Inputs and the School Quality Effects of Targeted Vouchers*

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Abstract

In this paper we examine two questions. First, whether a targeted voucher program in Chile had positive impacts on school value added. Second, whether and to what extent school value added effects of the program can be explained by observed educational inputs. Our results show that the program had some effects on school value added. Interestingly, complier schools are not the main drivers of such effects. Additionally, the program causally affected a number of educational inputs. Finally, we show the link between educational inputs and the effects the program had on school value added.

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1 Introduction

The education literature that studies markets that include voucher subsidies and school choice often focuses its attention on the demand side of these markets (i.e. students, parents).[1] Studies typically answer important policy questions, such as what are the gains in academic performance and achievement of attending a private school versus a public one, or what are the factors that determine parental school choice. However, in most of the cases, voucher policies involve conditions and changes in regulation that also affect the supply side of the education markets (i.e. schools). Furthermore, effects on student outcomes may, at least partially, be explained by school responses to policies (Neilson, 2020; Dinerstein and Smith, 2021). For instance, a voucher program may induce schools to increase the quality of education they provide, with the consequent effect of improving students' test scores, even in the absence of an effect on student sorting. Thus, understanding school responses to (voucher) policies is of first order importance for the effective design of policies, and for the complete understanding of the mechanisms driving the policies' overall effects.

In this paper, we study schools' responses to a recent targeted voucher reform in Chile that considerably increased government subsidies, and whose new set of rules changed the incentives faced by schools. We examine school responses on a measure of school value added, educational inputs, and the contribution of educational inputs to school value added.

Since 1981, public and private schools in Chile receive a flat subsidy for every student that they enroll. We call this subsidy the "universal voucher". In addition, private schools are allowed to charge fees on top of the flat voucher. In 2008, the Chilean government introduced a new subsidy in the form of a targeted voucher for economically disadvantaged students, that supplemented the existing universal voucher. Schools are invited to participate in the new program, and schools that opt in receive extra funds for every low income student that they enroll, with the requirement of not charging top-up fees to these students. The targeted voucher program represents a considerable budgetary effort for the government, with the size of the new subsidy being about 60% the amount of the flat voucher.

We estimate the impact of the targeted voucher program on schools' value added, and educational inputs. We identify treatment effect parameters by exploiting the differential incidence of the program across local educational markets. We use the share of low income students in the market to define the incidence of the program, or the "intensity of treatment". The idea is that, in a market where no low income student resides, the targeted voucher program has zero incidence, in terms of adding new funds, because no student is eligible to be a beneficiary of the program. Conversely, a market where all students come from low income families has the highest potential of

[1] See the extensive review in Epple et al. (2017).

adding new funds. Hence, we use a difference-in-differences (DID) design that compares outcomes before and after the introduction of the program across markets with different shares of low income students (Card, 1992; Duflo, 2001; Lucas and Mbiti, 2012).[2] We estimate the effects of the program distinguishing between public and private schools. We also use the "intensity of treatment" variation as an instrumental variable for the endogenous decision of the school to participate in the targeted voucher program, in an instrumental variable (IV) design.

We find...

When it comes to the effects of the reform on schools' educational inputs, we find that both public and private schools significantly adjust their educational inputs allocation due to the reform. More importantly, schools' adjustments are in general in the direction of increasing educational quality, both directly through the improvement of infrastructure items, and indirectly via the improvement of teachers' conditions at work. In particular, public and private schools make costly efforts to improve the subset of infrastructure related inputs we observe (share of multigrade classes, class size). A similar response is observed for schools' inputs that are related to their teaching staff. Specifically, schools employ enough teachers to reduce their pupil-teacher ratio (only in private schools; public schools do the opposite), and provide at least the same job conditions for their teachers than in the absence of the reform (same share of long term contracts, less time lecturing). Finally, the reform induces private schools to first reduce their share of specialized teachers, and then reverse this response, so that they end the period of analysis with their share of specialized teachers being unaffected by the reform.[3] Public schools' adjustment of the share of specialized teachers follows a similar trend to that of private schools, but with a lag. As a consequence, we are not able to observe the complete reversion of the effect in the time frame of our analysis.

