# TARGETED VOUCHERS, COMPETITION AMONG SCHOOLS, AND THE ACADEMIC ACHIEVEMENT OF POOR STUDENTS

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Abstract

I develop a model of supply and demand with imperfect competition to study the primary education market in Chile. I use this framework to empirically analyze how voucher policy affects competitive incentives for schools to supply quality. First, I show descriptive and causal evidence that the introduction of a voucher targeted at poorer students led private schools to improve quality, especially in the poorest neighborhoods. Then, I use my estimated demand model to quantify the mechanisms that incentivized for-profit schools to improve. My estimates indicate that schools mark down quality below the competitive benchmark, and this markdown is larger in poorer areas. The targeted voucher policy induced nuanced changes in the two mechanisms that drive the observed improvements in quality in my model : market power and marginal revenue. The results indicate that the policy improved equity by providing more resources and increasing competition in neighborhoods where incentives to invest in quality are weakest.

KEYWORDS: School Choice, School Competition, Targeted Vouchers, Market Power.

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The author wishes to thank the *Departamento de Estadisticas e Informacion de Salud del Ministerio de Salud* (MINSAL) and the *Ministerio de Educacion* (MINEDUC) of the government of Chile for facilitating joint work between government agencies that produced the data from Chile used in this study. The author has no financial interests related to this project to disclose.

# 1. INTRODUCTION

It has been debated whether school choice and competition will be the tide that lifts all boats, or if they will lead to segregation and worse outcomes for poor students.[1] This literature has centered on whether competition between public and private schools can improve outcomes relative to a benchmark of exclusive public provision and limited school choice. However, in many developing countries the private for-profit sector already plays a large role in the provision of education services and state capacity . In this context, the relevant policy question is how to make education markets more efficient and equitable, conditional on private provision and limited state capacity.

In this paper, I study the market for primary education in Chile and focus on the equilibrium supply-side response to voucher policy. I use a model of supply and demand with imperfect competition to design an empirical strategy to evaluate the impact of a large change to voucher policy that considers equilibrium spillover effects. Specifically, I present descriptive and causal evidence that the introduction of a larger voucher targeted at poorer students led to improved school quality, especially in the poorest neighborhoods. I then use my estimated model to quantify the role of competition and school market power in the initial distribution of quality and to explain the observed changes in school quality.

Since 1981 schools in Chile have received a fixed government transfer for each enrolled student. Private schools could also charge an out-of-pocket fee in addition to the government transfer. I call this system a "flat voucher policy" with out-of-pocket fees. I use detailed administrative data on a decade of students and schools to estimate yearly school value-added (quality) and describe how quality varies across schools under the flat voucher policy. I show descriptively that for-profit schools with more resources generally spend more on inputs and have higher value-added, and that both poorer and richer students benefit equally from attending higher value-added schools.

[1] See several excellent review papers such as Neal (2002), Hoxby (2007), Rouse and Barrow (2009), Urquiola (2016), Epple, Romano, and Urquiola (2017).

While out-of-pocket fees are correlated with value-added, schools in richer neighborhoods tend to have higher value-added than schools in poorer neighborhoods even when they receive similar revenues. In this context, out-of-pocket fees and residential segregation could both be contributing to the observed inequality.

Second, I study a policy that aims to increase the academic achievement of poorer students by expanding their access to higher quality schools and providing schools with more resources. In 2008, a new policy eliminated out-of-pocket fees for 40% of the poorest students and significantly increased transfers to schools. I call this system the "targeted voucher policy". I present descriptive and causal evidence that this targeted voucher policy both increased student achievement and improved equity. I show that the effects were driven primarily through the improvement of school quality, especially in the poorest neighborhoods. In addition, my results indicate that, while the increased resources introduced by the policy were important, this mechanism does not explain the entire increase in quality at for-profit schools in the poorest neighborhoods.

Building on these findings that highlight an important supply-side response to the policy, I develop a framework to quantify how the policy changed competitive incentives for schools to improve quality. I specify a model of supply and demand with imperfect competition among schools that incorporates relevant institutional details about the voucher policy in Chile. In my model, consumers have heterogeneous preferences over spatially differentiated schools, as in Hastings, Kane, and Staiger (2009). Departing from most of the school choice literature, I include school-level unobservable demand shifters and implement an empirical strategy that addresses concerns related to the endogeneity of price and quality (Berry and Haile, 2016). On the supply side, the model of school profit maximization highlights the tradeoffs that schools make when they choose quality and price, and how these tradeoffs change in response to the voucher policy.

The model provides three important insights. First, for-profit schools will mark down quality as a function of local market power, which crucially depends on how differentiated schools are in terms of price, distance, and quality. Local market power also depends on how sensitive families are to changes in school quality and other school attributes. The second insight is that the difference in price and quality before and after the policy will be determined by a combination of changing marginal revenue and changing market power. The third insight is that all schools will be affected by the policy regardless of whether they participate, due to increased competition. Similarly, students will also be affected by the policy even if they are not eligible for the new voucher due to spillovers within and across schools. It is an empirical question whether school market power influences school quality, and whether the policy effect operates through this mechanism. To evaluate the relevance of this competitive mechanism, I estimate the demand side of my model using administrative data on over 80% of all urban schools and students in Chile.

My demand estimates indicate that preferences for price, distance and quality are heterogeneous. In particular, more disadvantaged families are significantly more sensitive to price and distance. Given the distribution of estimated preferences and households across city blocks, I find that schools in poor neighborhoods tend to have more local market power. Under a flat voucher policy, this market power allows for-profit schools in poor neighborhoods to mark down their quality more than schools in more affluent areas. I find that significant inequality in the provision of school quality is due to local market power that stems from standard product differentiation and heterogeneity in preferences. This inequality can be explained by differences in competitive pressure, not due to differences in resources or additional education specific market frictions that would likely contribute to additional inequality.

Using the estimated model, I am able to quantify schools' market power both before and after the policy. My model shows that moving to a targeted voucher has two direct effects on the incentives for schools to provide quality. First, the targeted voucher reduces market power by eliminating out-of-pocket fees and reducing differentiation due to prices. Second, the targeted policy increases the marginal revenue from enrolling poor students, raising the optimal quality each school chooses for a given level of market power. My estimated model allows for detailed measurement and analysis of the key mechanisms that drive the change in incentives to provide quality. I show that the change in market power and marginal revenue at the school level captures much of the heterogeneity previously attributed to neighborhood poverty. While revenue increases contribute to improvements in quality, the most improved schools also lost more of their market power, thus helping explain a majority of their improvement through increasing competitive incentives.

These findings are important for several reasons. First, it is important to consider the potential for equilibrium spillover effects from the supply side reaction when studying policy changes in education markets.[2] Policy effects associated with competitive spillovers have the potential to affect all students and schools. This concern is fundamentally an empirical issue. In this application, the estimated model shows that competitive effects are important and influenced schools that did not participate in the targeted voucher program.

My results also provide specific guidance regarding the design of voucher policy. I show *why* a targeted voucher improves academic achievement and reduces inequality relative to a benchmark of flat vouchers and out-of-pocket fees. The flat voucher benchmark was characterized by inequality across poorer and higher income neighborhoods that was due to inequality in resources, but also due to the higher market power schools have in poorer areas. The targeted voucher policy in Chile was successful because it addrressed both factors driving inequality: increasing resources and increasing competitive incentives. This empirical finding is different from the original motivation of the policy and from past research on targeted vouchers. Prior work has emphasized that a targeted voucher can help disadvantaged students make the

[2]This idea is consistent with recent experimental evidence from education markets such as Muralidharan and Sundararaman (2015), Andrabi, Das, and Khwaja (2017). The supply side response to competitive pressure is emphasized by Hoxby (2000, 2003), Card, Dooley, and Payne (2010), Figlio and Hart (2014).

most of a market-oriented education system by expanding access to better schools.[3] This paper shows that, in addition to broadening choice, targeted voucher policies also improve equity by increasing competition in the neighborhoods with the weakest incentives to invest in quality.

More broadly, I show how modeling supply and demand and using the empirical industrial organization toolkit can be useful for quantitatively studying policy in education markets characterized by a large private school sector. My framework highlights how the details of the regulatory environment matter for the incentives schools face, and how these details impact the resulting equilibrium. The fact that my model can rationalize the observed changes in school behavior after the policy change suggests that my empirical framework can be used to conduct ex-ante evaluation of proposed policies in education markets in developing countries.

