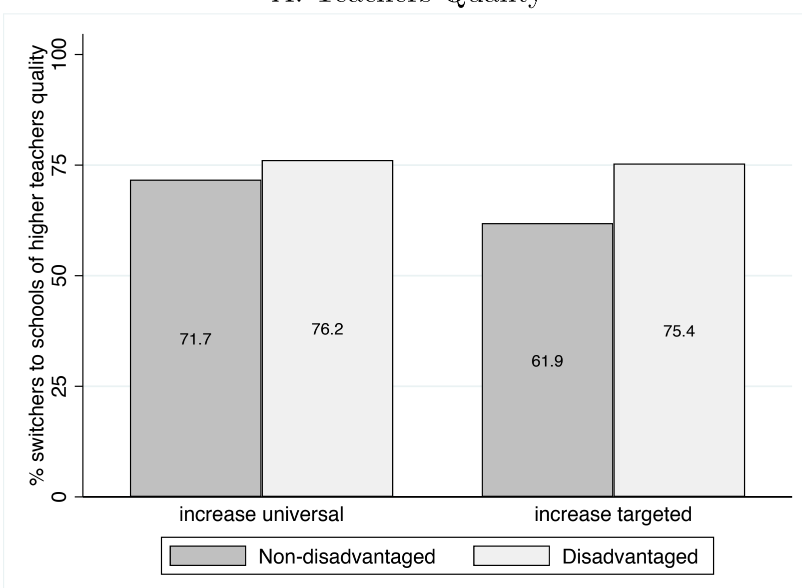
It is also important to examine whether students that switch schools are switching to schools of higher quality. From a policy perspective, this matters whenever a policymaker is interested in identifying policies that facilitate students' access to high quality schools. Figure 17 displays, for each counterfactual, the percentage of students that switch to a school of higher quality, given that they switch at all. It distinguishes between non-disadvantaged and disadvantaged students. Panel A shows results for schools' unobserved quality measure, while Panel B does analogously for schools' teachers quality. Under each of the policies, the majority of students switch to schools of higher quality. This is true for both non-disadvantaged and disadvantaged students, and when looking at either of the quality measures. Specifically, 64.5% of non-disadvantaged and 61.3% of disadvantaged switcher students switch to a school of higher unobserved quality when the universal voucher is increased, while 51.8% of non-disadvantaged and 61.2% of disadvantaged switchers do so when the targeted voucher is increased. Similarly, 71.7% of non-disadvantaged and 76.2% of disadvantaged switcher students switch to a schools of higher teachers quality when the universal voucher is increased, while 61.9% of non-disadvantaged and 75.4% of disadvantaged switchers do so when the targeted voucher is increased. These results are in line with the demand estimates from Table 9, where we noted that students have strong preferences for schools' quality, but dislike high tuition levels. As such, any policy that is able to drive down tuition levels is likely to increase demand for high quality schools.

Figure 17: Percentage of Switchers Choosing Schools of Higher Quality in Counterfactual Scenarios

A. Unobserved Quality



A. Teachers Quality



Notes: This figure displays, for each counterfactual scenario, the percentage of students that switch to a school of higher quality, given that they switch at all, and relative to the quality of the school they choose in the baseline. It distinguishes between non-disadvantaged and disadvantaged students. Panel A shows results for schools' unobserved quality measure, while Panel B does analogously for schools' teachers quality.

Table 15 complements the analysis from Figures 16 and 17. It shows the average difference in characteristics between the schools chosen by the switchers in each counterfactual scenario and the schools chosen by the switchers in the baseline scenarios. It includes the unobserved and teachers quality measures, distance travelled, and the probabilities that the school is private-voucher, rural, and secular as school characteristics. The table also distinguishes between non-disadvantaged and disadvantaged students. As shown in Figures 16 and 17, switchers, both non-disadvantaged and disadvantaged, switch to schools of higher quality on average. More precisely, switchers choose schools that are about 0.22–0.65σ higher in the quality measures. The only exception is non-disadvantaged students under the policy that increases the targeted voucher, where on average switchers choose a school that is 0.05σ lower in unobserved quality. However, that same group of students choose schools that are on average 0.22σ higher in teachers quality.