This paper contributes to the literature along two main fronts. First, it adds to the existing set of papers that estimate the impact of voucher programs. Epple et al. (2017) review this literature. They organize the evidence around five research questions that motivate the studies, which relate to the effects of vouchers on the students who use them, student sorting across schools, pressure on public schools to improve, overall educational performance in the market, and the political economy underlying the existence of such programs. Since our estimated treatment effects are identified at the market level, we advance our understanding of the mechanisms driving the overall (including equilibrium effects) impact of vouchers on achievement, namely school responses. In that respect, the effect of a voucher program on school behavior is a key determinant of the consequent impact of the program on achievement, as suggested by Abdulkadiroglu et al. (2018), that postulate that the joining of low quality private schools to the Louisiana Scholarship Program is the major driver

[2]To avoid endogeneity issues due to endogenous migration, we use the share of low income students in the market one year before the introduction of the program.

[3]A specialized teacher is a teacher with extra training in one or more subjects.

of this program's negative effects on students' test scores. Additionally, a subset of our results speak to the existing evidence on public schools' productivity, much of which is in the context of the United States (Hoxby, 2003a; Figlio and Rouse, 2006; Chakrabarti, 2008, 2013a,b; Figlio and Hart, 2014).[4]

Second, our paper adds to the existing literature on the industrial organization of education markets. Typically, studies in this literature develop and estimate structural models of demand and/or supply to investigate parental preferences for schools, schools' strategies in contexts of imperfect competition, and consequences of actual and counterfactual policies on markets' equilibria.[5] This paper is motivated by similar competition and regulation questions that motivate those studies, and answers them using a clean reduced form empirical design, that allows us to examine a larger set of outcomes than structural models often do.[6]

2 Chile's School System and the Targeted Voucher Program

Schools in Chile can be organized among 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.[7] The law mandates that each school that participates in the program receives an additional subsidy per every eligible low income student

[4]See, also, Hsieh and Urquiola (2006), that show that public schools' performance worsened in markets with a high degree of competition from the private sector after the introduction of the universal voucher in Chile.

[5]See, e.g., Gazmuri (2015), Ferreyra and Kosenok (2018), Allende (2019), Allende et al. (2019), Singleton (2019), Dinerstein et al. (2020), Neilson (2020), Sánchez (2022), and Dinerstein and Smith (2021).

[6]Dinerstein et al. (2020), and Dinerstein and Smith (2021) are other studies that examine schools' responses to policies using reduced form strategies.

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

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 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.[8] By 2011, about

[8]See Neilson (2013, 2020) and Aguirre (2020) for more details on the criteria to classify a student to be eligible to receive the targeted voucher.

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.

3 Data

We combine various administrative data sets of Chilean students and schools for the years 2004–2015 to form a twelve-year panel sample for schools. The data were obtained from the Ministry of Education, and include the censuses of students, schools, and teachers.[9] 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.[10] 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.

[9] See Appendix A for a more detailed description of each of the data sets we use.
[10] See Neilson (2013, 2020) 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 Table 3. We keep in the final sample all school-year observations that do not present missing observations in all variables of analysis. Table 3 presents averages and standard deviations (in parentheses) for a set of educational inputs for the years 2004–2015. We distinguish between public (panel A) and private-voucher (panel B) schools.[11] We analyze the share of multigrade classes, class size, pupil-teacher ratio, the share teachers with specialization, the share teachers that are female, the average teachers' experience, the share of teachers holding indefinite contracts, weekly teaching hours per teacher, and weekly teaching hours per class. 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.[12] 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 teachers' experience and the share of teachers holding indefinite contracts, which steadily decreases over time in public and private-voucher sectors.

[11]Summary statistics for private-non-voucher schools are presented in Table C.1 in Appendix C.

[12]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 3: Summary Statistics - Public and Private-voucher Schools

	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	19.2	18.48	17.85	17.81	16.79	16.92	17.02
	(11.1)	(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	12.9	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)
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)
female teachers (share)	0.60	0.60	0.60	0.61	0.61	0.61	0.62	0.64	0.65	0.65	0.66	0.67
	(0.33)	(0.33)	(0.33)	(0.33)	(0.33)	(0.32)	(0.32)	(0.31)	(0.30)	(0.29)	(0.28)	(0.27)
teachers' experience (years)	21.77	21.84	22.64	23.15	21.67	21.03	20.93	18.85	18.26	15.72	15.22	15.12
	(7.28)	(7.37)	(7.47)	(7.62)	(7.83)	(8.04)	(8.20)	(8.22)	(8.20)	(7.98)	(7.82)	(7.63)
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)
teaching hours per teacher	24.48	24.43	24.51	24.4	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	27.7	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)	(10.2)	(9.45)	(9.83)	(9.29)	(13.38)	(9.74)	(7.86)	(12.37)	(7.19)	(8.06)	(6.96)
specialized teachers (share)	0.15	0.16	0.16	0.16	0.17	0.18	0.19	0.29	0.29	0.46	0.5	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)
female teachers (share)	0.72	0.71	0.72	0.72	0.73	0.73	0.73	0.74	0.74	0.74	0.74	0.74
	(0.24)	(0.24)	(0.24)	(0.23)	(0.23)	(0.22)	(0.22)	(0.21)	(0.2)	(0.2)	(0.19)	(0.19)
teachers' experience (years)	14.13	13.77	14.19	14.01	14.07	13.86	13.84	12.21	12.43	12.09	12.09	12.28
	(7.05)	(7.22)	(7.36)	(7.36)	(7.51)	(7.41)	(7.38)	(6.96)	(6.97)	(7.05)	(6.94)	(6.93)
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)
teaching hours per teacher	21.39	21.36	21.34	21.3	21.35	21.3	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