It is important to note that I restrict my analysis and modeling framework to focus on the most salient aspect observed after the change in policy: the broad increase in achievement among the poorest students without a large change in sorting. This focus allows me to ignore potentially important education-specific market frictions such as selection, cream-skimming, peer effects and asymmetric information. While I argue that these are less relevant in this particular application, future work will need to expand the model to tackle a broader set of policy questions and counterfactuals.[4]

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[3]See Nechyba (2000), Epple and Romano (2008), Bettinger (2011). Early evidence on the positive effects of vouchers leading students to attend different schools includes Rouse (1998) in the U.S. and Angrist, Bettinger, Bloom, King, and Kremer (2002) in Colombia.

[4]For equilibrium effects of information disclosure policies see Andrabi, Das, and Khwaja (2017), Allende, Gallego, and Neilson (2019). For models with school cost heterogeneity see Gallego and Sapelli (2007), Singleton (2017). Dinerstein and Smith (2021) and Sanchez (2018) study the extensive margin supply side responses to policies. For social interactions in demand and the production function see Allende (2020).

## 2. THE MARKET FOR PRIMARY EDUCATION IN CHILE

### 2.1. *History and Background*

Many developing countries have urban education markets characterized by a significant share of private for-profit providers.[5] Chile has subsidized the private provision of educational services in both primary and secondary schools for almost 40 years.[6] The market for educational services in Chile is characterized by three types of providers: public schools owned and managed by the local municipality (public), privately owned and managed schools that are subsidized by the state (private voucher), and privately owned and managed unsubsidized schools (private non-voucher). Over time, the market share of private voucher schools has risen steadily. In 2007 68% of students in urban markets attended private voucher schools, 25% attended public schools, and 7% attended private non-voucher schools.

Public and private voucher schools receive a flat subsidy per student depending on the grade level (∼US$1000 in 2007 for first grade). There are several additional vouchers that are based on the geographic location of the school or whether the student has special needs. In the early 1990s, in an effort to increase overall investment in education, private voucher schools were allowed to charge out-of-pocket fees in addition to the flat government voucher. In 2007, 30% of voucher schools did not charge fees, 48% charged less than US$500, and only 6% charged fees over US$1000.[7]

Unsubsidized private schools represent a very small part of the overall urban market and charge much higher fees. A survey of private schools conducted in 2011 found that the median price at urban private elementary schools was $5,000 in 2012 US dollars. This represents approximately 110% of the annual wage for a fully employed minimum wage worker.

From 1990 until 2007, the basic features of the voucher program did not change, but public spending per student increased by 320% in real terms (8.8% annually). In addition, the government made significant efforts to help the most vulnerable schools by investing in infrastructure and materials with targeted programs like the *Programa*

[5] See Baum, Lewis, Patrinos, and Lusk-Stover (2014) and a discussion in The Economist Magazine titled "The $1-a-week school", published in 2015.

[6] The interested reader is directed to excellent reviews of the initial Chilean voucher reform such as Prieto (1983), Gauri (1999), Mizala and Romaguera (2000) and Beyer, Larraín, and Vergara (2000).

[7] Institutional aid such as scholarships is rare and typically provided to students already enrolled that face temporary hardship or children of staff (Anand, Mizala, and Repetto, 2009).

*MECE* and *P-900*, but there is little evidence that these programs raised academic achievement or reduced inequality (Chay, McEwan, and Urquiola, 2005).

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### 2.2. *Moving from a Flat to a Targeted Voucher Policy*

In 2008, the *Ley de Subvención Escolar Preferencial* (SEP), *Ley 20.248* established a new voucher for the poorest students in Chile. This additional voucher eliminated out-of-pocket fees for poorer students and compensated schools by transferring significantly more resources for each eligible student (∼US$ 500 in 2008). The SEP policy was motivated by the idea that a targeted voucher would remove out-of-pocket fees as a barrier for poor students (Gallego and Sapelli, 2007, Gallegos and Romaguera, 2010). This targeted voucher was seen as a way to help poor students benefit from a market-oriented school system by expanding choice as discussed in Nechyba (2000), Epple and Romano (2008).

The program was available to approximately the poorest 40% of the population. SEP eligibility was determined in several ways, but the two most common were for the student to be accredited as belonging to the lowest 33% of the income distribution according to the government's ranking of socioeconomic status called *Ficha de Protección Social* (FPS) or to belong to the social program for poor families called *Chile Solidario*. These two criteria accounted for 85% of all participants in the SEP program in 2010.

The program was available to all public and private voucher schools. Schools joined the program in large numbers, especially in poor neighborhoods. By 2011, 73% of schools receiving vouchers were participating in the targeted voucher program. Among schools located in neighborhoods in the highest quintile of poverty, 90% of subsidized schools participated. There are two aspects of the SEP voucher policy that are important to clarify. First, eligible students pay no out-of-pocket fees at participating private voucher schools. Second, schools receive the base voucher and an additional SEP voucher regardless of what the school charges other students. From the schools' perspective, eligible students previously generated income for the school from the baseline flat voucher (US$1000) and their out-of-pocket payment (between US$0 and US$1900). After 2008, these students trigger the additional SEP voucher subsidy so that the school receives a larger subsidy from the government but can not charge students the out-of-pocket fee.[8]

The policy also included measures to increase support and accountability at participating schools. These measures included regulations requiring participating schools to provide a written plan regarding how they would use the additional funds and asked them to set goals for themselves. In theory, the regulator would provide guidance and support to implement these plans as well as threaten to remove a school's SEP funding if they did not meet their goals.[9] It is impossible to know how school administrators actually perceived this increased regulatory pressure when the policy began and whether these aspects played an important role. In practice, virtually no schools were sanctioned for not meeting goals, and the government did not invest in the regulatory capacity necessary to implement their stated accountability policies until the passing of the *Ley General de Educación (LGE), Ley 20.370*.[10] In 2011, the SEP subsidy was further increased by 21%. Additional regulatory changes were implemented in the following years including the creation of the *Agencia de Calidad*, an agency in charge of regulating and monitoring school quality.

### 2.3. *The Evolution of Academic Achievement*

There are two primary stylized facts related to the evolution of student-level academic achievement during the period I study. First, average official state-mandated

[8]The law also introduced an extra subsidy of (US$100) for schools that had over 60% of poor students called the *Subvención por Concentración* (SC).

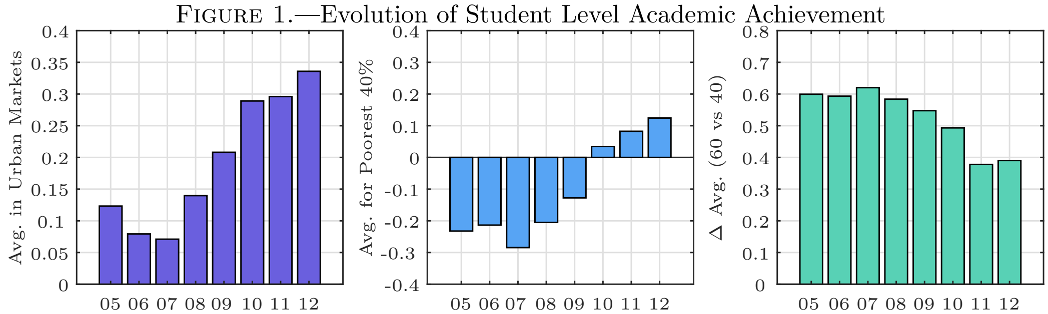
[9]See González, Mizala, and Romaguera (2002) for a rationalization of the provision of resources and the need for additional regulation and support to accompany it.

test scores improved starting in 2008, breaking with many years of stagnation. The growth in average test score was negligible from the baseline year of 1999 through to 2007, but improved by nearly $0.3\sigma$ between 2008 and 2012. There was again negligible variation in average achievement between 2012 and 2016.

Second, the academic achievement gap between students from different socioeconomic backgrounds narrowed significantly. Prior to 2008, students from the poorest 40% of households scored between $-0.2\sigma$ and $-0.3\sigma$ below the baseline average depending on the year and exact definition of poor. The average student in the richest 60% of households had an average score between $0.3\sigma$ and $0.4\sigma$ above the baseline average over the same period.

