# Price Effects of a Targeted Voucher Reform*

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**Abstract**

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# 1 Introduction

# 2 The Chilean School System and the Targeted Voucher Program

Schools in Chile can be organized within three main groups according to their management and financing scheme: public schools, private-voucher schools, and private-non-voucher schools. Both public and private-voucher schools are financed by per-student voucher subsidies paid by the government directly to the schools. In addition to the subsidies, private-voucher schools are allowed to charge fees on top of the vouchers they receive. Private-non-voucher schools are entirely financed by fees charged to parents, and serve the country's richest families. Today, 38% of students in primary education grades attend public schools, 53% attend private-voucher schools, and 9% attend private-non-voucher schools.

Since 1981, every student in Chile is entitled to an individual voucher to be used to (at least partially) cover tuition at any public or private-voucher school of her choice. In 2008, the government introduced a new source of subsidy to complement the existing flat voucher in the form of a targeted voucher to economically disadvantaged students. In February of that year, the *Ley de Subvención Escolar Preferencial (SEP)* law that regulates this new subsidy was enacted and immediately put into practice for the 2008 academic year.[1] The law mandates that each school that participates in the program receives an additional subsidy per every eligible low income student that it enrolls, with the requirement of not charging top-up fees to those students. In addition, each participating school also receives a per-student subsidy that depends on the share of low income students enrolled in the school, called *Subvención por Concentración*, or concentration subsidy. Participation in the program is voluntary on the part of schools, and only public and private-voucher schools are eligible to join. Participating schools are required to set short- and long-term learning goals (i.e. test score achievements), which are evaluated by the government every four years.

Table 1 displays the evolution of the monthly per-student voucher subsidies corresponding to elementary grades 1st–4th, decomposed by its different categories, for the years 2004–2015. The voucher amounts are in US$ as of May 2016, and correspond to schools with full day shifts. The universal voucher, which is set to represent the unit cost of educating a student, starts at $63 in 2004 and steadily increases to reach $93 in 2015. The targeted voucher is set to represent the additional unit cost of educating a low income student, and starts at $37 in 2008, reaching up to $57 in 2015. The concentration subsidy is considerably lower, and stays fairly constant over

[1] The yearly academic calendar in Chile starts in March and ends in December.

time at about 4% and 10% the universal voucher, depending on the share of eligible low income students enrolled in the school.

Table 1: Monthly Voucher Subsidy Decomposition for Students in 1st–4th Grades

| | subsidy (US$) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| category | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
| universal voucher | 62.66 | 63.07 | 64.92 | 63.82 | 62.40 | 80.86 | 82.48 | 82.71 | 84.77 | 91.50 | 90.93 | 92.62 |
| targeted voucher | – | – | – | – | 36.81 | 42.86 | 43.71 | 43.84 | 44.93 | 55.93 | 55.59 | 56.62 |
| concentration subsidy: | | | | | | | | | | | | |
| *15–30%* | – | – | – | – | 2.66 | 3.00 | 3.06 | 3.06 | 3.14 | 3.89 | 3.87 | 3.94 |
| *30–45%* | – | – | – | – | 4.56 | 5.14 | 5.24 | 5.26 | 5.39 | 6.67 | 6.62 | 6.75 |
| *45–60%* | – | – | – | – | 6.08 | 6.85 | 6.99 | 7.01 | 7.18 | 8.88 | 8.82 | 8.99 |
| *more than 60%* | – | – | – | – | 6.84 | 7.71 | 7.86 | 7.89 | 8.08 | 9.97 | 9.91 | 10.09 |

Notes: All values are real, and are converted from Chilean pesos to US dollars according to the exchange rate of Ch$686.52 per US dollar, as of May 16, 2016. The universal voucher values correspond to students at schools with full day shifts.

The criteria to classify a student as being eligible to be a beneficiary of the targeted voucher program was set to cover households in the lowest 40% of the income distribution. The eligibility criteria include various components, but the two most important are: 1) the household belongs to the lowest 33% of a socioeconomic index distribution used by the government to guide the delivery of social programs (i.e. *Ficha de Protección Social*), and 2) the household participates in *Chile Solidario*, a social program that serves families in vulnerable conditions.[2] By 2011, about 48% of students in the country were classified to be eligible to receive the targeted voucher, and 88% of them (42% of all students) enrolled in participating schools (either a public school or a private-voucher school that joined the program). In other words, the program impacts almost half of the student population in the country.

The evidence on the effects of Chile's targeted voucher program on student outcomes is encouraging. There is a wide consensus that the program causes test scores to increase (**??**), and income-based achievement gaps to narrow (**???**), meaning that it is the most vulnerable students that benefit the most from the program.[3] Our examination of schools' responses to the program thus come naturally, as a means to understanding the mechanisms driving the positive effects on students' achievement.[4]

[2]See **??** and **?** for more details on the criteria to classify a student to be eligible to receive the targeted voucher.

[3]An exception to the above-mentioned findings is **?**. She applies an RD design on an index for student eligibility, and finds no significant test scores effects. However, such results do not necessarily contradict the related (difference-in-differences based) evidence finding positive effects on test scores, as she does not estimate the effects of the reform but rather she examines the effects of being eligible to receive the targeted voucher in a context where the targeted voucher program is already in place. Also, her null effects for individuals that are close to the cutoff for eligibility may not necessarily imply that the effects are nonexistent for students in other parts of the eligibility index distribution.

[4]**?** investigate the effects of the reform on class size and a few characteristics of teachers. Their results are mostly in

# 3 Data

We combine various administrative data sets of Chilean students and schools for the years 2004–2015 to form a twelve-year (unbalanced) panel sample for schools, and a twelve-year (unbalanced) panel sample for municipalities. The data were obtained from the Ministry of Education, and include the censuses of students, schools, and teachers.[5] Our analysis sample consists of the universe of Chilean schools that offer any of 1st–8th grades (i.e. primary education).

Table 2 displays the total number of schools offering primary level grades, by type and participation in the targeted voucher program status, for the years 2004–2015. Panel A shows the number of schools, overall and by type. The total number of schools decreases slightly over time, going from 8,908 schools in 2004 to 8,425 in 2015, possibly reflecting the recent changes in demographics and family size preferences in Chile. Public and private-voucher schools represent about 94% of all schools in the country, highlighting the important (ex-ante) potential reach of the targeted voucher program. Public schools are the most numerous, but they importantly decrease their presence over the period studied, going from 5,426 in 2004 to 4,613 in 2015. Private-voucher schools, in contrast, see an increase in their presence in the system, going from 2,928 in 2004 to 3,386 in 2015. This observed pattern for public and private-voucher schools is consistent with estimated models of families' preferences for school types in Chile.[6] Private non-voucher schools represent a small fraction of all schools, and are 554 in 2004, and 426 in 2015. Panel B displays the number of schools that participate in the targeted voucher program, overall and by type. Almost all public schools (97%) immediately join the program in 2008, the year of its introduction. Public schools' participation in the program remains almost universal throughout the period, reaching 99% in 2015. Private-voucher schools' participation is also important in 2008, with 47% of these schools joining the program. Private-voucher schools' participation rapidly increases over time, reaching 75% in 2015. These figures highlight the important ex-post reach of the targeted voucher program in the Chilean system of education.

line with the subset of ours that relate to educational inputs.

[5] See Appendix A for a more detailed description of each of the data sets we use.

[6] See **??**, and **?**, among others.

Table 2: Schools by Type and Participation in the Targeted Voucher Program

| | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *A. All* | 8,908 | 8,924 | 8,871 | 8,839 | 8,827 | 8,848 | 8,804 | 8,699 | 8,674 | 8,573 | 8,491 | 8,425 |
| public | 5,426 | 5,397 | 5,267 | 5,192 | 5,126 | 5,080 | 5,004 | 4,882 | 4,826 | 4,740 | 4,660 | 4,613 |
| private-voucher | 2,928 | 3,068 | 3,159 | 3,202 | 3,259 | 3,336 | 3,365 | 3,390 | 3,425 | 3,414 | 3,409 | 3,386 |
| private-non-voucher | 554 | 459 | 445 | 445 | 442 | 432 | 435 | 427 | 423 | 419 | 422 | 426 |
| *B. In Program* | – | – | – | – | 6,503 | 6,864 | 6,912 | 7,011 | 7,150 | 7,133 | 7,111 | 7,125 |
| public | – | – | – | – | 4,957 | 4,969 | 4,898 | 4,782 | 4,759 | 4,665 | 4,618 | 4,582 |
| private-voucher | – | – | – | – | 1,546 | 1,895 | 2,014 | 2,229 | 2,391 | 2,468 | 2,493 | 2,543 |

Notes: Panel A shows the number of schools that offer primary education. Panel B shows the number of schools that offer primary education and that participate in the targeted voucher program.