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

4 Empirical Analysis

4.1 Identification Strategy

We follow Hsieh and Urquiola (2006) and Sánchez (2019), and use the geopolitical boundaries of municipalities to define educational markets in Chile.[13] 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. Note that other definitions of markets also work (e.g. Neilson, 2013; Sánchez, 2022), as we only seek to define a local buffer zone.

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.[14] 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.[15] 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.[16]

Figure 1 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

[13] See Topel (1986) and Card (2001) for other studies that use political and administrative boundaries to define local markets.

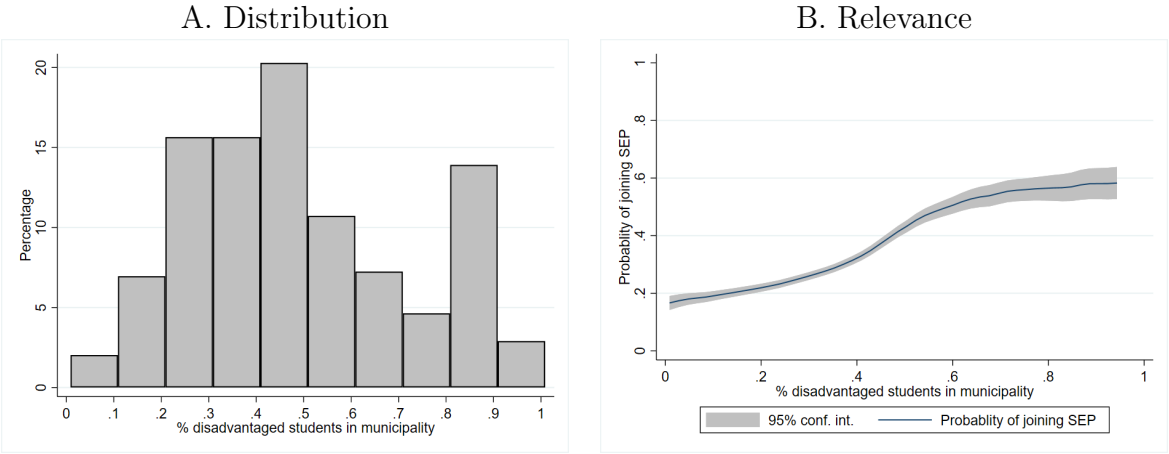
[14] We are careful to say that this increase in the funding is only potential (ex-ante) because it primarily depends on schools deciding to participate in the program. However, as we show below, the share of eligible students in the market highly predicts the likelihood that a school chooses to participate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

[15] 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 (Rosenzweig and Wolpin, 1988).

[16] 88% of 4th graders in 2008-2011 live in the same municipality as they did in 2007.

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

Figure 1: Distribution and Relevance of Intensity of Treatment



Notes: Panel A: distribution of markets according to their share of low income students one year prior to the introduction of the targeted voucher reform (2007). Panel B: 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 share of low income students in the market one year prior to the introduction of the targeted voucher program (2007).

4.2 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 difference-in-differences (DID) and instrumental variable (IV) designs. The implementation of the DID design allows us to test whether the reform has an effect on the various school variables of interest, regardless of whether the school participates in the program. The IV design allows us to test whether school's program participation has an effect on school value added and educational inputs.