I present these empirical findings in Figure 1. The left panel shows the rise in average student achievement in urban areas, particularly for the poorest students (middle panel). The right panel shows that the achievement gap between the richest 60% and poorest 40% of students reduced significantly during this period.[11]

FIGURE 1.—Evolution of Student Level Academic Achievement




Note: The left panel shows average math and language test scores in 4th grade for students in urban schools. The middle panel shows the average for the poorest 40% of students. The right panel shows the difference between the average test scores of the richest 60% and the poorest 40% students. Different income definitions provide similar patterns and are presented in Section 4 of the Online Appendix.

[11] Household survey data on income per capita, used for right panel of Figure 1, are only available until 2012, but Section 4 of the Online Appendix shows consistent evidence regarding achievement levels and gaps for the period between 2005 to 2016 using different measures of SES. In each case, achievement gaps were stable between 2005-2007, fell between 2008 and 2012, and since then there have been negligible changes to achievement.

These aggregate effects have been documented by a growing literature studying the SEP policy. A series of papers document the increase in academic achievement and the reduction in inequality.[12]

Murnane, Waldman, Willett, Bos, and Vegas (2017) and Mizala and Torche (2017) argue that the observed improvements in outcomes are a result of additional funding, regulation and support. In contrast, Aguirre (2020) and Feigenberg, Yan, and Rivkin (2019) present a dissenting point of view.[13] Muñoz, Irarrázaval, Keim, Gaete, Jiménez, and Quezada (2020) presents a recent review.

International evaluations, such as the PISA and TIMSS, are broadly consistent with observed increases in learning and academic achievement, and a decline in inequality in Chile during this period. Comparing TIMSS and PISA tests prior to 2008 and after 2011 shows that academic achievement grew substantially, and that the gap between socioeconomic groups declined. Specifically, TIMSS scores in Science and Math averaged close to 405 in 1999 and 2003, but rose to 435 in 2011 and 2015, making Chile one of the countries with the fastest growth during that period.[14] PISA international test scores from 2006 to 2015 also improved at a faster rate in Chile (3.4%) than in the rest of Latin America (2%) or the OECD (0%). A publication by the OECD in 2017 shows that, when comparing 2006 and 2015, Chile was one of the countries that improved the most, both in levels of achievement and also in measures of equity. In particular, Chile had the second largest improvement in equity as measured by PISA.[15]

[12] See for example Henriquez, Lara, Mizala, and Repetto (2012), Correa, Parro, and Reyes (2014).

[13] Feigenberg, Yan, and Rivkin (2019) and Cuesta, González, and Larroulet (2020) cite evidence of selective attendance on the day of the test (to game the testing system) as a potential issue that generates bias in student test scores. I explore these issues in Section 6 of the Online Appendix and conclude the general facts described above are robust to these concerns.

[14] When comparing 8th grade TIMSS results for science and math in 2011 to the previous evaluation in 2003, students from Chile had the 2nd and 4th highest growth out of more than fifty countries evaluated.

[15] On equity see PISA 2015 Table I.6.17. Section 4 in the Online Appendix describes these measures and the evolution of other international test scores over the time period under study.

### 2.4. *Interpreting Changes in Academic Achievement*

There are several possible explanations for the observed reduction of inequality and the sudden growth in academic achievement in Chile's schools. First, conditional on the quality of available schools, the reduction of out-of-pocket fees may have allowed families to choose better schools that they previously considered too expensive, thus expanding their effective choice set. However, administrative data show that the socioeconomic composition of schools remained very similar after the policy was implemented.[16] A second explanation, which is consistent with the lack of sorting, is that schools may have improved their quality, increasing achievement for all students irrespective of their eligibility status for the targeted voucher.

While the supply side seems to play an important role, it is not clear why schools improved. On the one hand, schools may improve due to increased resources that arise from enrolling SEP eligible students. On the other hand, schools may have incentives to raise quality or change prices in order to compete for enrollment and prevent students from choosing other schools. In addition, schools may improve due to increased regulation that accompanied the policy. In the next section I develop an empirical model of demand and supply that explicitly incorporates these mechanisms.

## 3. A MODEL OF SCHOOL CHOICE AND COMPETITION

In this section I develop an empirical model of demand and supply in the primary school market that incorporates voucher policy. On the supply side, my objective is to characterize how spatially differentiated for-profit schools choose price and quality under different voucher policy regimes. On the demand side, my goal is to characterize how families trade off school distance, academic quality, out-of-pocket fees and other school attributes when selecting a school. The challenge is to connect demand and supply with a flexible model that can capture the substitution patterns and school incentives while retaining tractability for the empirical application.

To help decide which school and family characteristics to include in the model, I draw on a survey that asked parents why they chose their school. Evidence suggests that parents in this context value *distance*, *cost* and *academic quality* when choosing a school. To a lesser degree, parents also consider a series of other school attributes such as whether the school is private or public, the *school infrastructure*, and perceived

[16] I estimate the correlation between the share of poor students at each school in 2007 and 2011 to be 0.94 (see Section 4 in the Online Appendix).

*school values*. The relative importance of these school characteristics seems to vary significantly by household income.[17] In the empirical model, the price and academic quality of a school are the two endogenous variables schools can modify, and they are at the center of the demand model. The model allows for heterogeneous preferences for distance, academic quality and the cost. The framework will also be able to capture preferences for persistent school traits that matter to parents but are not easy to measure such as the school's values, prestige, and infrastructure.

### 3.1. *Demand*

A family is indexed by $i$ and characterized by their income level (low, not low) and the mother's education (less than high school, high school, two year degree, or a four year or more degree). Because mothers with at least some postsecondary education are never low income, these two variables define six discrete types of families where $k \in \{1, 2, ..., 6\}$.[18] Each family is located at one of the discrete locations $\text{loc}(i) \in L^m$ within a market $m$. I model the utility for family $i$ from sending their child to school $j$ as a linear function of the school's observable and unobservable characteristics. The observable characteristics include school academic quality $q_j$, which is a measure of how much the school increases students' test scores. Distance from a family $i$ to the school $j$, denoted by $d_{\text{loc}(i),j}$, is another dimension that differentiates schools across families within a market. Out-of-pocket fees $\text{op}_{k(i),j}$ are how much family $i$ has to pay at school $j$ given the prevailing voucher policy and their type $k$.

Observable school characteristics that are fixed over time and parents have common preferences over are summarized in $x_j$. These characteristics include whether the school is for-profit, serves grades K through 12, and has a religious affiliation (catholic or other). As a proxy for reputation, I also include an indicator for each type of school when the school has been in operation since 1995 and if it is only observed in the post period. To capture additional unobserved reasons families may systematically prefer school $j$ over other schools in their market, I model a common preference for a school-specific index $\xi_j$. This term is defined to include fixed school attributes that are unobserved to the econometrician but relevant to school choice independently of

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[17] Parents were asked three reasons why they choose their school: Distance (52%), Academic Excellence (31%), School Values (29%), Cost (27%), and Infrastructure (23%). There is significant heterogeneity by income as well.

[18] Type $k = 1(2)$ if the mother has less than a high school education and the family is low-income (not low); $k = 3(4)$ if the mother has a high school education and the family is low income (not low); $k = 5(6)$ if the mother has a two-year (four-year +) degree and not low-income.

any effect these characteristics have on student learning which is captured by $q_j$. This term can include school attributes such as the principal's charisma, the school's brand name, its stated values, or its school infrastructure.

Finally, to add additional flexibility to the model along the most important dimensions, I allow preferences over school characteristics $\left\{op_{k(i),j}, q_j, d_{\mathrm{loc}(i),j}\right\}$ to be heterogeneous across observable family type $k$. Preferences for quality are also heterogeneous across an unobserved family characteristic $\nu_i$. Families have random iid preference shocks for schools, $\epsilon_{i,j}$. A family $i$'s utility derived from school $j$ is

$$U_{i,j} = \bar{\beta} x_j + \xi_j + \beta_i q_j - \alpha_i \mathrm{op}_{k(i),j} + \lambda_i d_{\mathrm{loc}(i),j} + \epsilon_{i,j}. \tag{1}$$

The heterogeneity of preferences is given by $\beta_i = \sum_{k=1}^{K} \mathbb{1}(k(i) = k)\beta_k + \beta^u \nu_i$ for quality, $\alpha_i = \sum_{k=1}^{K} \mathbb{1}(k(i) = k)\alpha_k$ for price, and $\lambda_i = \sum_{k=1}^{K} \mathbb{1}(k(i) = k)\lambda_k$ for distance. I assume that the distribution of unobservable preferences $\nu_i$ is normal with a zero mean and a variance of $\sigma^2$ so that $\nu_i \sim N(0, \sigma)$. I also assume that the distribution of random preference shocks $\epsilon_{i,j}$ has an extreme-value distribution.