Table 15 also shows that the increase in the universal voucher policy induces non-disadvantaged (disadvantaged) students to switch to schools that are on average 2.5 (2.9) meters farther away than the baseline school. Conversely, the increase in the targeted voucher policy induces non-disadvantaged (disadvantaged) students to switch to schools that are on average 26.5 (3.4) meters closer than the baseline school. A priori, it is not obvious whether lower prices that result from the counterfactual policies should induce students to switch to schools that are farther away or closer to the students' home. It depends on the spatial distribution of the schools that are responding to the policies, as well as on the location of the residences of the switching students, among other things. For instance, if a high-quality school lowering its tuition due to a policy is located far away from a student's residence, then one might expect that student to be more likely to attend the high-quality school after the implementation of the policy. And the opposite is expected to occur if the high-quality school lowering its tuition is located closer to the student's home.

Switchers are also more likely to choose schools that are private-voucher, urban, and religious under each of the counterfactual policies. The results for the private-voucher and urban characteristics follow a similar intuition than the results found for the quality measures, which is that we expect that students be more likely to attend schools with the characteristics they enjoy after a reduction in the tuition levels due to a policy, whenever those characteristics are priced higher in the absence of the policy (see Tables 4, 9 and 10). The result found for the secular/religious characteristic of schools is likely to be due to the positive correlation between high-quality schools and their likelihood of being religious. For instance, if a high-quality school is also religious, and the student cares more about quality than whether the school is secular (see Table 9), then a fall in tuition levels due to a policy should increase the likelihood that a student attends a religious school (that is also high-quality).

Table 15: Characteristics of Schools Chosen by Switchers in Counterfactual Scenarios

students:	non-disadvantaged		disadvantaged	
counterfactual:	universal	targeted	universal	targeted
unobserved quality (std. dev.)	0.397	-0.050	0.299	0.313
teachers quality (std. dev.)	0.495	0.220	0.649	0.289
distance (km)	0.025	-0.265	0.099	-0.034
private voucher (p.p.)	0.410	0.176	0.502	0.438
rural (p.p.)	-0.018	-0.015	-0.018	-0.022
secular (p.p.)	-0.137	-0.412	-0.095	-0.270

Notes: This table displays the average difference in the characteristics of the schools chosen by the switchers in each of the counterfactual scenarios and the characteristics of the schools chosen by the switchers in the baseline scenario. It distinguishes between non-disadvantaged and disadvantaged students.

Finally, I analyze students' welfare changes associated to each voucher policy. To do so, I take advantage of the logit specification assumed for the error term in the indirect utility, and note that student i's expected utility is,

$$w_i = \ln\left(\sum_j e^{V_{ij}}\right).$$

Thus, the change in welfare associated to a particular counterfactual policy can be written as,

$$\Delta w_i = \ln\left(\sum_j e^{V_{ij}(counterfactual)}\right) - \ln\left(\sum_j e^{V_{ij}(baseline)}\right),$$