We describe our analysis sample and outcomes of interest in Tables 3–5. We keep in the final sample all school-year observations that do not present missing observations in all variables of analysis. Table 3 displays averages and standard deviations (in parentheses) for the number of schools that initiate operations (entry), and the number of schools that finalize operations (exit) per municipality, for the years 2005–2015. We separately describe the data for public (panel A), private-voucher (panel B), and private-non-voucher (panel C) schools. On average, 0.16 public schools enter the market in 2005.[7] Entries slow down importantly throughout the period, and in 2015 only 0.03 public schools initiate operations, on average. Public school exits are always considerably higher than entries, a pattern that is consistent with the diminishing number of public schools we described in Table 2. In 2005, 0.25 public schools exit the market, on average. In 2015, 0.17 schools finalize operations, on average. Private-voucher schools enter the market more aggressively than public schools, especially early in the period. In 2005, 0.38 private-voucher schools enter the market. The entry frequency slows down over time, and in 2015 we see 0.1 private-voucher schools enter the market, on average. Exits are lower than entries in the years 2005–2012. In 2013, this pattern reverses, and for the rest of the period, we observe a higher number of private-voucher schools exiting than entering the market. The entry and exit behavior of private-non-voucher schools are relatively less dynamic. Early in the period, the frequency of entries is in general lower than that of exits (e.g. 0.03 entries and 0.08 exits per market in 2005). In 2012–2015, private-non-voucher schools enter and exit at the same frequency, 0.02 schools, on average.

[7]We define a market as being a municipality.

Table 3: Summary Statistics - Entry and Exit

| | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *A. Public* | | | | | | | | | | | |
| entry | 0.16 | 0.04 | 0.04 | 0.04 | 0.06 | 0.04 | 0.11 | 0.10 | 0.04 | 0.08 | 0.03 |
| | (0.50) | (0.21) | (0.23) | (0.25) | (0.26) | (0.20) | (0.34) | (0.34) | (0.22) | (0.29) | (0.25) |
| exit | 0.25 | 0.41 | 0.26 | 0.23 | 0.18 | 0.26 | 0.46 | 0.27 | 0.29 | 0.31 | 0.17 |
| | (0.62) | (0.88) | (0.66) | (0.54) | (0.55) | (0.75) | (1.18) | (0.70) | (0.71) | (0.79) | (0.48) |
| *B. Private-voucher* | | | | | | | | | | | |
| entry | 0.38 | 0.38 | 0.29 | 0.34 | 0.35 | 0.19 | 0.19 | 0.31 | 0.18 | 0.16 | 0.10 |
| | (0.86) | (0.87) | (0.67) | (0.80) | (0.77) | (0.53) | (0.52) | (0.69) | (0.61) | (0.45) | (0.38) |
| exit | 0.21 | 0.15 | 0.19 | 0.18 | 0.17 | 0.09 | 0.12 | 0.21 | 0.22 | 0.17 | 0.16 |
| | (0.68) | (0.47) | (0.57) | (0.60) | (0.47) | (0.31) | (0.43) | (0.52) | (0.56) | (0.50) | (0.50) |
| *C. Private-non-voucher* | | | | | | | | | | | |
| entry | 0.03 | 0.03 | 0.05 | 0.04 | 0.02 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 |
| | (0.19) | (0.23) | (0.34) | (0.23) | (0.19) | (0.11) | (0.08) | (0.13) | (0.15) | (0.17) | (0.14) |
| exit | 0.08 | 0.04 | 0.03 | 0.04 | 0.02 | 0.01 | 0.03 | 0.02 | 0.02 | 0.02 | 0.02 |
| | (0.37) | (0.23) | (0.21) | (0.23) | (0.15) | (0.11) | (0.22) | (0.18) | (0.19) | (0.15) | (0.15) |
| observations | 345 | 345 | 345 | 345 | 345 | 345 | 343 | 341 | 341 | 341 | 341 |

Notes: Municipality level mean values for entry and exit. Standard deviations are in parentheses.

Table 4 presents averages and standard deviations (in parentheses) for a set of educational inputs that represent school efforts to increase the quality of education, for the years 2004–2015. We distinguish between public (panel A), private-voucher (panel B), and private-non-voucher (panel C) schools. We analyze the share of multigrade classes, class size, pupil-teacher ratio, the share of teachers holding indefinite contracts, the share teachers with specialization, and weekly teaching hours per teacher. There is important heterogeneity in educational inputs across types of school, possibly reflecting the different objective and production functions in each sector, as well as schools' characteristics.[8] However, regardless of the intrinsic differences between sectors, almost all variables evolve in the direction of increasing education quality, especially in the period after the introduction of the reform. For instance, the share of multigrade classes reduces to about half in each sector during the period of study. The only exception is the share of teachers holding indefinite contracts, which steadily decreases over time, in all three sectors.

[8]For instance, public schools are more likely to be located in rural areas than are private schools (**?**), and schools in rural locations are more likely to offer multigrade classes.

Table 4: Summary Statistics - Educational Inputs

| | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *A. Public* | | | | | | | | | | | | |
| multigrade classes (share) | 0.46 | 0.45 | 0.45 | 0.45 | 0.44 | 0.44 | 0.40 | 0.31 | 0.34 | 0.23 | 0.24 | 0.26 |
| | (0.47) | (0.47) | (0.47) | (0.47) | (0.47) | (0.47) | (0.45) | (0.44) | (0.45) | (0.39) | (0.39) | (0.41) |
| class size | 21.42 | 20.90 | 20.56 | 20.08 | 19.62 | 19.20 | 18.48 | 17.85 | 17.81 | 16.79 | 16.92 | 17.02 |
| | (11.10) | (11.08) | (11.07) | (11.03) | (10.99) | (10.97) | (11.07) | (11.42) | (11.14) | (11.84) | (11.69) | (11.49) |
| pupil-teacher ratio | 16.46 | 15.68 | 15.52 | 14.80 | 14.59 | 14.32 | 13.74 | 12.90 | 11.45 | 10.70 | 10.00 | 9.56 |
| | (11.09) | (9.96) | (9.63) | (7.75) | (8.17) | (19.44) | (12.41) | (13.43) | (8.66) | (7.20) | (6.89) | (6.47) |
| indefinite contracts (share) | 0.81 | 0.82 | 0.81 | 0.81 | 0.76 | 0.73 | 0.72 | 0.61 | 0.57 | 0.47 | 0.43 | 0.45 |
| | (0.24) | (0.23) | (0.23) | (0.23) | (0.25) | (0.26) | (0.27) | (0.29) | (0.29) | (0.29) | (0.29) | (0.28) |
| specialized teachers (share) | 0.04 | 0.04 | 0.04 | 0.04 | 0.05 | 0.06 | 0.06 | 0.19 | 0.19 | 0.37 | 0.42 | 0.46 |
| | (0.10) | (0.10) | (0.11) | (0.10) | (0.11) | (0.12) | (0.12) | (0.20) | (0.21) | (0.28) | (0.28) | (0.28) |
| teaching hours per teacher | 24.48 | 24.43 | 24.51 | 24.40 | 24.55 | 24.70 | 24.70 | 22.66 | 22.63 | 21.81 | 21.48 | 20.84 |
| | (4.98) | (5.09) | (5.17) | (5.16) | (5.28) | (5.39) | (5.54) | (5.87) | (5.78) | (5.75) | (5.74) | (5.72) |
| observations | 5,411 | 5,375 | 5,253 | 5,176 | 5,100 | 5,052 | 4,971 | 4,758 | 4,777 | 4,713 | 4,638 | 4,601 |
| *B. Private-voucher* | | | | | | | | | | | | |
| multigrade classes (share) | 0.23 | 0.23 | 0.22 | 0.22 | 0.21 | 0.20 | 0.19 | 0.15 | 0.14 | 0.09 | 0.10 | 0.11 |
| | (0.40) | (0.39) | (0.39) | (0.39) | (0.39) | (0.38) | (0.37) | (0.33) | (0.33) | (0.27) | (0.28) | (0.29) |
| class size | 28.35 | 27.81 | 27.74 | 27.70 | 27.64 | 27.59 | 27.17 | 26.48 | 26.51 | 25.77 | 25.97 | 26.24 |
| | (11.07) | (11.07) | (11.05) | (10.87) | (11.06) | (10.81) | (11.01) | (11.46) | (11.32) | (12.34) | (12.14) | (11.96) |
| pupil-teacher ratio | 21.37 | 20.06 | 20.08 | 19.83 | 19.62 | 19.71 | 18.74 | 17.24 | 17.20 | 15.99 | 15.51 | 15.18 |
| | (12.35) | (10.20) | (9.45) | (9.83) | (9.29) | (13.38) | (9.74) | (7.86) | (12.37) | (7.19) | (8.06) | (6.96) |
| indefinite contracts (share) | 0.77 | 0.76 | 0.75 | 0.74 | 0.73 | 0.73 | 0.73 | 0.68 | 0.64 | 0.59 | 0.56 | 0.56 |
| | (0.27) | (0.27) | (0.27) | (0.27) | (0.27) | (0.27) | (0.26) | (0.26) | (0.27) | (0.27) | (0.26) | (0.26) |
| specialized teachers (share) | 0.15 | 0.16 | 0.16 | 0.16 | 0.17 | 0.18 | 0.19 | 0.29 | 0.29 | 0.46 | 0.50 | 0.53 |
| | (0.18) | (0.18) | (0.18) | (0.18) | (0.18) | (0.19) | (0.19) | (0.22) | (0.22) | (0.25) | (0.25) | (0.25) |
| teaching hours per teacher | 21.39 | 21.36 | 21.34 | 21.30 | 21.35 | 21.30 | 21.26 | 20.14 | 20.22 | 19.30 | 19.03 | 18.40 |
| | (5.66) | (5.62) | (5.59) | (5.61) | (5.52) | (5.46) | (5.46) | (5.51) | (5.47) | (5.39) | (5.23) | (5.18) |
| observations | 2,853 | 3,013 | 3,106 | 3,143 | 3,201 | 3,247 | 3,283 | 3,341 | 3,369 | 3,397 | 3,395 | 3,374 |
| *C. Private-non-voucher* | | | | | | | | | | | | |
| multigrade classes (share) | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.00 | 0.01 |
| | (0.11) | (0.10) | (0.11) | (0.10) | (0.11) | (0.09) | (0.08) | (0.10) | (0.08) | (0.06) | (0.06) | (0.06) |
| class size | 20.55 | 20.49 | 20.75 | 20.99 | 21.02 | 22.49 | 21.23 | 21.83 | 21.00 | 21.87 | 21.59 | 21.74 |
| | (9.00) | (8.66) | (8.80) | (8.49) | (8.37) | (10.94) | (8.24) | (7.76) | (8.18) | (11.72) | (8.08) | (8.21) |
| pupil-teacher ratio | 13.21 | 11.75 | 11.79 | 12.09 | 12.12 | 12.53 | 12.46 | 15.52 | 11.95 | 11.59 | 12.00 | 25.02 |
| | (11.28) | (6.49) | (6.29) | (6.34) | (6.17) | (7.19) | (6.65) | (32.73) | (8.26) | (5.36) | (20.40) | (58.22) |
| indefinite contracts (share) | 0.82 | 0.84 | 0.84 | 0.82 | 0.82 | 0.81 | 0.81 | 0.84 | 0.81 | 0.76 | 0.73 | 0.71 |
| | (0.22) | (0.2) | (0.2) | (0.21) | (0.19) | (0.21) | (0.21) | (0.19) | (0.22) | (0.23) | (0.24) | (0.24) |
| specialized teachers (share) | 0.36 | 0.38 | 0.39 | 0.38 | 0.39 | 0.40 | 0.41 | 0.50 | 0.48 | 0.58 | 0.63 | 0.66 |
| | (0.21) | (0.20) | (0.20) | (0.20) | (0.21) | (0.20) | (0.21) | (0.19) | (0.20) | (0.18) | (0.18) | (0.16) |
| teaching hours per teacher | 17.98 | 17.69 | 17.68 | 17.72 | 17.7 | 17.67 | 17.68 | 17.18 | 17.06 | 15.98 | 15.33 | 14.63 |
| | (5.26) | (5.48) | (5.21) | (4.97) | (4.94) | (5.13) | (5.08) | (5.48) | (5.16) | (4.67) | (4.38) | (4.86) |
| observations | 541 | 458 | 443 | 436 | 434 | 421 | 422 | 323 | 415 | 416 | 420 | 413 |