To test the effects of the reform on schools' value added and educational input choices, we estimate the following DID equation,

$$y_{ist} = \gamma_s + \lambda_t + \delta(\text{post}_t \times \text{intensity}_s) + \varepsilon_{ist}, \quad (1)$$

where y_{ist} is the outcome of interest for school i in municipality s in period t, γ_s is a municipality

fixed effect, λ_t is a year fixed effect, post_t indicates the period after the introduction of the reform, 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 ε_{ist} is an error term. The coefficient of interest is δ, as it captures a version of the average effect of the targeted voucher reform on treated populations. In the empirical implementation of these regressions, we cluster the standard errors at the municipality level (Bertrand et al., 2004; Cameron and Miller, 2015). We also estimate an event study version of equation (1) to test pre-trends and observe dynamics in the estimated treatment effects. Such results are reported in Appendix B.

The treatment effect parameters identified by our DID designs 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.[17]

We investigate the role of educational inputs in shaping the effects of the reform on school value added by fitting the following DID regression,

$$y_{ist} = \gamma_s + \lambda_t + \delta(\text{post}_t \times \text{intensity}_s) + \sum_q \delta_q(\text{post}_t \times \text{intensity}_s \times I^q_{ist}) + \sum_q \zeta_q I^q_{ist} + \varepsilon_{ist}, \quad (2)$$

where y_{ist} is school value added, and I^q_{ist} denotes the value of educational input q for school i in municipality s in period t. The parameters of interest are δ_q, that capture the contribution of input q to the overall effect of the targeted program on school value added.

To estimate the effect of school participation in the targeted program, we implement the following IV model,

$$y_{is} = \xi D_{is} + X_{is}\gamma + \varepsilon_{is} \quad (3)$$

$$D_{is} = \beta \text{intensity}_s + X_{is}\phi + \epsilon_{is}, \quad (4)$$

where equation (3) is the structural equation, and equation (4) is the first stage. The dummy variable D_{is} is the (endogenous) program participation decision of the school, which is instrumented using the intensity of treatment variable, intensity_s. The vector of exogenous variables, X_{is}, includes regional dummies and the pre-reform (as of 2007) value of the dependent variable. In the

[17] 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 Sánchez (2022) and the evidence in Andrabi et al. (2023).

empirical implementation, we estimate the coefficient of interest, ξ, by 2SLS, and cluster standard errors at the municipality level.

The IV model just described identifies a LATE parameter. That is, we identify the average effect of participating in the program for compliers, which are the schools that are induced to join the program when the share of eligible low income students in the municipality increases. This treatment parameter and, therefore, our results on this part of the analysis are to some extent comparable to the evidence in Correa et al. (2014) and Feigenberg et al. (2019). However, contrary to those studies, we are careful in taking into account the endogenous nature of schools' decision to participate in the targeted program.

To understand the role of educational inputs on the school value added effects of program participation, we implement a similar IV model as the one described by equations (3) and (4), where the dependent variable is school value added, and where we include interactions of schools' program participation with educational inputs as follows,

$$y_{is} = \xi D_{is} + \sum_q \xi_q (D_{is} \times I_{is}^q) + \sum_q \omega_q I_{is}^q + X_{is}\gamma + \varepsilon_{is} \tag{5}$$

$$D_{is} = \beta \text{intensity}_s + \sum_q \beta_q (\text{intensity}_s \times I_{is}^q) + \sum_q \eta_q I_{is}^q + X_{is}\phi + \epsilon_{is} \tag{6}$$

$$D_{is} \times I_{is}^q = \psi \text{intensity}_s + \sum_q \psi_q (\text{intensity}_s \times I_{is}^q) + \sum_q \psi_q I_{is}^q + X_{is}\lambda + \nu_{is}, \quad \text{for each } q, \tag{7}$$

where equation (5) is the structural equation, and equations (6) and (7) are the corresponding first stages. The parameters of interest are ξ_q, that capture the contribution of input q to the overall effect of program participation on school value added for compliers.

It is important to emphasize that educational inputs are not randomly assigned to schools. In fact, our results below show that some input choices are affected by the reform. As a result, the estimates on the role of educational inputs on school value added may not reflect causal impacts of changing inputs in isolation, and may be biased towards zero relative to the corresponding causal effects (Walters, 2015). Nonetheless, our empirical exercises shed important light in our understanding on which input improvement determines higher school effectiveness.

We make a few sampling decisions for our empirical analyses. In the DID regressions, we include all before-treatment years (2004–2007) and post-treatment years 2011–2015; that is, we exclude post-treatment years 2008–2010. This decision is motivated by the incremental design of the policy implementation, where every year one additional grade was added to the program. In particular, in 2008 participating schools received the targeted voucher only for their eligible first grade students. Similarly, in 2009 participating schools received the subsidy for their eligible first and second grade students. The year 2011 is thus the first year where standardized test takers, i.e.