Families choose the school with the highest $U_{i,j}$ out of the $F^m$ schools in their market $m$.[19] Note that there is no outside option, so I choose one school to be the reference for each market and normalize $\xi_{1,m} = 0$ without loss of generality. The share of families of type $k$ who live at location loc who will select school $j$ is

$$s_{j,k}^{\mathrm{loc}}(\mathbf{q}, \mathbf{op}) = \int_{\nu} \left( \frac{\exp\left(\bar{\beta} x_j + \xi_j + \beta_k q_j - \alpha_k \mathrm{op}_{j,k} + \lambda_k d_{\mathrm{loc},j} + q_j \nu\right)}{\sum_{\ell=1}^{F^m} \exp\left(\bar{\beta} x_\ell + \xi_\ell + \beta_k q_\ell - \alpha_k \mathrm{op}_{\ell,k} + \lambda_k d_{\mathrm{loc},\ell} + q_\ell \nu\right)} \right) d\nu, \tag{2}$$

where $\mathbf{q}$ represents a vector of length $F^m$ of school quality and $\mathbf{op}$ is a matrix of size $F^m \times K$ representing the resulting out-of-pocket price for each type $k$ given sticker prices and voucher policy.

[19]This assumption requires all schools in the market to be available to the student. This rules out capacity constraints and selection by schools. I argue in subsection 3.3 that this assumption is reasonable in a developing country education market characterized by private for-profit schools.

I calculate the total demand for a school by aggregating across the demand from students of each type $k$ who live at any of the discrete set of $L^m$ locations within the market $m$. The distribution of where students of type $k$ live is given by the vector $w_k^{\text{loc}}$ so that $\sum_{\text{loc}}^{L^m} w_k^{\text{loc}} = 1$, while the total proportion of the students in the market who are of type $k$ is given by $\Pi_k^m$ so that $\sum_k \Pi_k^m = 1$.

The total market share of students of type $k$ that attend school $j$ is $s_{j,k}$, and the total market share of a given school $j$ is $s_j$, which is given by the following expression

$$s_j(\mathbf{q}, \mathbf{op}) = \sum_k^K \Pi_k^m \sum_{\text{loc}}^{L^m} w_k^{\text{loc}} s_{j,k}^{\text{loc}}(\mathbf{q}, \mathbf{op}). \tag{3}$$

Finally, I group students by whether they are poor and eligible for the SEP policy, so I can write $k = \mathrm{E}$ for all $k$ that are eligible ($k \in 1, 3$) and $k = \not{\mathrm{E}}$ for all $k$ that are not eligible ($k \in 2, 4, 5, 6$).

## 3.2. *Supply*

I now develop an empirical framework to model the conduct of for-profit schools. My first objective is to derive the optimal equilibrium behavior of schools that receive a flat voucher and can charge a copay. I show how market power stems from heterogeneous preferences and product differentiation, and that I can characterize this market power using only demand parameters and information on the distribution of preferences and locations of family types. My second objective is to show how incentives and optimal behavior change as a function of voucher policy, specifically contrasting a flat voucher policy with the targeted voucher policy implemented in Chile. In both cases, I focus on the school's static optimization problem in equilibrium, given the school's fixed characteristics and after having determined prior decisions such as their location, choice of technology, and participation in the government voucher policy.

I begin by assuming that privately owned and administered for-profit schools choose prices and the quality of education they provide to maximize profit. The school chooses a sticker price $p_j$ and an academic quality $q_j$, which represents the school's ability to increase students' test scores. School $j$ has a fixed cost $F_j$ and, after choosing an academic quality level $q_j$, has a marginal cost given by $\mathrm{MgC}(q_j)$.

In general, a voucher policy affects the school's decisions in two ways. First, it changes the marginal revenue a school gets for each student. It also modifies the demand for each school by changing the out-of-pocket expense that families incur by enrolling at an eligible school. I define voucher policy with two functions. The first function maps the school's chosen price $p_j$ and the student type $k$ to a marginal revenue for the school. The second function maps the price chosen by the school and the type of student to an out-of-pocket cost for families.

When the voucher policy is given by a simple flat voucher, the marginal revenue per student is $v_b^m + p_j$ and the out-of-pocket fee is $\text{op}_{j,k} = p_j$, where $v_b^m$ is the base voucher per student in market $m$ and $p_j$ is the out-of-pocket fee. In this case, the school gets a marginal revenue of $v_b^m + p_j$ for each student independent of their type $k$, and each student has to pay $p_j$ independent of their type.[20] Finally, let $F_j$ represent fixed costs for school $j$. I can write the profit function for school $j$ as the sum of the net profit derived from each type of student given the sticker price, quality, and voucher policy:

$$\pi_j\ (\mathbf{q}, \mathbf{p}, V) = \mathrm{N} \sum_k^K \Pi_k^m \sum_{\text{loc} \in L} w_k^{\text{loc}} s_{j,k}^{\text{loc}}(\mathbf{q}, \mathbf{op}) \left[ v_b^m + p_j - \mathrm{MgC}(q_j) \right] - F_j. \tag{4}$$

First consider how schools choose prices when the market is in equilibrium. Schools compare the marginal gain from raising the price to the marginal cost of attracting fewer students. The first order condition with regard to price can be rearranged as

$$p_j^* = \underbrace{\left[ \mathrm{MgC}(q_j^*) - v_b^m \right]}_{\textbf{Competitive Price}} \underbrace{- s_j(\mathbf{q}, \mathbf{op}) \left[ \frac{\partial s_j(\mathbf{q}, \mathbf{op})}{\partial p_j} \right]^{-1}}_{\textbf{Price Markup}\,(\mu_j^p)}. \tag{5}$$

The first term represents the price under perfect competition. Absent market power, the price should be equal to the marginal cost of providing $q_j^*$ minus the subsidy per student $v_b^m$. The second term represents the "markup" of price over marginal cost that schools can charge because of their local market power. The price markup is smaller if the school's market share is more sensitive to its own price changes. Note

[20] In Chile, the voucher policy initially provided a flat voucher for all students at the school regardless of student type. However, it was progressive in the sense that the baseline subsidy $v_b^m$ is reduced as out-of-pocket fees rise based on a step function with four broad fee categories. For simplicity, I assume schools with positive prices are on an interior part of the subsidy step function so that $\frac{\partial v_b^m}{\partial p_j} = 0$.

also that the markup depends on the prices and qualities of all other schools in the market.

Schools have to choose quality by comparing the marginal benefit of attracting more students to the marginal increase in costs of providing higher quality. I specify marginal costs to be a linear function of quality and a vector of school specific cost shifters that are summarized in the vector $\omega_j^g$, so the marginal cost of school $j$ can be expressed as $\text{MgC}(q_j) = c^m + \sum_g c_g \omega_j^g + c_q q_j$. I can derive an expression for a school's quality as a function of its marginal revenue, marginal costs and market power:

$$q_j^* = \underbrace{\left[\frac{1}{c_q}\left(p_j^* + v_b^m - c^m - \sum_g c_g \omega_j^g\right)\right]}_{\textbf{Competitive Quality}} - \underbrace{s_j(\mathbf{q}, \mathbf{op})\left[\frac{\partial s_j(\mathbf{q}, \mathbf{op})}{\partial q_j}\right]^{-1}}_{\textbf{Quality Markdown}\,(\mu_j^q)}. \tag{6}$$

Schools can provide quality with a "markdown" relative to perfectly competitive quality because they have market power[21]:

$$\mu_j^q(\mathbf{q}, \mathbf{op}) = s_j(\mathbf{q}, \mathbf{op})\left[\frac{\partial s_j(\mathbf{q}, \mathbf{op})}{\partial q_j}\right]^{-1} = s_j\left[\sum_k^K \Pi_k^m \sum_{\text{loc}}^{L_m} w_k^{\text{loc}} \frac{\partial s_{j,k}^{\text{loc}}(\mathbf{q}, \mathbf{op})}{\partial q_j}\right]^{-1}. \tag{7}$$

A school's market power depends on the set of competitor characteristics, including price, academic quality and their unobservable $\xi$. Equation 7 also shows that a school's market power depends on the types of students that live near the school and the school characteristics most valued by these households. Note that by setting $v_b^m = 0$ the conditions described here also hold for a for-profit non-subsidized school that does not participate in the voucher program. For these schools, sticker prices are always equal to marginal revenue since they receive no subsidies from the government.[22] The distribution of prices and academic quality provided by for-profit schools will in part reflect local market conditions that could vary both *across* and *within* markets.