Notes: School level mean values. Standard deviations are in parentheses.

Table 5 shows the average and the standard deviation (in parentheses) of top-up fees charged by private-voucher schools, for the years 2004–2015. Fees are in real US$, as of May 2016. Notice that, before the introduction of the targeted voucher program, schools were allowed to charge a unique (possibly positive) fee on top of the subsidies to all students, regardless of the socioeconomic status of the student. Then, the targeted voucher program introduced a version of a third-degree price discrimination scheme for participating schools. Specifically, schools that decide to join the program are mandated to charge zero fees to eligible low income students, and continue to be allowed to charge any (possibly positive) top-up fee to higher income students. Non-participating schools, in contrast, continue to be allowed to charge a unique (possibly positive) top-up fee to all students. Thus, starting in 2008, there exists two vectors of top-up fees, one faced by low income students that are eligible to be beneficiaries of the targeted voucher program, and another faced by non-eligible higher income students. Before the reform, the average top-up fee is $16.14 in 2004, and it slightly increases to $17.24 in 2007. After the introduction of the targeted voucher reform, top-up fees faced by low income students are considerably reduced to about $14–15, on average. In contrast, top-up fees charged to higher income students continue to increase slowly, reaching $20.04 in 2015.

Table 5: Summary Statistics - Private-voucher School Top-up Fees

| | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| low income | 16.14 | 17.36 | 18.34 | 17.24 | 14.46 | 14.97 | 15.04 | 14.40 | 14.96 | 15.41 | 14.95 | 14.71 |
| | (25.29) | (26.81) | (31.25) | (26.92) | (27.31) | (34.07) | (29.86) | (30.05) | (35.24) | (37.28) | (33.32) | (34.31) |
| higher income | 16.14 | 17.36 | 18.34 | 17.24 | 17.82 | 19.33 | 19.29 | 18.98 | 20.49 | 20.87 | 20.13 | 20.04 |
| | (25.29) | (26.81) | (31.25) | (26.92) | (27.47) | (34.36) | (30.39) | (30.42) | (36.67) | (37.36) | (33.51) | (34.67) |
| observations | 2,853 | 3,013 | 3,106 | 3,143 | 3,201 | 3,247 | 3,283 | 3,341 | 3,369 | 3,397 | 3,395 | 3,374 |

Notes: School level mean values. Standard deviations are in parentheses. All values are real, and are converted from Chilean pesos to US dollars according to the exchange rate of Ch$686.52 per US dollar, as of May 16, 2016.

# 4 Estimation

## 4.1 Demand model

We propose a model to estimate the demand. Formally, in each market $m \in \{1, \ldots, M\}$, student $i \in \{1, \ldots, I\}$ chooses school that maximizes her utility. We specify the student's indirect utility by:

$$u_{ijt} = \beta_{1i} p_{jt}^{\zeta} + \beta_{2i}^{\zeta} d_{ij} + \beta_{3i}' X_{it} + \beta_{4i} q_{jt} + \beta_{5i} \hat{z}_{jt}^{y^H} + \beta_{6i} \tau_{jt} + \xi_{jt} + \varepsilon_{ijt}$$

Where:

$$\beta_{ki} = D_i^y \beta_{ki}^{y^L} + (1 - D_i^y)\, \beta_{ki}^{y^H} \text{ for } k = \{1, 2, 3\}$$

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$$D_i^y = \mathbb{1}[\text{i is low income}]$$

$$p_{jt}^{\zeta} = \tau_{jt} \left(1 - D_l^y\right) p_j^1 + (1 - \tau_{jt})\, p_j^0 \text{ where } \tau_{jt} = \mathbb{1}[j \text{ is in SEP's program}]$$

$p_j^1$ is the counterfactual price when school participates in the SEP program.

$p_j^0$ is the counterfactual price when school does not participate in the SEP program.

$\beta_{ki}^{\gamma} = \beta_k^{\gamma} + \Sigma_r z_{ir} \beta_{kr}^{\gamma}$ with $z_i r$ the student's $i$ demographic of $r$ characteristic for $r = \{y^L, y^H\}$ and $k = \{1, 2\}$.

$\beta_{ri} = \bar{\beta}_r + \beta_{ry} x_i^y + \beta_{ru} v_i$ for $r = \{4, 5\}$ where $x_i^y = \mathbb{1}[y_i \geq \bar{y}]$ and $v_i$ is an observed characteristic from student's $i$ school with $v_i \sim ln\mathcal{N}(m_v, \Sigma)$ which allows for a correlation between the preferences for the student body.

$q_{jt}$ is quality of the school $j$.

$\hat{z}_{jt}^{y^H}$ is the variable that characterize student body composition in terms of the share of high income families.

$\beta_{6i} = \bar{\beta}_6 + \sigma^{SEP} v_i^{SEP}$, with $v_i^{SEP} \sim \mathcal{N}(0, 1)$ where $v_i^{SEP}$ is an observed SEP school characteristic by the family.

$\xi_{jt}$ is the common preference that students of type $\gamma = \{y^L, y^H\}$ have for non observable characteristics of the school.

$\epsilon_{ij}$ Type 1 Extreme Value preference shock.

## 4.2 Demand estimation

### 4.2.1 Preference for schools

We use Maximum Likelihood to estimate preference for proximity, taste for heterogeneity, student body composition in terms of the share of high income families and schools that participate in SEP's program.

$$\delta_j^\zeta = \beta_1^\zeta p_j^\zeta + \beta_3^\zeta X_j^\beta + \beta_4^\zeta q_j + \beta_5^\zeta \hat{z}_j^{y^H} + \beta_6^\zeta \tau_j + \xi_j^\zeta$$

Mean utilities vary at the student's socieconomic status $\zeta = \{L, H\}$ and absorb the remaining components from the indirect utility function.