4th grade students, had been part of the reform since the start of their primary education. Next, and for the same argument just displayed, in the IV analysis we use data for post-treatment years 2011–2015.[18]

In addition, we perform the IV exercises on private-voucher schools only. We are not able to include public schools in these analyses because virtually all public schools joined the program the year of its introduction, offering no statistical variation to be exploited on the extensive margin of program participation for that group of schools.

4.3 Results

We present and discuss DID and IV results for school value added, educational inputs, and the role of educational inputs in explaining the effects of the targeted voucher reform/program participation on school value added. 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.

4.3.1 The Effects of the Targeted Voucher Reform

We begin our empirical analysis by constructing the school value added measure. We use student scores in national standardized math and verbal exams for 4th graders, and estimate test scores equations using a selection-on-observables approach, very similar to the work in Neilson (2013), Ferreyra and Kosenok (2018), Allende (2019), Allende et al. (2019), Singleton (2019), and Sánchez (2022). Specifically, we estimate by OLS the parameters that enter the following test scores equation,

$$Y_{ij} \quad = \quad W_i\gamma + q_j + u_{ij},$$

where Y_{ij} is student i's score in school j, W_i is a set of student-level observable determinants of test scores, q_j is school j fixed effects, and u_{ij} is an idiosyncratic error term. We are careful to include a large set of observables in W_i to capture as much variation as possible, and therefore minimize the potential inconsistency in the estimates.[19] The estimated q_j parameters are our measures of school value added. We focus on the average of verbal and math test scores as our measure of academic performance, Y_{ij}. Figure D.1 in Appendix D shows the distributions of the estimated

[18] In the event studies, we include all 2004–2015 years in our data, as we are interested in the dynamics of the voucher reform effects, as well as on the pre-trends.

[19] The set of covariates I include in the regressions are gender, targeted program eligibility, grade repetition, mother's education, father's education, household income, having attended pre-K, having attended kindergarten, computer availability at home, internet availability at home, indigenous status, number of books at home, and class attendance.

school value added measures.

Figure D.2 in Appendix D displays the pre-trends and dynamic effects of the reform on school value added and educational inputs, using the dynamic version of the DID regression described in Appendix B. Results show that the vast majority of pre-trends are parallel, again confirming the internal validity of our research design. Interesting dynamics in the effects of the reform are also found. We summarize such effects in the presentation of our DID regressions below.

Table 4 presents our DID results for the effects of the targeted voucher reform on school value added and educational inputs.

Table 4: The Effects of the Targeted Voucher Reform

	public	private-voucher
school value added (s.d.)	0.075	0.096*
	(0.040)	(0.046)
multigrade classes (share)	-0.276***	-0.457***
	(0.037)	(0.035)
class size	-1.298*	-7.649***
	(0.546)	(0.703)
pupil-teacher ratio	2.534***	-2.045**
	(0.763)	(0.661)
specialized teachers (share)	-0.124***	-0.054*
	(0.023)	(0.022)
female teachers (share)	0.049*	0.065***
	(0.021)	(0.018)
teachers' experience (years)	4.058***	2.424**
	(1.129)	(0.753)
indefinite contracts (share)	0.033	0.050
	(0.034)	(0.028)
teaching hours per teacher	-1.714*	-3.830**
	(0.704)	(0.584)

Notes:

Next, we examine the contribution of each educational input on the effects of the reform on school value added, by estimating equation (2). Table 5 presents the results.

Table 5: The Contribution of Inputs to School Value Added and to the Program's Effect

	public	private-voucher
multigrade classes	-0.078***	-0.308***
	(0.016)	(0.035)
multigrade classes × post × intensity	-0.157***	0.101
	(0.037)	(0.063)
class size	0.007***	0.015***
	(0.001)	(0.001)
class size × post × intensity	0.008***	0.003
	(0.002)	(0.002)
pupil-teacher ratio	0.006***	0.005***
	(0.001)	(0.001)
pupil-teacher ratio × post × intensity	0.002	0.013**
	(0.004)	(0.005)
specialized teachers	-0.077	0.514***
	(0.050)	(0.033)
specialized teachers × post × intensity	0.087	-0.568***
	(0.088)	(0.077)
female teachers	0.081**	0.178***
	(0.025)	(0.035)
female teachers × post × intensity	0.168**	0.048
	(0.055)	(0.079)
teachers' experience	0.004***	0.005***
	(0.001)	(0.001)
teachers' experience × post × intensity	-0.009***	-0.010***
	(0.002)	(0.003)
indefinite contracts	0.158***	0.253***
	(0.026)	(0.030)
indefinite contracts × post × intensity	-0.182**	-0.262***
	(0.064)	(0.074)
teaching hours per teacher	0.005***	-0.005**
	(0.001)	(0.002)
teaching hours per teacher × post × intensity	-0.004	0.007
	(0.003)	(0.004)