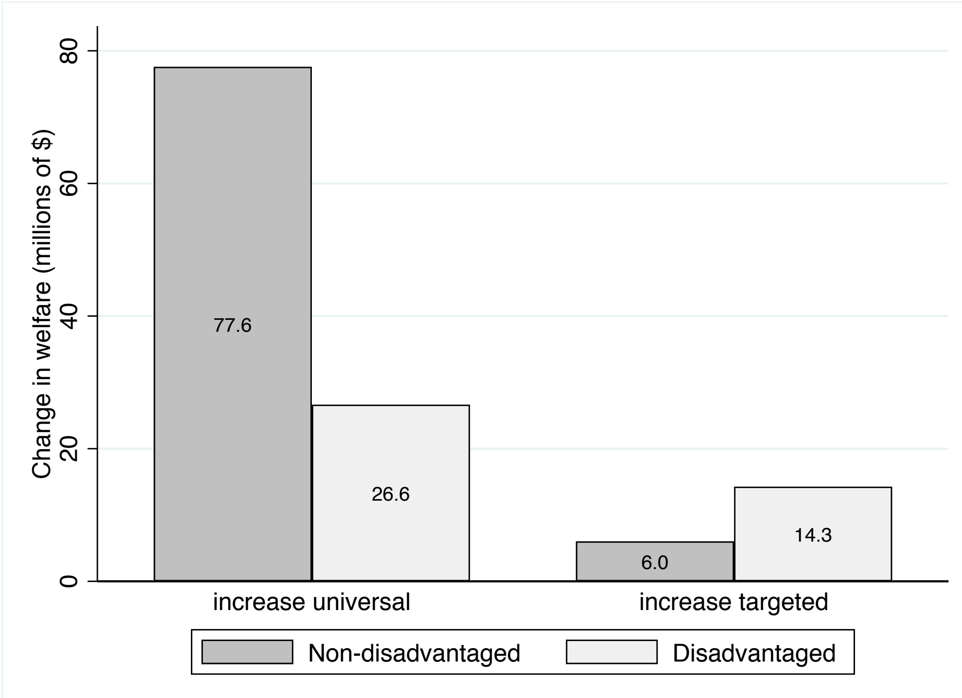
which, in turn, can be used to compute a measure of the aggregate welfare change in dollar terms,

$$\Delta w = \sum_i \frac{\Delta w_i}{-\hat{\beta}_{1i}},$$

where $\hat{\beta}_{1i}$ is student i's estimated coefficient for tuition in the indirect utility.

Figure 18 displays the aggregate welfare changes associated to each counterfactual voucher policy, relative to the baseline scenario. It distinguishes between non-disadvantaged and disadvantaged students' welfare changes. Both policies produce sizable welfare gains, for both types of students. More precisely, increasing the universal voucher by \$342 produces aggregate welfare gains of about \$77.6 million and \$26.6 million for non-disadvantaged and disadvantaged students, respectively. On the other hand, increasing the targeted voucher by \$539 produces aggregate welfare gains of about \$6 million and \$14.3 million for non-disadvantaged and disadvantaged students, respectively.

Figure 18: Change in Students' Welfare in Counterfactual Scenarios



Notes: This figure displays changes in aggregate students' welfare associated to each counterfactual voucher policy, relative to the baseline scenario of no voucher increase. It distinguishes between non-disadvantaged and disadvantaged students. Welfare measures are in real prices for the year 2013, and were transformed from Ch$ to US$ according to the exchange rate as of March 1, 2013 (472.96 Ch$/US$).

When comparing the welfare results of the two voucher policies, we have that the increase in the universal voucher policy produces larger aggregate welfare gains than the increase in the targeted voucher policy, overall and for each type of student. However, the universal voucher policy produces more gains for non-disadvantaged than for disadvantaged students, thus widening the welfare gap between the two groups.[38] On the contrary, the targeted voucher policy produces larger welfare gains for disadvantaged than for non-disadvantaged students, therefore narrowing the gap in welfare between the groups. Thus, a policymaker that is interested in maximizing aggregate welfare among students would tend to prefer increasing the universal voucher,

[38]Recall from Section 5 that the student population is approximately evenly distributed between disadvantaged and non-disadvantaged students. Specifically, in my sample, 53% of students are classified as being disadvantaged, while the remaining 47% are considered to be non-disadvantaged.

while a policymaker that is more concerned about welfare inequality results would tend to prefer increasing the targeted voucher.