The corresponding log-likelihood function is:

$$LL(\beta) = \sum_i \sum_j e_{ij} \ln \left( \frac{\exp\left(\left(\bar{\beta}_1^\zeta\right) p_j^\zeta + \beta_2^\zeta d_{ij} + \left(\bar{\beta}_3^\zeta\right) X_j^\beta + (\bar{\beta}_5^\zeta) \hat{z}_j^{y^H} + (\bar{\beta}_6^\zeta)\tau_j + \delta_j^\zeta\right)}{\sum_k \exp\left(\left(\bar{\beta}_1^\zeta\right) p_k^\zeta + \beta_2^\zeta d_{ik} + \left(\bar{\beta}_3^\zeta\right) X_k^\beta + \left(\bar{\beta}_5^\zeta\right) \hat{z}_k^{y^H} + \left(\bar{\beta}_6^\zeta\right) \tau_k + \delta_k^\zeta\right)} \right)$$

where $e_{ij}$ is the choice indicator that student $i$ attends school $j$ and $\bar{\beta}_k^\zeta = (\beta_{ki}^\zeta - \beta_k^\zeta)$ for $k = \{1, 3, 5, 6\}$

### 4.2.2 School Value Added

We estimate the parameters that enter the test scores equation using an offline selection-on-observables and linear-in-the-parameters model.

$$Y_i = W_i \gamma + q_j + \epsilon_j,$$

Where we include a set of observables in $W_i$ to capture as much variation as possible, and therefore minimize the inconsistency in the estimates. We estimate the test scores equation market by market.

### 4.2.3 Linking Mean Utilities to School Value Added and Other Characteristics

We use the estimated $\hat{\delta}_j^\zeta$ terms from the first step of demand estimation, as well as the $\hat{q}_j$ estimated school value added to estimate the remaining mean preference parameters in a linear regression of the form:

$$\hat{\delta}_j^\zeta = \beta_1^\zeta p_j^\zeta + \beta_3^\zeta X_j^\beta + \beta_4^\zeta q_j + \beta_5^\zeta \hat{z}_j^{y^H} + \beta_6^\zeta \tau_j + \xi_j^\zeta$$

As is usual in demand models, we assume that $X_j^{\beta}$ is uncorrelated with $\xi_j^{\zeta}$. However, we allow prices, quality and student body composition in terms of families of high income share to be endogenous.

Therefore, estimation for mean utility equation for school $j$ will be done with 2SLS and the following instruments:

For prices and quality we will use the average per student universal voucher received by the school, other per student non-voucher subsidies (e.g. teacher incentives, rurality bonus), the share of low income students in the school's census block, and whether the school's neighborhood is considered vulnerable.

For the variable that characterize the student body composition we will use instruments that exploit exogenous geographic shocks that i) provide independent and differential exposure for different schools, and ii) shift the behavior of families differentially by type. The instruments we will use are the following:

- Motivated by Hausman instruments, the average characteristics like highly educated mother (or other characteristics of importance) of the $N$ closest students from the school.
- In a similar fashion as the previous instrument, the next one will be the average of an important characteristic of schools $-j$ that are similar to the school $j$. We denote similar if the school is in the same school bin which is determined by the exogenous characteristics of schools.
- The share of private and number of schools.

We need to address that instruments must be distance weighted with respect the distance from school $j$.

Instruments related to market structure and demographic characteristics make sense in a context in which families don't travel long distances to go to school. Taking residential sorting and market structure as given, a school located in a neighborhood with high concentration of high income families and with less competition from other private schools (that did not participated in SEP's program) should enroll a higher share of that group than a school located in a neighborhood with lower concentration of high income families and more closer to other private schools that also did not participated in SEP's program.

# 5 Empirical Analysis

## 5.1 Identification Strategy

We follow **?** and **?**, and use the geopolitical boundaries of municipalities to define educational markets in Chile.[9] Enrollment data is consistent with this definition, as about 90% of students attend a school that is located in the same municipality of their residence.

The particular design of the targeted voucher program implies that some markets are more affected by the program than others, depending on their share of students that are eligible to be beneficiaries of the new subsidy (i.e. low income students). To make this point clear, take the extreme case of a market in which no eligible low income student resides. The targeted voucher reform has zero incidence in this market, in terms of adding new funds, because no student is eligible to receive the targeted subsidy. Conversely, a market in which all students come from economically disadvantaged families has the maximum potential of receiving additional funds.[10] Thus, it is possible to argue that different markets have different intensities of treatment, and that these treatment intensities depend on the markets' share of eligible students.

To avoid endogeneity issues when conducting our empirical analysis, we use students' municipality of residence one year prior to the introduction of the targeted voucher program.[11] This variable is highly correlated with the current municipality of residence, and is free of endogeneity because the residential decision was made before the program was announced and implemented.[12]

Figure **??** displays the distribution and relevance of the intensity of treatment variable. Panel A shows the distribution of municipalities according to their share of eligible students one year before the targeted voucher reform was implemented. The support of the distribution is complete in the [0,1] range. Also, about half of municipalities have between 20% and 50% of eligible low income students, and only a few have less than 10% or more than 90% of eligible students. Panel B displays a nonparametric estimation of the probability that a private-voucher school joins the targeted voucher program in the first year of its implementation (2008) with respect to the municipality's share of low income students in 2007. The estimated function is monotonically increasing in the full domain [0,1], going from about 0.2 to about 0.6 in the probability. We can, thus, conclude that 1) the distribution of the intensity of treatment provides enough variation to perform our statistical analysis, and 2) the share of low income students in the municipality (one year before

[9] See **?** and **?** for other studies that use political and administrative boundaries to define local markets.

[10] We are careful to say that this increase in the funding is only potential (ex-ante) because it primarily depends on schools deciding to participate in the program. However, as we show below, the share of eligible students in the market highly predicts the likelihood that a school chooses to participate in the targeted voucher program.

[11] As opposed to the municipality of residence prior to the introduction of the program, the current municipality of residence is subject to endogeneity issues via, for example, endogenous migration (**?**).

[12] 88% of 4th graders in 2008-2011 live in the same municipality as they did in 2007.

the reform) is a strong predictor of private-voucher schools' decision to join the program.

## 5.2 Empirical Strategy

We exploit the exogenous variation given by the (unanticipated) implementation of the targeted voucher reform, as well as the one given by the intensity of treatment in the form of the share of eligible students in the municipality (one year prior to the reform) to implement an event study design. The implementation of the event study allows us to test whether the reform has an effect on the various variables of interest presented in Tables 3–5.

To test the effects of the reform on the number of schools entering and exiting the market, we estimate the following equation,

$$y_{st} = \gamma_s + \lambda_t + \sum_{\tau=-3}^{7} \delta_\tau (D_{\tau t} \times \text{intensity}_s) + \varepsilon_{st}, \quad (1)$$

where $y_{st}$ is the outcome of interest (entry/exit) for municipality $s$ in period $t$, $\gamma_s$ is a municipality fixed effect, $\lambda_t$ is a year fixed effect, $D_{\tau t}$ is a year dummy variable, with $\tau = 0$ indicating the year of the introduction of the reform, $\text{intensity}_s$ is the intensity of treatment (i.e. share of eligible low income students in the municipality of residence one year before the reform), and $\varepsilon_{st}$ is an error term. In the empirical implementation of this regression, we cluster the standard errors at the municipality level (**??**). The coefficients of interest are $\delta_\tau$, as they capture the period effects of the targeted voucher reform.

To test the effects of the reform on schools' educational inputs and top-up fee decisions, we estimate the following equation,

$$y_{ist} = \gamma_s + \lambda_t + \sum_{\tau=-4}^{7} \delta_\tau (D_{\tau t} \times \text{intensity}_s) + \varepsilon_{ist}, \quad (2)$$

which is analogous to equation (1), except that here the data are at the school-municipality-period level. Once again, we cluster standard errors at the municipality level at the moment of performing estimation.

The treatment effect parameters identified by our event study design are the average treatment effects on the treated, where the treatment corresponds to being located in a market where all students are eligible to receive the targeted voucher as opposed to being located in a market where none of the students is eligible to be a targeted voucher beneficiary. Consequently, our estimates incorporate equilibrium effects on the demand (e.g. student sorting among schools) and on the supply (e.g. schools' decision to participate in the program) sides of the market. Moreover, our

results include the responses of both participating and non-participating schools.[13]

Our treatment, and therefore its interpretation, is in contrast to that of **?** and **?**, which corresponds to the effect of a school choosing to participate in the program, and does not necessarily account for equilibrium effects in the market.

## 5.3 Results

We present and discuss event study results for school entry and exit, educational inputs (multigrade classes, class size, pupil-teacher ratio, teachers under indefinite contracts, specialized teachers, teaching hours per teacher), and top-up fees. For clarity of exposition, we present our results in figures. We report our results separately for public and private-voucher schools, and omit results for private-non-voucher schools. Estimates for private-non-voucher schools are imprecise and in general statistically not distinguishable from zero. Tables B.1–B.8 in Appendix B present the corresponding point estimates and standard errors, including those for private-non-voucher schools.