Notes:

4.3.2 The Effects of Program Participation

We now turn to examining the effects of participating in the targeted voucher program on school value added and educational inputs. We first implement the IV model described in equations (3) and (4), to then investigate the contribution of each input to the effect of program participation on school value added, by fitting the interacted IV model of equations (5)–(7).

Table 6 presents the results of the IV regressions for the effects of participating in the targeted voucher program on school value added and educational inputs.

Table 6: The Effects of Program Participation

	first stage	IV estimate
school value added (s.d.)	0.489***	-0.613**
	(0.082)	(0.211)
multigrade classes (share)	0.556***	0.205**
	(0.081)	(0.066)
class size	0.607***	-12.550***
	(0.079)	(2.580)
pupil-teacher ratio	0.583***	-7.233***
	(0.078)	(1.762)
specialized teachers (share)	0.396***	-0.521***
	(0.072)	(0.117)
female teachers (share)	0.548***	-0.090*
	(0.081)	(0.044)
teachers' experience (years)	0.558***	4.961*
	(0.081)	(2.021)
indefinite contracts (share)	0.561***	0.104
	(0.081)	(0.075)
teaching hours per teacher	0.470***	4.861**
	(0.079)	(1.488)

Notes:

As final empirical exercise, we estimate the contribution of each educational input in the effect of program participation on school value added. Table 7 summarizes the estimates from the IV model described by equations (5)–(7).

Table 7: The Contribution of Inputs to School Value Added and to the Effects of Program Participation

	estimate
multigrade classes	0.891
	(2.979)
multigrade classes × participation	-1.337
	(3.243)
class size	0.021***
	(0.005)
class size × participation	-0.009
	(0.006)
pupil-teacher ratio	-0.006
	(0.008)
pupil-teacher ratio × participation	0.031**
	(0.011)
specialized teachers	0.289
	(0.233)
specialized teachers × participation	0.223
	(0.277)
female teachers	-0.440
	(0.430)
female teachers × participation	0.870
	(0.569)
teachers' experience	-0.010
	(0.010)
teachers' experience × participation	0.003
	(0.013)
indefinite contracts	0.059
	(0.394)
indefinite contracts × participation	-0.105
	(0.461)
teaching hours per teacher	0.027
	(0.018)
teaching hours per teacher × participation	-0.038
	(0.022)

Notes:

5 Conclusions

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 (Epple et al., 2017).

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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.
- National standardized exams (SIMCE) for 4th graders, student-level, 2005-2015.
  These data provide information on students' test scores for three different subjects: verbal, mathematics, and either social sciences or natural sciences, depending on the year. They also provide information on students' gender and grade.
- 4th grade SIMCE's questionnaire to parents and tutors, 2005-2015.
  These data consist of 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 choose to respond it every year. It provides information on students' household size, house amenities, and time use, total number of books available in the household, household's 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.

B Event Study

To examine DID dynamics and test pre-trends in the data, we implement the following event study equation,

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

where y_{ist} is the outcome of interest for school i in municipality s in period t, γ_s is a municipality fixed effect, λ_t is a year fixed effect, $A_{\tau t}$ is a year dummy variable, with $\tau = 0$ indicating the year of the introduction of the reform, 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 ε_{ist} is an error term. The coefficients of interest are δ_τ, as they capture versions of the average effects of the targeted voucher reform on treated populations. In the empirical implementation of these regressions, we cluster the standard errors at the municipality level (Bertrand et al., 2004; Cameron and Miller, 2015).