7 Conclusions

This paper empirically studies the program participation and tuition setting behavior of Chilean elementary private-voucher schools in a context in which they are eligible to receive a universal voucher and a targeted voucher, and investigates how such behavior determines students' school choices. To that aim, I build and estimate a model of demand and supply of schools that approximates the Chilean elementary education system. I use the model and its estimated parameters to produce counterfactuals and learn about schools' and students' responses to different policy scenarios. I show that schools respond substantially to changes in the voucher amounts, and that the mechanisms through which they respond greatly depend on whether the change in policy affects the universal or the targeted vouchers. In particular, I find that a higher targeted voucher attracts more schools to join the targeted voucher program, but that high quality schools join only if the subsidy is sufficiently high. I also find that a higher universal subsidy induces schools to lower their tuition. Specifically, a $1 increase in the universal subsidy translates into a $0.58 decrease in average tuition. Finally, I quantify the consequences that these supply responses to policies have on students' mobility and welfare. I show that policies that favor the universal voucher are more mobility- and welfare-enhancing in the aggregate, but that policies favoring the targeted voucher are more effective in narrowing the welfare gap between low- and high-income students.

This paper's analysis captures schools' program participation and pricing behavior relatively well, and is able to generate intuitive predictions for different counterfactual voucher policies. To the best of my knowledge, this a novel feature for models that combine demand and supply decisions in elementary school markets. Nevertheless, my model has some limitations. For instance, I do not allow for voucher policies to affect schools' productivity or quality levels. Other studies

(Neilson, 2013; Correa et al., 2014; Murnane et al., 2017) have found important improvements in schools' productivity associated to the introduction of the targeted voucher in Chile. Although, more recent studies (e.g. Feigenberg et al., 2017; Sánchez, 2018) have challenged such findings, arguing that a more careful analysis of the data shows smaller or no improvement in schools' productivity attributed to the targeted voucher. This paper's future agenda includes incorporating an economic and empirical channel that links changes in voucher policies to potential changes in school productivity.

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A Data

Below, I present a detailed description of the data sets used in this paper:[39]

- *Registry of students, 2013.*

  These data provide information on students' gender, date of birth, age, residential address, type and level of education, grade, class, grade repetition status, special education status, and various characteristics of the school of attendance, such as municipality, type of management (public, private-voucher, private-non-voucher), single/double shift schedule, and urban status.

- *Registry of schools, 2013.*

  These data provide information on schools' municipality, type of management, urban status, address, tuition, religious orientation and type and level of education offered.

- *Registry of students that are eligible to participate in the targeted voucher program, 2013.*

  These data provide information on the characteristics of students that are eligible to participate in the targeted voucher program. They provide information on students' gender, date of birth, program participation status, level of education, grade, single/double shift schedule, and on the type of management, and urban status of the school attended by the student.

- *Registry of schools that participate in the targeted voucher program, 2013.*

  These data provide information on the characteristics of the schools that participate in the targeted voucher program. Information on schools' municipality, type of management, urban status, number of disadvantaged students that are eligible for the targeted voucher subsidy, and number of students that are beneficiary of the targeted voucher is available.

- *National standardized exams (SIMCE) for 4th graders, student-level, 2013*

  These data provide information on students' test scores for three different subjects: verbal, mathematics, and natural sciences.

[39]These data sets were kindly provided by the Chilean Ministry of Education and Agencia de Calidad de la Educación.

- *4th grade SIMCE's questionnaire to parents and tutors, 2013.*

  These data consist in the responses to a survey that parents and tutors answer during the days when the national standardized tests are taken. The survey is voluntary, though more than 90% of parents respond it every year. It provides information on students' household size, house amenities, and time use, total number of books available in the house, household total monthly income, parents and tutors' time use, education, indigenous identification, occupation, health insurance, participation in social programs, reasons for the choice of the school, beliefs on the student's future educational attainment, satisfaction with the school, knowledge of school's average performance in standardized tests, total monthly expenses related to the student's education other than tuition, and school's admission criteria, tuition, and fees.