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[21] Spence (1975) notes that in a situation where firms with market power choose price and quality, it is possible to have an equilibrium with high prices and over provision of quality. The functional forms I use do not do not force quality markdowns to be increasing in market power, but given that I observe low-to-zero prices in my data, a low quality equilibrium seems more consistent with the data. I assume that this is the prevailing equilibrium in the rest of the paper.

[22] Absent any additional costs or regulation, for-profit schools should (weakly) benefit from participation in a voucher program. In practice, 7% of schools chose to be non subsidized, a decision likely due to the imposed restrictions on maximum prices.

Empirically, these differences in market power stem from the spatial distribution of families and schools and estimated family preferences. In particular, if richer and poorer households differ in the way they trade off out-of-pocket prices, distance and academic quality, schools may face very different incentives depending on where they are located. Before moving to the targeted voucher policy, I define $(\mathbf{q}_0^{\mathrm{e}}, \mathbf{p}_0^{\mathrm{e}}, \mathbf{op}(\mathbf{p}_0^{\mathrm{e}}, V^{\mathrm{flat}}))$ as the academic quality and sticker prices that satisfy each school's first order conditions under the flat voucher system donoted by $V^{\mathrm{flat}}$.

3.2.1. *Supply Incentives Under A Targeted Voucher Policy*

One straightforward way to implement a targeted voucher policy is to provide an additional subsidy $v_{\mathrm{sep}}$ for poor students so that out-of-pocket expenses are $\mathrm{op}_j = 0$ for $k = \mathrm{E}$ and $\mathrm{MgR}(p_j, k, V) = p_j + v_b^m$ for all $k$. In this case the schools' first order conditions are unchanged since they still receive the same marginal revenue for each student. However, price markups $\mu_j^p$ and quality markdowns $\mu_j^q$ would be altered at all schools, whether they participate in the policy or not, for two reasons.

First, the policy changes demand at *all schools* by reducing out-of-pocket prices at participating schools for the subset of eligible students. Given that families care about out-of-pocket fees and not sticker prices, the change in voucher policy affects market power through the change in $\mathrm{op}(p_j, k; V)$. In this simple targeted voucher policy case, "on impact" out-of-pocket fees change instantly leading to a new out-of-pocket fee schedule holding quality and sticker prices fixed as $\mathbf{op}(\mathbf{p}_0^{\mathrm{e}}, V^{\mathrm{flat}}) \rightarrow \mathbf{op}'(\mathbf{p}_0^{\mathrm{e}}, V^{\mathrm{target}})$. This change in out-of-pocket fees will only affect the subset of eligible family types ($k = \mathrm{E}$), but the effects on incentives will spill over to all schools, whether the schools participate in the policy or not, and the effects will vary depending on how much of the relevant demand is eligible for the subsidy and the local market structure. Second, as families and schools adjust to the changing demand induced by the new $\mathrm{op}(p_j, k; V^{\mathrm{target}})$, there will be a new set of equilibrium sticker prices $p_j^*(\mathbf{q}_1^{\mathrm{e}}, \mathbf{p}_1^{\mathrm{e}}, \mathbf{op}_1^{\mathrm{e}})$ and qualities $q_j^*(\mathbf{q}_1^{\mathrm{e}}, \mathbf{p}_1^{\mathrm{e}}, \mathbf{op}_1^{\mathrm{e}})$ at all schools, which will again affect price markups $\mu_j^p$ and quality markdowns $\mu_j^q$. It is important to note that all schools, whether public, private subsidized or private non subsidized, can be affected regardless of whether they participate in the policy, but the effect will vary depending on how demand and supply react to the new conditions.

The actual implementation of targeted vouchers in Chile is slightly different, as it transfers an additional amount $v_{\text{sep}}$ to the school regardless of the sticker price. This introduces a wedge between the additional voucher and the sticker price for schools that participate in the policy. Under the simple targeted voucher policy as well as in the SEP policy, out-of-pocket prices are zero ($\text{op}_{i,j} = 0$) for all eligible students independent of the sticker price $p_j$. However, what is different is that marginal revenue is fixed at $\text{MgR}(p_j, k, V) = v_b^m + v_{sep}$ for $k = \text{E}$ and continues to be $\text{MgR}(p_j, k, V) = p_j + v_b^m$ for all $\not{\text{E}}$. This slight difference severs the link between the marginal revenue a school gets for each eligible student and $p_j$ given $\frac{\partial \text{op}_j}{p_j} = 0$ for $k = \text{E}$. Once the link between first order conditions and prices is broken, schools that participate in the targeted voucher program have different first order conditions and the model generates different predictions for equilibrium outcomes. I present modified equations for $p_j^*(\mathbf{q}_1^{\text{e}}, \mathbf{p}_1^{\text{e}}, \mathbf{op}_1^{\text{e}})$ and $q_j^*(\mathbf{q}_1^{\text{e}}, \mathbf{p}_1^{\text{e}}, \mathbf{op}_1^{\text{e}})$ under the new SEP policy below.[23]

$$p_{j,1}^* = \left[ c^m + \sum_l c_l \omega_j^l + c_q q_{j,1}^* - v_{b,1}^m \right] - s_{j,\not{\text{E}}}(\mathbf{q}_1^{\text{e}}, \mathbf{op}_1^{\text{e}}) \left[ \frac{\partial s_{j,\not{\text{E}}}(\mathbf{q}_1^{\text{e}}, \mathbf{op}_1^{\text{e}})}{\partial p_{j,1}} \right]^{-1}. \tag{8}$$

The key difference in the pricing equation is that, given $\frac{\partial \text{op}_j}{p_j} = 0$ for $k = \text{E}$, eligible families play no direct role in determining the sticker price at a school. The policy changes prices through a new markup term that is a function only of ineligible families. These families are presumably less price sensitive and thus should push prices upward. Prices might also rise if $q_j^*$ rises, since increasing school quality raises marginal costs. Eventually, prices may go down if the school's local market power falls in the new equilibrium $(\mathbf{q}, \mathbf{op})$, when competitors are less differentiated by prices and have higher $q_j$ leading the school to price more aggressively.

Equation 9 shows that academic quality can again be described by a competitive quality minus a markdown term that captures how sensitive demand is to changes in the school's quality. However, now the new competitive quality is determined by

[23] I develop the schools' optimization problem in Section 7 of the Online Appendix.

the total voucher size $v_b^m + v_{\text{sep}}$, with a correction based on the difference between the additional targeted voucher and the price ineligible students pay $(v_{\text{sep}} - p_j)$. This term captures the lower marginal revenue coming from ineligible students when quality improves $(v_{\text{sep}} - p_{j,1})$. While the base voucher and the additional targeted voucher provide resources that shift academic quality up, if the relevant demand faced by the school is composed mostly of ineligible students, the school will get less resources as it improves its academic quality because the marginal student is likely to provide $p_j$ and not $v_{\text{sep}}$,

$$q^*_{j,1} = \left[\frac{1}{c_q}\left(v^m_{b,1} + v_{\text{sep}} - c^m - \sum_l c_l \omega^l_j\right)\right] - \mu^q_j - \left[\frac{v_{\text{sep}} - p_{j,1}}{c_q}\right]\left[\frac{\partial s_{j,\not{\mathrm{E}}}}{\partial q_{j,1}}\right]\left[\frac{\partial s_j}{\partial q_{j,1}}\right]^{-1} \tag{9}$$