C Additional Tables

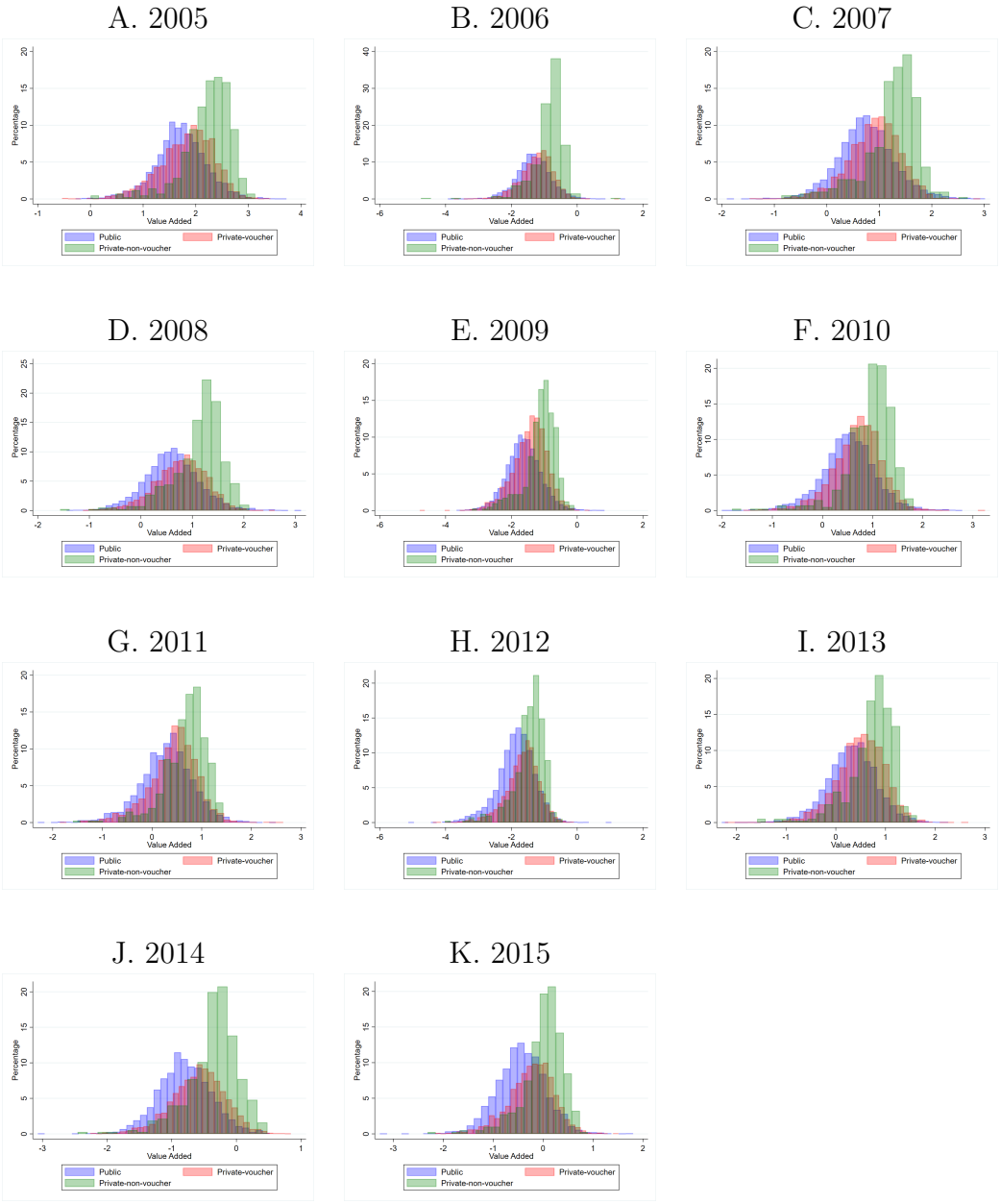
Table C.1: Summary Statistics - Private-non-voucher Schools

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
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)	(20.4)	(58.22)
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)	(0.2)	(0.21)	(0.19)	(0.20)	(0.18)	(0.18)	(0.16)
female teachers (share)	0.76	0.76	0.76	0.77	0.76	0.76	0.76	0.77	0.77	0.76	0.76	0.76
	(0.16)	(0.16)	(0.16)	(0.16)	(0.16)	(0.16)	(0.16)	(0.14)	(0.15)	(0.14)	(0.14)	(0.14)
teachers' experience (years)	14.14	13.89	14.39	14.34	14.42	14.64	14.81	13.59	14.03	13.65	13.63	13.58
	(5.37)	(5.2)	(5.28)	(5.05)	(5.05)	(4.83)	(4.57)	(5.28)	(5.59)	(5.45)	(5.14)	(5.02)
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)
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.