### 5.3.1 Entry and Exit

Figure **??** presents the effects of the targeted voucher program on school entry (panel A) and exit (panel B) into the market. A school enters the market in period $t$ if it is present in the market in $t$ and it was not present in the market in $t-1$. Similarly, a school exits the market in period $t$ if it is not present in the market in $t$ and it was present in the market in $t-1$. We set 2007 as the base year for comparison in the event study, and assign the value $-1$ to that period. Estimates are presented in blue circles for public schools and in red diamonds for private-voucher schools. Clustered at the municipality level 95% confidence intervals are also included. We do not observe the existence of statistically significant pre-trends before the introduction of the reform, confirming the internal validity of our design.

Panel A in Figure **??** shows that public schools are not too responsive to the program, in terms of school entry. If anything, public schools enter less as a consequence of the reform; however, such effects are only significant at the 10% level in periods 3 and 6, where the reform decreases public schools entry in about 0.2 schools. On the contrary, the effect of the reform on private-voucher schools' entry is important, though not immediate. Only in period 2 the effects start being statistically significant, where about 0.3 new private-voucher schools enter the market. This effect is somewhat larger in period 3. The largest effects are found in periods 6 and 7, where

[13] In a game-theoretic and oligopolistic competition setting, where a school's strategies impose externalities on its competitors, the targeted voucher reform impacts the decisions of schools that decide to participate in the program, as well as the strategies of schools that choose not to participate in the program. See, for instance, the model developed in **?**.

about 0.6 new private-voucher schools enter the market. Once again, these effects are considerable, representing more than 100% the average entry frequency of private-voucher schools one year prior to the reform (Table 3).

Panel B in Figure **??** displays the effects of the reform on school exit. These results are similar to the ones we observed for school entry. Public schools do not respond much to the reform and, if anything, they exit less; however, none of the corresponding estimates is statistically significant at the 5% level. Private-voucher schools, in turn, increase their exit frequency by a somewhat constant 0.3 schools per period, with the estimated effects being statistically significant in periods 1, 2, 3, and 6. These effects are sizable when compared to the average exit frequency of 0.19 private-voucher schools in 2007 (Table 3).

In sum, public schools do not modify their entry and exit behavior due to the targeted voucher reform. Private schools, on the other hand, respond relatively quickly, entering and exiting the market in sizable numbers. This evidence is in line with the argument in **?**, which blames the lack of flexibility in top-down bureaucracies that are often behind the administration of public schools for the slow reaction observed in this sector. At the same time, **?** posits that it is private schools' high exposure to market incentives, and the fact that their decisions are made at the institution level, that allows schools in the private sector to respond rapidly to changes in policies and regulation.

### 5.3.2 Educational Inputs

Figure **??** presents the effects of the reform on public and private-voucher schools' educational inputs allocation. We examine six inputs that measure infrastructure and teaching staff efforts schools may make in order to increase the quality of education they provide: share of multigrade classes, class size, pupil-teacher ratio, share of teachers holding indefinite contracts, share of specialized teachers, and teaching hours per teacher. Each panel in Figure **??** shows the effects of the reform on a particular educational input.

We first observe that the vast majority of pre-trends are parallel, again confirming the internal validity of our research design.

The evidence presented in panels A and B of Figure **??** shows that in general schools respond to the reform by improving their infrastructure related inputs. Panel A shows that both public and private-voucher schools reduce their share of multigrade classes due to the reform. Responses are not immediate, but once estimates start being statistically significant (period 3), responses are economically important, especially late in the period. For instance, public schools end the period with a decrease in the share of multigrade classes larger than 80% the average value public schools have for this input in 2007 (Table 4). Private-voucher schools, in turn, end the period with a reduction in the share of multigrade classes of about 220% their average value in 2007.

Panel B in Figure **??** shows that the reform induces schools to reduce their class size, especially in the private sector. Public schools' response goes in the direction of improving educational quality, but is not particularly large. Statistically significant effects are only found in periods 5 and 6, where public schools on average reduce their class size by about 1–2 students per class (5–10% relative to 2007). Private-voucher schools, in contrast, show an important response to the reform. They almost immediately reduce their class size in period 1, and estimates are all statistically significant thereafter. The largest effects are found in periods 5 and 6, where private-voucher schools reduce their average class size by about 9 students.

Panels C–F show evidence on the effects of the targeted voucher reform on schools' educational inputs that are related to the staff of teachers they employ. The findings are in general in the direction of improving quality, especially for private-voucher schools.

Panel C in Figure **??** shows schools' responses to the reform in terms of the number of students per teacher they allocate. Interestingly, public schools increase their pupil-teacher ratio due to the reform. The estimated effects are statistically significant only late in the period, and represent 10–25% the average value for this input one year before the reform. In contrast, estimated responses in the private sector show that private-voucher schools immediately reduce their pupil-teacher ratio by about 1 student per teacher in the year of introduction of the program, and end the period with estimated effects of about $-3$ students per teacher.

Panel D shows no statistically significant effect of the reform on the share of teachers hired under long-term indefinite contracts, suggesting that teachers did not see affected their work stability in any of the public and private sectors as a consequence of the reform.

Panel E presents the effects of the reform on the share of specialized teachers hired by the schools. A specialized teacher is one with extra training in one or more subjects, and is therefore expected to have higher teaching skills than an otherwise identical non-specialized teacher. Both public and private-voucher schools respond to the reform by reducing their share of teachers with some kind of specialization at some point in time. However, the corresponding reduction in the public sector is considerably larger, and the reduction in the private sector is reversed by the end of the period. Public schools' statistically significant estimates appear in period 3, and represent 225–350% the average value of this input in the public sector one year prior to the reform. Private-voucher schools, in turn, start the period by reducing their share of specialized teachers, but the estimates are much smaller. The largest effect is found in period 4, where private schools reduce the input in question only by about 5% of its average value in 2007. Furthermore, the statistical significance of the effects for schools in the private sector disappears by the end of the period.

Lastly, panel F shows the effects of the reform on schools' decisions on the number of weekly teaching hours per teacher. Quite plausibly, the more time teachers spend in front of students, the higher the likelihood teachers experience work fatigue, which may harm their performance as

lecturers. Results show that both public and private-voucher schools respond to the reform by reducing the average time teachers spend in class. Public schools react to the reform with some delay, and after slightly increasing the time teachers spend teaching in period 2, they reduce it in periods 6 and 7 in about 2–3 hours per week. The estimated effects for private-voucher schools indicate larger responses for schools in this sector relative to those observed for public schools. Estimated effects for private-voucher schools are all negative and statistically significant in periods 2–7, ranging between $-5$ and $-1.2$ weekly hours per teacher.

In summary, our results show that both public and private-voucher schools react in important manners to the introduction of the targeted voucher program. Schools, in general, improve their infrastructure related inputs, as well as the inputs related to their teaching staff. In line with the arguments in **?**, public schools take some time to respond to policy changes relative to private schools; however, public schools end up responding, and their responses are mostly in the direction of increasing quality (**?**).

### 5.3.3 Top-up Fees

Before we examine the effects of the targeted voucher reform on private-voucher schools' top-up fee decisions, it is important to note that the reform introduced a kind of a third-degree price discrimination scheme for participating private schools. To see this, notice that before the introduction of the targeted voucher program, all private-voucher schools were allowed to charge a unique fee to students on top of the per student subsidy they received. The reform, once implemented, did not bring any change to the pricing rules for non-participating schools. However, private-voucher schools that decided to be part of the targeted voucher program were imposed a restriction on the fees they charge to low income students, which resulted in these schools (potentially) charging differently to low and higher income students. Specifically, participating schools were mandated to charge zero top-up fees to low income students, and they continued to be allowed to charge any (possibly positive) fee to higher income students. Consequently, as long as at least one private-voucher school joins the program, two different vectors of top-up fees exist in the market: one that is faced by low income students, who are charged zero in participating schools and the sticker top-up fee in non-participating schools; and another that is faced by higher income students, who pay the sticker top-up fee at each school, regardless of the program participation status of the school.

Thus, examining the effects of the reform on private-voucher schools' top-up fee decisions necessarily implies distinguishing between the effects on the top-up fees charged to low income students and the effects on the top-up fees charged to higher income students.