Now comparing across two equilibria, $(\mathbf{q}^{\mathrm{e}}_0, \mathbf{p}^{\mathrm{e}}_0, \mathbf{op}^{\mathrm{e}}_0) \rightarrow (\mathbf{q}^{\mathrm{e}}_1, \mathbf{p}^{\mathrm{e}}_1, \mathbf{op}^{\mathrm{e}}_1)$, we can decompose the difference in the equilibrium quality provided at a school $j$ is

$$\begin{aligned} q^{\mathrm{e}}_{j,1} - q^{\mathrm{e}}_{j,0} = s_j(\mathbf{q}^{\mathrm{e}}_0, \mathbf{op}^{\mathrm{e}}_0)\left[\frac{\partial s_j(\mathbf{q}^{\mathrm{e}}_0, \mathbf{op}^{\mathrm{e}}_0)}{\partial q_{j,0}}\right]^{-1} - s_j(\mathbf{q}^{\mathrm{e}}_1, \mathbf{op}^{\mathrm{e}}_1)\left[\frac{\partial s_j(\mathbf{q}^{\mathrm{e}}_1, \mathbf{op}^{\mathrm{e}}_1)}{\partial q_{j,1}}\right]^{-1} \\ + \left[\frac{v^m_{b,1} - v^m_{b,0}}{c_q}\right] + \left[\left[\frac{v_{sep} - p^{\mathrm{e}}_{j,0}}{c_q}\right]\left[\frac{\partial s_{j,\mathrm{E}}(\mathbf{q}^{\mathrm{e}}_1, \mathbf{op}^{\mathrm{e}}_1)}{\partial q_{j,1}}\right] + \left[\frac{p^{\mathrm{e}}_{j,1} - p^{\mathrm{e}}_{j,0}}{c_q}\right]\left[\frac{\partial s_{j,\not{\mathrm{E}}}(\mathbf{q}^{\mathrm{e}}_1, \mathbf{op}^{\mathrm{e}}_1)}{\partial q_{j,1}}\right]\right]\left[\frac{\partial s_j(\mathbf{q}^{\mathrm{e}}_1, \mathbf{op}^{\mathrm{e}}_1)}{\partial q_{j,1}}\right]^{-1} \end{aligned} \tag{10}$$

Equation 10 shows that the difference in equilibrium academic quality at school $j$ is driven by two forces. The first is the change in market power. Recall that a school can mark down quality relative to the competitive benchmark by an amount given by $\mu = s_j\left[\frac{\partial s_j}{\partial q_j}\right]^{-1}$. As the new policy reduces out-of-pocket fees for some students at some schools, part of the observed changes in quality can be attributed to the change in the mark down across the two equilibria given by $\Delta\mu = \mu(\mathbf{q}^{\mathrm{e}}_0, \mathbf{op}^{\mathrm{e}}_0) - \mu(\mathbf{q}^{\mathrm{e}}_1, \mathbf{op}^{\mathrm{e}}_1)$. Take for example a school with an initial zero out-of-pocket fee $p_{j,0} = 0$ in the baseline equilibrium under a flat voucher. The moment the targeted voucher policy is implemented, this type of school will unambiguously lose market power as more expensive competitors become more affordable due to the policy. Other schools who had higher prices and participate in the program may become more attractive initially but regardless of the initial effect, the resulting outcome will also depend on the new equilibrium quantities of prices and quality as well.

The second force that leads to a change in academic quality is the change in marginal revenue the school obtains when quality improves. Recall that the policy induces a wedge between marginal revenue provided by an eligible student $(v_{sep} + v_b^m)$ and an ineligible student $(p_j + v_b^m)$ where $v_{sep} >= p_j$. The second line of Equation 10 shows that the change in quality depends on a weighted average of the change in marginal revenue stemming from eligible and ineligible students. The first term shows the difference between the SEP subsidy and the previous price $(v_{sep} - p^{\mathrm{e}}_{j,0})$, weighted by how sensitive demand from *eligible students* is to quality at that school. The second term on the same line shows that the change in quality also depends on the difference between the new price and the old price, $(p^{\mathrm{e}}_{j,1} - p^{\mathrm{e}}_{j,0})$, again weighted by how sensitive demand from ineligible students is to quality.

As for prices, the change in policy leads to a change in prices driven partly by the increase in costs due to changes in quality and the changes in market power:

$$p^{\mathrm{e}}_{j,1} - p^{\mathrm{e}}_{j,0} = s_j(\mathbf{q}^{\mathrm{e}}_0, \mathbf{op}^{\mathrm{e}}_0) \left[ \frac{s_j(\mathbf{q}^{\mathrm{e}}_0, \mathbf{op}^{\mathrm{e}}_0)}{\partial p_{j,0}} \right]^{-1} - s_{j,\not{\mathrm{E}}}(\mathbf{q}^{\mathrm{e}}_1, \mathbf{op}^{\mathrm{e}}_1) \left[ \frac{\partial s_{j,\not{\mathrm{E}}}(\mathbf{q}^{\mathrm{e}}_1, \mathbf{op}^{\mathrm{e}}_1)}{\partial p_{j,1}} \right]^{-1} + v^m_{b,0} - v^m_{b,1} + c_q \left( q^{\mathrm{e}}_{j,1} - q^{\mathrm{e}}_{j,0} \right). \tag{11}$$

The policy leads participating schools to choose sticker prices considering only the ineligible students. If these families are less price elastic, the new policy will push prices higher. Higher quality levels will increase marginal costs, which will push towards higher prices as well. At the same time, a more competitive environment, with smaller markups and markdowns, can lead schools to price more aggressively, leading them to eventually have lower prices.

The effect on prices and quality in the new equilibrium is generally ambiguous and is an empirical issue which depends on a variety of factors. However, schools that had zero out-of-pocket prices in the pre-policy period would likely increase their academic quality due to the increase in transfers from eligible students and increased competition from schools with higher quality. These forces would be magnified in neighborhoods with a higher concentration of eligible students $w_{\mathrm{E}}$ and thus is where we are likely to see the biggest changes in markdowns, marginal revenue and increases in quality. Note that $\mu(\mathbf{q}^{\mathrm{e}}_0, \mathbf{op}^{\mathrm{e}}_0)$ and $\mu(\mathbf{q}^{\mathrm{e}}_1, \mathbf{op}^{\mathrm{e}}_1)$ are possible to construct in the data with only the estimated demand parameters and the data on families and schools.

### 3.3. *Modeling Limitations*

I have made several assumptions in order to derive my empirical model of school application these limitations are less problematic and allow for a parsimonious model that provides useful insights.

One important assumption is that unobservable preferences for quality are not correlated with residential location. I estimate the model using data both before and after the policy change, and I require that families chose their location before knowing about the policy and do not change location in the next five years as a result of the policy change. Second, I assume that families are fully aware of all the schools in the market and their characteristics. A lack of awareness is likely to induce downward bias in the estimated preferences for school quality, but my approach will accurately capture the tradeoffs schools face when they decide price and quality. I further assume that students can attend any school in their market, ruling out selection and capacity constraints. While some schools may have excess demand and reject students, I argue this is not common in the Chilean education market and rather it is prices, distance, and residential segregation that drive inequality in school choice. First, regulation during this period makes it illegal for voucher schools to select students at the primary level. I see limited evidence in the data for capacity constraints or selection.[24] Finally, for-profit schools can eliminate excess demand by raising prices or lowering their quality, and over time can expand capacity or open new locations. Therefore, it is unlikely that a significant number of schools will have excess demand in equilibrium. This assumption is more restrictive following a large policy change, so I avoid using data from years immediately after the policy change when I estimate my model.

[24] While the legal class size limit is 45 students (established in *Decreto 8144, 1980*), this cap binds in only 2% of urban primary schools. In 2009, parents of fourth grade students were asked the main reasons why they chose their current school and only 2% indicated they prefered another school but had been turned away.

# 4. DATA AND URBAN SCHOOLING MARKETS

## 4.1. *Schools and Students*

I use administrative records from the Ministry of Education of the Chilean government (MINEDUC) on all schools in the country from 2005 to 2016. These data provide information on aggregate matriculation by grade level, the address of each school, and other school characteristics such as the type of administration. I also use data on government transfers to public schools and voucher schools. These data indicate the source of funding and the amount transferred to each school for each month. Since voucher transfers depend on school characteristics, these data also include information on the average out-of-pocket price charged to non-SEP students and whether the school is a recipient of the SNED achievement prize.

I use administrative panel data from 2005 to 2016 on all students in Chile. These data record the school each student attended each year, as well as information on grades and basic demographics. They also include students' eligibility for the SEP targeted voucher starting in 2008. This dataset contains addresses for a subset of students, which I geocode to the nearest census block.