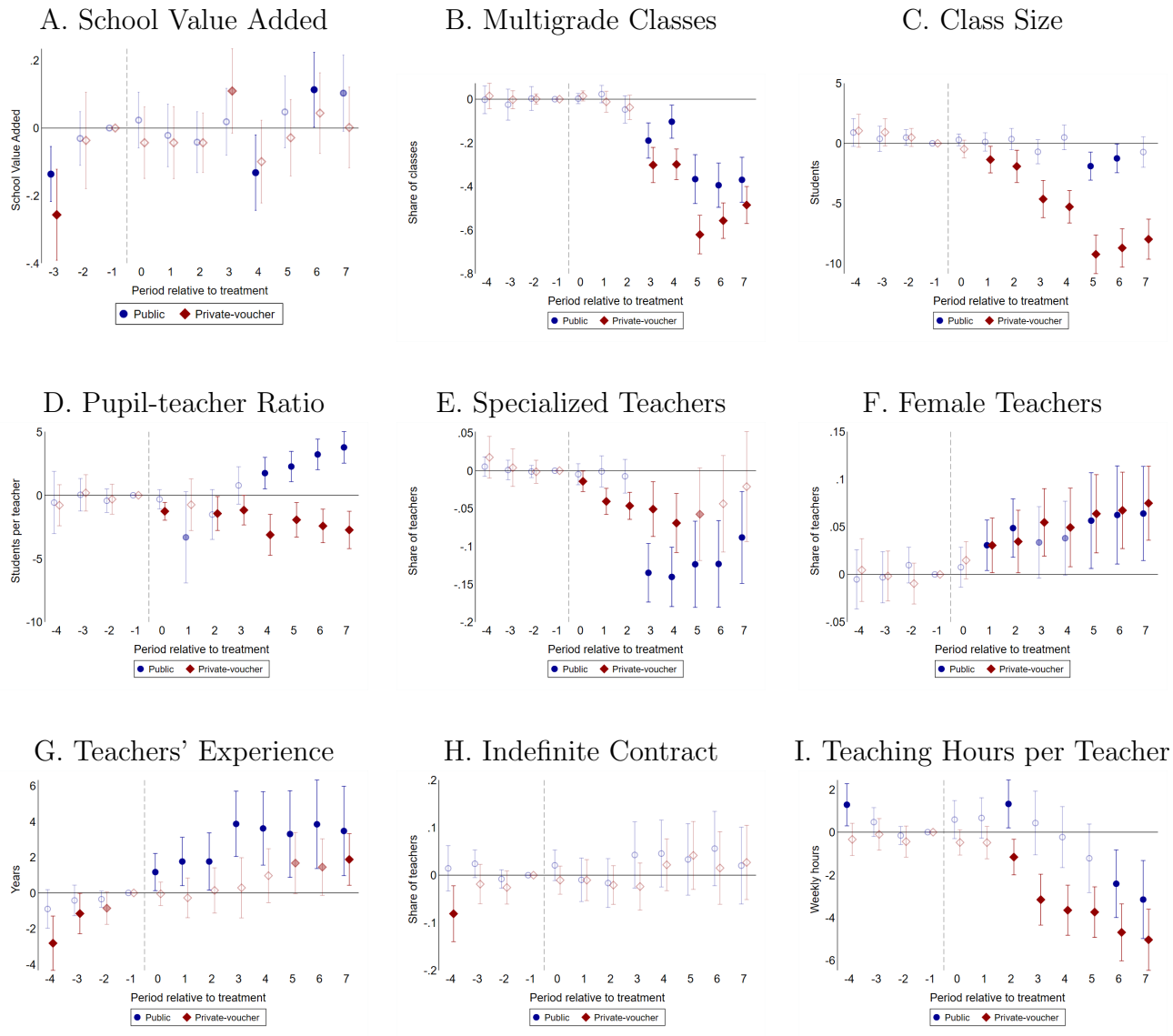
D Additional Figures

Figure D.1: School Value Added Distributions by Year



Notes: School value added is estimated from 4th grade test scores regressions. Each panel shows the distribution of the estimated value added for a particular year, distinguishing between public, private-voucher, and private-non-voucher schools.

Figure D.2: Effects of the Targeted Voucher Program on Public and Private-voucher Schools - Educational Inputs



Notes: Results come from the estimation of event study regressions that use school level data for the period 2004–2015. Each panel shows the effect of the reform on a particular educational input. Point estimates and 95% confidence intervals are presented for public (blue) and private-voucher (red) schools. Hollow circles/diamonds denote statistical insignificance. Light colored circles/diamonds denote statistical significance at the 10% level. Dark colored circles/diamonds denote statistical significance at the 5% level.