To make things clear, let $p_j$ be the top-up fee private-voucher school $j$ charges in the absence of the targeted voucher reform. Consequently, $E[p_j]$ is the expected top-up fee schools charge in

the absence of the reform. With the introduction of the targeted voucher program, schools must decide whether they participate in the program or not. Denote by $\tau_j \in \{0,1\}$ school $j$'s decision to participate in the targeted voucher program once implemented (1 indicates participation, 0 non-participation). Also, let $p_j^1$ denote the counterfactual top-up fee school $j$ charges to high income students if the school participates in the program.[14] Similarly, let $p_j^0$ denote the counterfactual top-up fee school $j$ charges to all students in the case the school does not participate in the program. Thus,

$$\begin{aligned} E\left[p_j^L\right] &= E\left[\tau_j 0 + (1-\tau_j)p_j^0\right] \\ &= E\left[(1-\tau_j)p_j^0\right] \end{aligned}$$

is the expected top-up fee schools charge to low income students under the targeted voucher program, which includes the mandated zero fees for participating schools ($\tau_j = 1$) and the sticker fee for non-participating schools ($\tau_j = 0$). Similarly,

$$E\left[p_j^H\right] = E\left[\tau_j p_j^1 + (1-\tau_j)p_j^0\right]$$

is the expected top-up fee schools charge to higher income students under the targeted voucher program.

Using this notation (and iterated expectations), the effect of the reform on the average top-up fee schools charge to low income students is

$$\begin{aligned} E\left[p_j^L\right] - E\left[p_j\right] &= E\left[(1-\tau_j)p_j^0\right] - E\left[p_j\right] \\ &= E\left\{(1-\tau_j)E\left[p_j^0 \mid \tau\right] - E\left[p_j\right]\right\}. \end{aligned} \tag{3}$$

Likewise, the effect of the reform on the average top-up fee schools charge to higher income students is

$$\begin{aligned} E\left[p_j^H\right] - E\left[p_j\right] &= E\left[\tau_j p_j^1 + (1-\tau_j)p_j^0\right] - E\left[p_j\right] \\ &= E\left\{\tau_j E\left[p_j^1 - p_j \mid \tau\right] + (1-\tau_j)E\left[p_j^0 - p_j \mid \tau\right]\right\}. \end{aligned} \tag{4}$$

Figure **??** presents the effects of the targeted voucher reform on the average top-up fees schools charge to low income students (panel A) and on the average top-up fees schools charge to higher income students (panel B).[15] Pre-trends are in general parallel, except in period $-2$. Panel A shows that on average private-voucher schools respond to the reform by increasing the top-up

[14] Recall that participating schools are mandated to charge \$0 to low income students.

[15] Table B.8 in Appendix B presents the corresponding point estimates and standard errors.

fee they charge to low income students. Such response is immediate, statistically significant, and stays somewhat constant over the period of study, at about $3–6. Given that participating schools are mandated to charge no fee to low income students, this increase in the average fee result is necessarily driven by the counterfactual fees schools charge in the case they do not participate in the program, as is shown in equation (3).

Panel B shows that the reform induces private-voucher schools to lower the top-up fees they charge to higher income students, on average. The estimates show a quick and fairly constant reaction, of about $8–11 reduction in fees. This response represents 45–65% the average fee private-voucher schools charge in 2007.

To have a better understanding of our findings, we analyze them through the lens of equations (3) and (4). Our results imply that equation (3) is greater than zero, and equation (4) is less than zero, simultaneously. Equivalently,

$$E\left\{(1-\tau_j)E\left[p_j^0 \mid \tau\right]\right\} > E\left[p_j\right], \tag{5}$$

$$E\left\{\tau_j E\left[p_j^1 - p_j \mid \tau\right]\right\} < -E\left\{(1-\tau_j)E\left[p_j^0 - p_j \mid \tau\right]\right\}. \tag{6}$$

That is, in expectation, the counterfactual top-up fees schools charge if they do not join the program under the reform need to be sufficiently higher than the top-up fees schools charge in the absence of the reform. Additionally, the difference between the counterfactual top-up fees schools charge to higher income students if they join the program under the reform and the top-up fees schools charge in the absence of the reform needs to be negative and sufficiently larger in absolute value than the difference between the counterfactual top-up fees schools charge if they do not join the program under the reform and the top-up fees schools charge in the absence of the reform.

We are not able to directly test conditions (5) and (6) with the variation the data provides. Recall that our research design identifies the average response to the reform over all schools in the market, and does not separately identify the average response of participating schools from that of non-participating schools. In other words, we identify $E\left\{(1-\tau_j)E\left[p_j^0 \mid \tau\right] - E\left[p_j\right]\right\}$ in equation (3), but do not separately identify the terms $E\left\{(1-\tau_j)E\left[p_j^0 \mid \tau\right]\right\}$ and $E\left[p_j\right]$ in that same equation. Similarly, we identify $E\left\{\tau_j E\left[p_j^1 - p_j \mid \tau\right] + (1-\tau_j)E\left[p_j^0 - p_j \mid \tau\right]\right\}$ in equation (4), but do not separately identify the terms $E\left\{\tau_j E\left[p_j^1 - p_j \mid \tau\right]\right\}$ and $E\left\{(1-\tau_j)E\left[p_j^0 - p_j \mid \tau\right]\right\}$ in that same equation. Nevertheless, we can examine the data descriptively and see if summary statistics are in line with conditions (5) and (6). We do exactly that in Figures **??** and **??**.

Figure **??** displays the distributions of top-up fees charged by private-voucher schools to low and higher income students, for the year immediately preceding the introduction of the reform, 2007, and four years after the program was first implemented, 2011. We arbitrarily group schools

into those that are part of the program in 2011, and those that are not part of the program in 2011, as a way to distinguish schools that are prone to participate in the program from schools that are less inclined to do so. Panels A and B show fee distributions for the former group of schools. Panel A displays the distribution of top-up fees schools that participate in the program in 2011 charge to low income students in 2007 and 2011. About 70% of schools charge zero fees in 2007, and in general fee levels are low. Also, all participating schools charge zero tuition to low income students in 2011, as is mandated by the program.

Panel B presents the distribution of top-up fees charged to higher income students in 2007 and 2011, for the group of schools that are part of the program in 2011. The distributions resemble each other substantially. More importantly, a visual inspection shows that the fee distribution in 2011 is shifted to the left relative to the 2007 distribution, suggesting that participating private-voucher schools decrease the top-up fees they charge to higher income students due to the reform. This descriptive fact suggests condition (6) is likely to be met.

Panel C displays the top-up fee distributions charged by schools that are not part of the program in 2011, for the years 2007 and 2011. The distributions resemble one another. Notice that a much smaller share of schools in this group charges zero fees (about 23% in 2007, and 25% in 2011) than is observed for schools that participate in the program in 2011 (panels A and B). More importantly, the fee distribution in 2011 is shifted to the right relative to that of 2007, suggesting that non-participating private-voucher schools increase the top-up fee they charge due to the reform, which is in line with condition (5).

Figure **??** complements the description of the data in Figure **??**. It displays the average top-up fees charged by private-voucher schools to low and higher income students over time. Panels A and B show mean fees charged by schools that are part of the program in 2011. Panel A shows that the average top-up fees schools that participate in the program in 2011 charge to low income students dramatically decreases in the period post-implementation of the reform, going from about \$8 in 2007 to near \$0 in 2015. Note that this observation is consistent with the mandate of the program that participating schools charge zero fees to eligible low income students.[16] In panel B we observe that mean fees charged to higher income students steadily decreases in the period after the introduction of the reform, going from about \$8 in 2007 to about \$6 in 2015. Panel C presents mean top-up fees charged by schools that are not part of the program in 2011, over time. The average fee steadily increases over time, both before and after the implementation of the reform. Fees are on average about \$30 in 2004, \$35 in 2007, and \$42 in 2015. All these descriptive facts are in line with conditions (5) and (6).

[16]Note that the mean top-up fee is not exactly \$0 for years other than 2011 in the post-reform period. This fact is explained by some schools in this group not joining the program immediately in 2008, as well as some other schools leaving the program after 2011.

To sum up, the reform increases the average top-up fee schools charge to eligible low income students. This is so despite the mandate of the program that participating schools charge no fees to eligible students. Additionally, the reform reduces the top-up fees schools charge to higher income students. For both these results to occur, counterfactual fees schools charge if they do not join the program under the reform need to be sufficiently higher than fees schools charge in the absence of the reform, and counterfactual fees schools charge to higher income students if schools participate in the program under the reform need to be sufficiently lower than fees schools charge in the absence of the reform. Descriptive statistics suggest this is the case.

# 6 Conclusions

We examine school responses to the implementation of a recent targeted voucher program in Chile. Our results show that public and (especially) subsidized private schools respond to the reform along various margins. Private schools enter and exit more often the market than in the absence of the reform. Schools make successful efforts in improving infrastructure related inputs. When it comes to educational inputs that are related to schools' teaching staff, in general schools' responses are in the direction of improving quality. Lastly, private schools' top-up fee responses are such that low income students see the average fee they face in the market increase, while higher income students see the average fee they face in the market decrease.

Possibly the most interesting result we find is the one on private-voucher schools' fees. Surprisingly, the reform induces schools to increase the top-up fee that is charged to low income students, even with the reform's mandate of participating schools charging zero top-up fees to eligible low income students. We examine the mathematical conditions for our results on fees to occur, and conclude that the counterfactual fees schools charge in the case they do not join the program under the reform need to be sufficiently higher than their fees in the absence of the reform, and that the counterfactual fees schools charge to higher income students in the case they participate in the program under the reform need to be sufficiently lower than their fees in the absence of the reform. We show descriptive statistics supporting these conditions.