I also use student birth records from the Ministry of Health. This database covers all births in the country after 1992 and includes 97% of all students enrolled in first grade during my sample period. These data contain information on the health conditions of a child at birth such as birth weight, birth length and gestation. They also include demographic information about the child's parents, as well as administrative education information on the mother. My final source of student data is the SIMCE test and associated household surveys.[25]

The resulting student-year level dataset of first grade students contains almost 2 million student-year observations. I use this dataset to calculate market shares and to characterize student choices.[26] I use the same panel dataset to track students from first

[25]Birth record data is described in Bharadwaj, Eberhard, and Neilson (2018). College entrance exam data was collected from archival records as part of the *Proyecto 3E* (Beyer, Hastings, Neilson, and Zimmerman, 2015).

[26]Students are classified into types based on whether they are poor as defined by eligibility for the SEP targeted voucher (44% Poor, 56% Not Poor for first grade students in 2011) and the highest level of

grade through fourth grade (when they take standardized tests). This fourth grade test score dataset contains 1.5 million observations and covers 90% of all students. 97% of these observations have a full set of covariates based on birth record family demographics, employment and health.

### 4.2. *Urban Markets in Chile*

In this application, I define education markets using a combination of aggregate administrative data on schools, microdata on the population of students, and individual level census block data. I define an urban education market by six features. Each market has a geographic boundary (a polygon) described by $B^m$. I join all areas classified as urban by the Chilean Census that are two kilometers apart or less at their closest point. I define the union of all connected urban areas as one market under the assumption that students could feasibly travel within this set of urban areas.

I add a one-km buffer zone around the edge of each market since some schools locate at the edge of urban areas to lower costs. The second feature of a market is a set of schools $F^m$ that are located within the market boundary defined by $B^m$. I divide each market into a set of locations $L^m$ spread evenly within the boundaries $B^m$ of the market at five block intervals. These locations help capture heterogeneity within the market by aggregating the census block level data to a fixed grid of locations. I define the student population in each market as a set of $S^m$ students of $K$ observable types. Students can live at any of the $L^m$ locations inside the market. I assign students to a market based on the school they attend (which is included in the administrative data for all students). Each market has a vector $\Pi^m = \{\Pi_1, \Pi_2, ..., \Pi_K\}$ of length $K$ that contains the shares of each type of student, and $\sum_k^K \Pi_k^m = 1$ for each market $m$. I calculate these shares from the microlevel population data for all students in each market each year.

Finally, the sixth aspect that defines a market is the distribution of student types across nodes within each market described by $w_k^{\text{loc}}$, which indicates what share of students of type $k$ live at a specific location. The Chilean census provides detailed block-level data on every urban area and thus on every market in my analysis. I approximate the distribution of student characteristics at each node by aggregating block-level census information. I then use these covariates and a sample of students for whom SEP eligibility is known to infer the density of students at each node,

education their mother had achieved when she gave birth (32% less than high school, 43% high school, conditional on mother's education and SEP eligibility.[27] This density at loc given student type $k$ is $w_k^{\text{loc}}$, such that $\sum_{\text{loc}\in L^m} w_k^{\text{loc}} = 1$. I assume this density is fixed across time.

The final sample of markets is limited to urban areas with at least five elementary schools, at least 500 students in the first grade, at least one private voucher school, and with available geolocated student microdata. This defines 53 markets that contain over 3,600 schools and over 80% of all urban students in first grade in each year between 2005 and 2016. The resulting school-year level database contains prices, government transfers, local SEP exposure, and characteristics of teachers working there from 2005 to 2016.[28]

This market definition is useful for several reasons. First, this micro level structure does not require knowing where all families live, just the joint distribution of family types conditional on block characteristics. Second, aggregating at the level of equidistant nodes instead of unevenly sized blocks keeps the estimation step manageable by reducing the dimensionality. Finally, this structure allows for a detailed characterization of the within market heterogeneity and local market conditions schools and students face. This heterogeneity can be very important; in particular, if households are very sensitive to distance, then competition will be extremely local.

One important aspect of within-market heterogeneity is the concentration of SEP eligible students that live near schools in each part of the city. I calculate the percent of SEP eligible students that are within 0.5km and I categorize schools into quintiles based on this measure. The highest quintile has an average of 70% of students who will become eligible, while schools located in the richest areas have an average of 20% of students who will become eligible for the SEP voucher.

[27] I use node-level covariates and the students' mothers' education to predict their SEP eligibility with a random forest. I then extrapolate, conditional on a level of mother's education, the proportion of SEP-eligible students at each node in my broader sample. Combining this proportion with the population density at each node allows me to estimate $w_k^m$. See details in the Online Appendix.

[28] Sections 1 and 2 of the Online Appendix provide details about data sources and market construction.

## 5. DESCRIPTIVE EVIDENCE ON ACADEMIC QUALITY AND VOUCHER POLICY

### 5.1. *Estimating Measures of Academic Quality*

I define the relationship between test scores $y_{ijt}$, student characteristics, and each school's ability to increase test scores, $q_{jt}$, as

$$y_{i,j,t} = q_{j,t} + X_{i,t}\gamma + e_{i,j,t}. \tag{12}$$

$X_{i,t}$ is a large vector of observable individual student characteristics and $e_{i,j,t}$ is a random iid shock to test scores. Student characteristics include health information at birth, the demographic composition of the families, parents' employment and educational levels as well as mothers' math and language college entrance exam scores. The estimated value of $q_{j,t}$ represents the school fixed effect and is the component of the average test score for each school that is not explained by the individual characteristics of its students. This term will capture unobserved school inputs such as teacher quality, infrastructure, and any other school-specific characteristics that raise the average test score.

TABLE I

ESTIMATED PRODUCTION FUNCTION - SELECTED COEFFICIENTS

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Mother High School | 0.29 (0.00) | 0.24 (0.00) | 0.24 (0.00) | 0.24 (0.00) | 0.21 (0.00) | 0.21 (0.00) |
| Mother Technical | 0.42 (0.01) | 0.34 (0.00) | 0.34 (0.00) | 0.26 (0.01) | 0.23 (0.00) | 0.23 (0.00) |
| Mother College | 0.55 (0.01) | 0.47 (0.00) | 0.47 (0.00) | 0.27 (0.01) | 0.23 (0.00) | 0.23 (0.00) |
| Male | -0.02 (0.00) | -0.05 (0.00) | -0.05 (0.00) | -0.04 (0.00) | -0.06 (0.00) | -0.06 (0.00) |
| Mother Age $> 35$ | | | | 0.14 (0.01) | 0.12 (0.00) | 0.11 (0.00) |
| Mother High Math Score | | | | 0.16 (0.01) | 0.18 (0.01) | 0.18 (0.01) |
| Parents Married | | | | 0.05 (0.00) | 0.04 (0.00) | 0.05 (0.00) |
| Low Birth Weight $< 3$kg | | | | -0.07 (0.01) | -0.06 (0.00) | -0.06 (0.00) |
| First Born | | | | 0.13 (0.00) | 0.10 (0.00) | 0.10 (0.00) |
| Additional controls (50) | | | | ✓ | ✓ | ✓ |
| FE Type (xSchool) | Year | Year | Group | Year | Year | Group |
| $R^2$ | 0.30 | 0.31 | 0.27 | 0.31 | 0.32 | 0.28 |
| N Obs | 566,912 | 2,166,941 | 1,808,410 | 561,096 | 2,048,694 | 1,693,104 |

Note: This table presents selected covariates; the full table in Section 5 of the Online Appendix contains all of my covariates. Columns (1) and (4) use only the subsample before the SEP policy (2005 to 2007), columns (2) and (5) use all the available years (2005 to 2016), and columns (3) and (6) also use all the available years, estimating fixed effects by group of years (2005–2007, 2010–2012 and 2014–2016). Additional controls include SES, health and geographic controls. All listed coefficients are statistically significant at the 1% level and have $\sigma < 0.01$.

Table I presents results that are largely consistent with prior research. It shows that socioeconomic status, parents' education, and health at birth are all important predictors of later life outcomes including academic success.[29] Birth weight, birth length and weeks of gestation are all significantly related to test scores, even after controlling for school and year fixed effects, as well as many other demographic characteristics. In addition, both parents' education levels have significant and large coefficients. Students whose mother took the college entrance exam and scored above average went on to score almost 3 standard deviations higher themselves.

Private voucher schools have consistently higher estimated value-added than public schools, and private non-voucher schools have much higher value-added than either.[30] More salient is the significant heterogeneity in estimated value-added within each type of school. In 2007, the difference between the 25th and 75th percentile of the estimated school value added was $1.04\sigma$ among public schools and $1.23\sigma$ for private voucher schools. Estimated value added varies substantially across private voucher schools; 22% had lower value added than the median public school in their market.