Our paper greatly adds to the educational vouchers literature. In particular, it complements existing evidence on the effects of Chile's recent targeted voucher reform, by investigating a piece of the puzzle (supply side) that is rarely the focus of study, but that is central to explaining and producing the observed effects on students' achievement. Furthermore, policymakers wanting to evaluate existing voucher programs or considering implementing voucher policies are in great need of understanding the supply side responses that are triggered by this type of program. Effective designs of voucher programs take into account all of the consequences these programs have on school markets; in particular, supply side responses (**?**).

# A Data

We combine various administrative data sets for Chilean students and schools for the years 2004–2015. Specifically, we use:

- Registry of students, 2004–2015.
  These data provide information on students' gender, date of birth, age, municipality of residence, 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 administration (public, private-voucher, private-non-voucher), single/double shift schedule, and urban status.
- Registry of students' academic performance, 2004–2015.
  These data provide information on students' gender, date of birth, municipality of residence, type and level of education, grade, class, GPA, average class attendance, and various characteristics of the school of attendance, such as municipality, type of administration, and urban status.
- Registry of schools, 2004–2015.
  These data provide information on schools' municipality, type of administration, urban status, address, and type and level of education offered.
- Registry of schools' summary of enrollment, 2004-2015.
  These data provide information on schools' municipality, type of administration, urban status, male enrollment by education type and level, female enrollment by education type and level, total enrollment by education type and level, total enrollment, number of single-grade classes by education type and level, total number of single-grade classes, number of multigrade classes by education type and level, and total number of multigrade classes.
- Registry of teachers, 2004–2015.
  These data provide information on teachers' gender, date of birth, education degree, subject specialization, institution attended, graduation year, and duration of the degree studied. They also provide information on the characteristics of all schools in which each teacher is hired (municipality, type of management, rural status), and on the teachers' primary and secondary roles (e.g. teacher, principal, supervisor), type of contract, hours contracted, teaching hours, experience, tenure, and teaching subject and level of education.
- Registry of schools that participate in the targeted voucher program, 2008–2015.
  These data provide information on the characteristics of schools that participate in the targeted voucher program. Information on schools' municipality, type of administration, urban

status, targeted voucher classification, number of low income students that are eligible to benefit from the targeted voucher subsidy, and number of targeted voucher beneficiary students is also available.

- Registry of students that are eligible to participate in the targeted voucher program, 2008–2015.
  These data provide information on the characteristics of low income students that are eligible to be beneficiaries of the targeted voucher program. They provide information on students' gender, date of birth, targeted voucher participation status, level of education, grade, single/double shift schedule, and on the type of administration, urban status, and targeted voucher category of the school attended by the student.
- Private-voucher schools' top-up fees, 2004–2015.
  These databases list all private-voucher schools that charge strictly positive top-up fees and indicate the amount of such fees.

# B Additional Tables

Table B.1: Effects of the Targeted Voucher Program on School Entry and Exit

| | *Entry* | | | *Exit* | | |
|---|---|---|---|---|---|---|
| | public | private-voucher | private-non-voucher | public | private-voucher | private-non-voucher |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| -3 | -0.072 | 0.079 | 0.148 | -0.225 | 0.131 | -0.291 |
| | (0.151) | (0.224) | (0.126) | (0.196) | (0.182) | (0.139) |
| -2 | 0.025 | -0.073 | 0.072 | -0.093 | 0.150 | -0.034 |
| | (0.086) | (0.215) | (0.086) | (0.268) | (0.156) | (0.094) |
| 0 | -0.010 | -0.041 | 0.093 | -0.210 | 0.194 | -0.005 |
| | (0.069) | (0.204) | (0.158) | (0.173) | (0.165) | (0.113) |
| 1 | -0.082 | -0.105 | 0.204 | -0.076 | 0.322 | 0.073 |
| | (0.083) | (0.186) | (0.146) | (0.187) | (0.179) | (0.102) |
| 2 | -0.013 | 0.330 | 0.258 | 0.111 | 0.352 | 0.146 |
| | (0.071) | (0.158) | (0.142) | (0.220) | (0.167) | (0.094) |
| 3 | -0.206 | 0.454 | 0.278 | 0.090 | 0.373 | 0.027 |
| | (0.106) | (0.159) | (0.116) | (0.239) | (0.174) | (0.126) |
| 4 | -0.088 | -0.067 | 0.225 | -0.088 | 0.227 | 0.089 |
| | (0.109) | (0.185) | (0.140) | (0.184) | (0.161) | (0.080) |
| 5 | 0.008 | 0.309 | 0.203 | -0.343 | 0.271 | 0.035 |
| | (0.085) | (0.183) | (0.137) | (0.205) | (0.195) | (0.070) |
| 6 | -0.187 | 0.675 | 0.170 | 0.271 | 0.304 | 0.084 |
| | (0.101) | (0.164) | (0.127) | (0.198) | (0.151) | (0.106) |
| 7 | 0.041 | 0.574 | 0.226 | 0.013 | 0.137 | 0.096 |
| | (0.077) | (0.153) | (0.142) | (0.180) | (0.154) | (0.103) |
| observations | 3,795 | 3,795 | 3,795 | 3,795 | 3,795 | 3,795 |
| $R^2$ | 0.167 | 0.412 | 0.281 | 0.229 | 0.372 | 0.348 |

Notes: A school enters the market in year $t$ if it is observed in period $t$, but is not in the market in year $t-1$. A school exits the market in year $t$ if it is observed in year $t-1$, but not in $t$. Results come from the estimation of event study regressions that use school data from three years prior to the introduction of the 2008 targeted voucher program, and from the following eight years. Clustered (at the municipality level) standard errors are in parentheses.

Table B.2: Effects of the Targeted Voucher Program on School Share of Multigrade Classes

| | public | private-voucher | private-non-voucher |
|---|---|---|---|
| | (1) | (2) | (3) |
| -4 | -0.003 | 0.015 | 0.027 |
| | (0.032) | (0.030) | (0.054) |
| -3 | -0.025 | -0.002 | -0.017 |
| | (0.036) | (0.021) | (0.037) |
| -2 | 0.003 | 0.001 | 0.030 |
| | (0.028) | (0.012) | (0.059) |
| 0 | 0.003 | 0.015 | -0.065 |
| | (0.012) | (0.012) | (0.034) |
| 1 | 0.023 | -0.012 | -0.091 |
| | (0.020) | (0.024) | (0.042) |
| 2 | -0.047 | -0.038 | -0.096 |
| | (0.032) | (0.028) | (0.047) |
| 3 | -0.190 | -0.302 | -0.106 |
| | (0.041) | (0.041) | (0.053) |
| 4 | -0.103 | -0.299 | -0.070 |
| | (0.039) | (0.036) | (0.060) |
| 5 | -0.367 | -0.621 | -0.083 |
| | (0.057) | (0.045) | (0.046) |
| 6 | -0.394 | -0.557 | -0.073 |
| | (0.052) | (0.041) | (0.048) |
| 7 | -0.370 | -0.485 | -0.055 |
| | (0.052) | (0.043) | (0.043) |
| observations | 59,566 | 38,271 | 5,110 |
| $R^2$ | 0.309 | 0.526 | 0.147 |

Notes: Results come from the estimation of event study regressions that use school data from four years prior to the introduction of the 2008 targeted voucher program, and from the following eight years. Clustered (at the municipality level) standard errors are in parentheses.

Table B.3: Effects of the Targeted Voucher Program on School Class Size

| | public | private-voucher | private-non-voucher |
|---|---|---|---|
| | (1) | (2) | (3) |
| -4 | 0.900 | 1.044 | 0.652 |
| | (0.586) | (0.696) | (2.065) |
| -3 | 0.373 | 0.921 | -1.672 |
| | (0.535) | (0.575) | (2.190) |
| -2 | 0.482 | 0.488 | 0.539 |
| | (0.330) | (0.381) | (1.945) |
| 0 | 0.288 | -0.477 | 2.135 |
| | (0.248) | (0.375) | (1.356) |
| 1 | 0.114 | -1.355 | 7.145 |
| | (0.387) | (0.562) | (3.553) |
| 2 | 0.350 | -1.922 | 2.546 |
| | (0.452) | (0.684) | (1.975) |
| 3 | -0.705 | -4.641 | 1.617 |
| | (0.509) | (0.790) | (2.523) |
| 4 | 0.491 | -5.287 | 0.763 |
| | (0.522) | (0.685) | (2.451) |
| 5 | -1.901 | -9.243 | 2.473 |
| | (0.592) | (0.818) | (2.584) |
| 6 | -1.253 | -8.711 | 3.268 |
| | (0.609) | (0.813) | (2.417) |
| 7 | -0.726 | -7.986 | 4.939 |
| | (0.646) | (0.847) | (2.751) |
| observations | 59,566 | 38,271 | 5,110 |
| $R^2$ | 0.457 | 0.367 | 0.173 |

Notes: Results come from the estimation of event study regressions that use school data from four years prior to the introduction of the 2008 targeted voucher program, and from the following eight years. Clustered (at the municipality level) standard errors are in parentheses.

Table B.4: Effects of the Targeted Voucher Program on School Pupil-teacher Ratio

| | public | private-voucher | private-non-voucher |
|---|---|---|---|
| | (1) | (2) | (3) |
| -4 | -0.574 | -0.788 | -0.858 |
| | (1.249) | (0.823) | (2.455) |
| -3 | 0.040 | 0.188 | -1.239 |
| | (0.652) | (0.729) | (1.506) |
| -2 | -0.432 | -0.314 | 0.875 |
| | (0.470) | (0.598) | (1.190) |
| 0 | -0.319 | -1.265 | 1.400 |
| | (0.388) | (0.357) | (1.073) |
| 1 | -3.320 | -0.750 | -0.200 |
| | (1.831) | (1.036) | (1.608) |
| 2 | -1.521 | -1.443 | -0.137 |
| | (0.999) | (0.679) | (1.482) |
| 3 | 0.775 | -1.173 | -10.489 |
| | (0.750) | (0.592) | (11.766) |
| 4 | 1.746 | -3.123 | 5.813 |
| | (0.631) | (0.821) | (3.299) |
| 5 | 2.265 | -1.938 | 4.080 |
| | (0.608) | (0.690) | (2.464) |
| 6 | 3.221 | -2.423 | 13.207 |
| | (0.614) | (0.674) | (10.054) |
| 7 | 3.777 | -2.737 | -16.837 |
| | (0.632) | (0.748) | (17.091) |
| observations | 59,566 | 38,271 | 5,110 |
| $R^2$ | 0.203 | 0.191 | 0.056 |

Notes: Results come from the estimation of event study regressions that use school data from four years prior to the introduction of the 2008 targeted voucher program, and from the following eight years. Clustered (at the municipality level) standard errors are in parentheses.

Table B.5: Effects of the Targeted Voucher Program on School Share of Indefinite Contracts

| | public | private-voucher | private-non-voucher |
|---|---|---|---|
| | (1) | (2) | (3) |
| -4 | 0.014 | -0.081 | 0.032 |
| | (0.024) | (0.030) | (0.101) |
| -3 | 0.024 | -0.019 | 0.115 |
| | (0.015) | (0.021) | (0.069) |
| -2 | -0.008 | -0.026 | 0.067 |
| | (0.010) | (0.018) | (0.060) |
| 0 | 0.021 | -0.010 | -0.087 |
| | (0.016) | (0.015) | (0.075) |
| 1 | -0.010 | -0.010 | -0.053 |
| | (0.023) | (0.022) | (0.084) |
| 2 | -0.017 | -0.021 | -0.103 |
| | (0.026) | (0.021) | (0.089) |
| 3 | 0.043 | -0.024 | 0.022 |
| | (0.035) | (0.025) | (0.089) |
| 4 | 0.046 | 0.022 | -0.060 |
| | (0.036) | (0.028) | (0.107) |
| 5 | 0.033 | 0.041 | -0.064 |
| | (0.038) | (0.036) | (0.108) |
| 6 | 0.056 | 0.015 | -0.106 |
| | (0.040) | (0.039) | (0.106) |
| 7 | 0.020 | 0.027 | -0.011 |
| | (0.041) | (0.040) | (0.108) |
| observations | 59,566 | 38,271 | 5,110 |
| $R^2$ | 0.326 | 0.158 | 0.174 |

Notes: Results come from the estimation of event study regressions that use school data from four years prior to the introduction of the 2008 targeted voucher program, and from the following eight years. Clustered (at the municipality level) standard errors are in parentheses.

Table B.6: Effects of the Targeted Voucher Program on School Share of Specialized Teachers

| | public | private-voucher | private-non-voucher |
|---|---|---|---|
| | (1) | (2) | (3) |
| -4 | 0.005 | 0.018 | -0.199 |
| | (0.007) | (0.014) | (0.060) |
| -3 | 0.001 | 0.004 | -0.058 |
| | (0.007) | (0.013) | (0.054) |
| -2 | -0.001 | -0.001 | -0.048 |
| | (0.004) | (0.008) | (0.026) |
| 0 | -0.005 | -0.014 | -0.005 |
| | (0.007) | (0.007) | (0.035) |
| 1 | -0.001 | -0.041 | -0.014 |
| | (0.010) | (0.009) | (0.044) |
| 2 | -0.007 | -0.046 | 0.012 |
| | (0.011) | (0.009) | (0.055) |
| 3 | -0.135 | -0.051 | -0.138 |
| | (0.020) | (0.018) | (0.093) |
| 4 | -0.140 | -0.069 | -0.090 |
| | (0.020) | (0.020) | (0.065) |
| 5 | -0.124 | -0.058 | -0.080 |
| | (0.029) | (0.031) | (0.093) |
| 6 | -0.123 | -0.044 | -0.127 |
| | (0.029) | (0.032) | (0.110) |
| 7 | -0.088 | -0.021 | -0.145 |
| | (0.031) | (0.037) | (0.110) |
| observations | 59,566 | 38,271 | 5,110 |
| $R^2$ | 0.506 | 0.459 | 0.335 |

Notes: A specialized teacher is one with extra training in one or more subjects. Results come from the estimation of event study regressions that use school data from four years prior to the introduction of the 2008 targeted voucher program, and from the following eight years. Clustered (at the municipality level) standard errors are in parentheses.

Table B.7: Effects of the Targeted Voucher Program on School Weekly Teaching Hours per Teacher

| | public | private-voucher | private-non-voucher |
|---|---|---|---|
| | (1) | (2) | (3) |
| -4 | 1.285 | -0.340 | 2.257 |
| | (0.503) | (0.383) | (1.808) |
| -3 | 0.472 | -0.103 | 1.419 |
| | (0.345) | (0.375) | (1.294) |
| -2 | -0.158 | -0.442 | 1.365 |
| | (0.214) | (0.371) | (0.887) |
| 0 | 0.589 | -0.483 | 0.074 |
| | (0.453) | (0.300) | (0.677) |
| 1 | 0.665 | -0.490 | -0.993 |
| | (0.481) | (0.384) | (1.168) |
| 2 | 1.323 | -1.167 | -1.646 |
| | (0.569) | (0.423) | (1.233) |
| 3 | 0.428 | -3.163 | -0.066 |
| | (0.758) | (0.606) | (2.170) |
| 4 | -0.232 | -3.657 | -0.200 |
| | (0.727) | (0.596) | (1.876) |
| 5 | -1.226 | -3.745 | -1.497 |
| | (0.816) | (0.601) | (1.965) |
| 6 | -2.417 | -4.695 | -1.687 |
| | (0.806) | (0.678) | (1.919) |
| 7 | -3.157 | -5.042 | -0.896 |
| | (0.929) | (0.728) | (2.506) |
| observations | 59,566 | 38,271 | 5,110 |
| $R^2$ | 0.308 | 0.292 | 0.163 |

Notes: Results come from the estimation of event study regressions that use school data from four years prior to the introduction of the 2008 targeted voucher program, and from the following eight years. Clustered (at the municipality level) standard errors are in parentheses.

Table B.8: Effects of the Targeted Voucher Program on Private-voucher School Top-up Fees

| | low income | higher income |
|---|---|---|
| | (1) | (2) |
| -4 | 0.941 | 1.148 |
| | (1.700) | (1.724) |
| -3 | -1.040 | -1.039 |
| | (1.773) | (1.776) |
| -2 | -5.368 | -5.384 |
| | (2.269) | (2.270) |
| 0 | 5.071 | -2.352 |
| | (1.693) | (1.630) |
| 1 | 2.605 | -7.909 |
| | (2.056) | (2.104) |
| 2 | 3.216 | -7.815 |
| | (1.796) | (1.866) |
| 3 | 5.808 | -5.871 |
| | (2.077) | (1.987) |
| 4 | 4.876 | -9.798 |
| | (2.100) | (1.989) |
| 5 | 2.493 | -11.158 |
| | (2.429) | (2.434) |
| 6 | 5.020 | -8.227 |
| | (2.505) | (2.634) |
| 7 | 4.722 | -8.734 |
| | (2.336) | (2.480) |
| observations | 38,271 | 38,271 |
| $R^2$ | 0.272 | 0.218 |

Notes: Fee values are real, and are converted from Chilean pesos to US dollars according to the exchange rate of Ch$686.52 per US dollar, as of May 16, 2016. Results come from the estimation of event study regressions that use school data from four years prior to the introduction of the 2008 targeted voucher program, and from the following eight years. Column (1) shows the effects of the reform on the top-up fees faced by low income students that are eligible to participate in the program, and column (2) shows the effects of the reform on the top-up fees faced by higher income students. Clustered (at the municipality level) standard errors are in parentheses.