The heterogeneity in estimated school value-added is significantly correlated with differences in resources and inputs, which is consistent with the fact that schools can choose to charge co-payments. Detailed data on school expenditures are available starting in 2013 and show that over 80% of expenses are teacher salaries. Using this data, the second panel of Figure 2 shows a clear positive relationship between average spending on teachers and the estimated value-added, especially for private voucher schools.

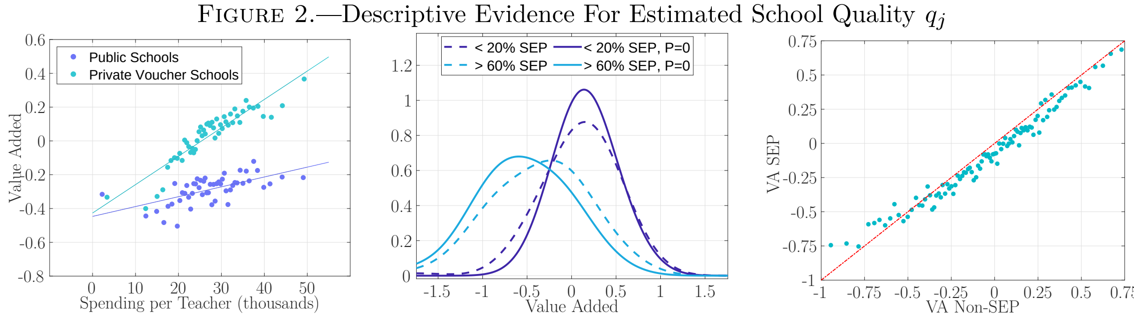
The variation in value-added is also explained by neighborhood characteristics. Even schools with no co-pay will systematically vary in value-added depending on whether they are located in a poorer or richer neighborhood. For example, private voucher schools in neighborhoods with more than 60% of SEP eligible students had an average estimated value-added of $-0.36\sigma$ in 2007. The same type of school in neighborhoods with less than 20% of SEP eligible students had an average value-

[29]See Currie and Almond (2011) for examples. Bharadwaj, Eberhard, and Neilson (2018) show that health outcomes at birth are systematically correlated with academic outcomes in Chile.

[30]In 49 of 53 markets (92%), the median private voucher school had higher value-added than the median public school.

added of $0.09\sigma$, representing a $0.45\sigma$ difference in standardized value-added depending on the location of the school. The middle panel of Figure 2 shows the distribution of value-added for private voucher schools prior to the SEP policy in both high- and low-poverty areas (dotted lines), as well as for schools that have zero out-of-pocket fees (solid lines).

FIGURE 2.—Descriptive Evidence For Estimated School Quality $q_j$




Note: The panel on the left shows a binscatter plot with average expenditure on teachers in 2014 on the x-axis, (at voucher schools (■) and public schools (■) and value-added on the y-axis. The middle panel shows the distribution of school value-added in 2005–2007 for schools with a high % of eligible students $\mathtt{E}$ nearby (■) and with very a low % of eligible students (■). Solid lines indicate the distribution conditional on having $p_j = 0$ and dotted lines include all schools. The right panel compares value-added at each school in 2011 estimated using only data on $\cancel{\mathtt{E}}$ students (x-axis) and only data on $\mathtt{E}$ students (y-axis).

Increasing resources and investment at a school could produce improvements for some students but not others, if these improvements can be targeted to students with a higher marginal revenue for the school. To explore this possibility I estimate the value-added for each school using only SEP eligible students and compare that estimate to the value added estimated using only non-SEP eligible students. The right panel of Figure 2 shows a strong correlation between these two estimates of school academic quality, indicating that improvements in academic quality seem to have spillover effects to all students within the school, independent of how much revenue individual students are worth. In addition, this result suggests that schools choose one level of academic quality for all students.[31]

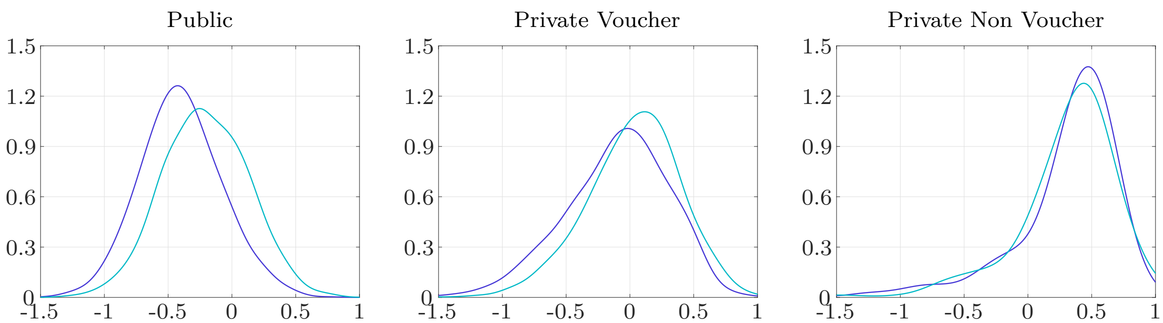
### 5.2. *Decomposing Sorting and School Improvement*

I find that on average, value-added increases at both public and private voucher schools, but there is no change in the non-voucher private sector. Public schools

[31]Section 5 of the Online Appendix presents further analysis on inputs and value-added.

improved evenly across the distribution, with an average increase of $0.16\sigma$. Private voucher schools increased their quality by $0.12\sigma$ on average, with the largest changes coming from the bottom of the quality distribution. Figure 3 plots the distribution of value added conditional on the type of school for the pre and post-policy periods (2005–2007 and 2010–2012).

FIGURE 3.—Distribution of Estimated School Quality




Note: This figure shows the distribution of school value-added in the pre-policy period 2005–2007 ( ■ ) and the post-policy period 2010–2012 ( ■ ). Estimates correspond to Column (6) in Table I.

The model predicts that the overall effect of the policy on inequality will be a combination of the effects from both students sorting and schools adjusting. I can decompose the contribution of both sorting and changes in school quality to explain the evolution of the gap in access across richer and poorer students by using the estimated value-added and the microdata on the population of all students to measure shares. Letting $\Delta\overline{q}^{\cancel{\mathrm{E}},\mathrm{E}}(\mathbf{q}_1^{\mathrm{e}},\mathbf{p}_1^{\mathrm{e}},\mathbf{op}_1^{\mathrm{e}}) = \Delta\overline{q}_1^{\cancel{\mathrm{E}},\mathrm{E}}$ and $\Delta\overline{q}^{\cancel{\mathrm{E}},\mathrm{E}}(\mathbf{q}_0^{\mathrm{e}},\mathbf{p}_0^{\mathrm{e}},\mathbf{op}_0^{\mathrm{e}}) = \Delta\overline{q}_0^{\cancel{\mathrm{E}},\mathrm{E}}$, I group students by SEP eligibility and can write how the gap in average student achievement changes as

$$\Delta\overline{q}_1^{\cancel{\mathrm{E}},\mathrm{E}} - \Delta\overline{q}_0^{\cancel{\mathrm{E}},\mathrm{E}} = \sum_{j}^{F_m} \left[ q_{1,j}^{\mathrm{e}} \left[ s_{j,\cancel{\mathrm{E}}}(\mathbf{q}_1^{\mathrm{e}},\mathbf{op}_1^{\mathrm{e}}) - s_{j,\mathrm{E}}(\mathbf{q}_1^{\mathrm{e}},\mathbf{op}_1^{\mathrm{e}}) \right] - q_{0,j}^{\mathrm{e}} \left[ s_{j,\cancel{\mathrm{E}}}(\mathbf{q}_0^{\mathrm{e}},\mathbf{op}_0^{\mathrm{e}}) - s_{j,\mathrm{E}}(\mathbf{q}_0^{\mathrm{e}},\mathbf{op}_0^{\mathrm{e}}) \right] \right]. \quad (13)$$

The narrowing of the gap in school value-added is very similar to the shrinking gap in student-level test scores across ineligible and eligible students documented in Figure 1. In 2007 $\Delta\overline{q}_0^{\cancel{\mathrm{E}},\mathrm{E}} = 0.31$ and in 2011 $\Delta\overline{q}_1^{\cancel{\mathrm{E}},\mathrm{E}} = 0.19$ for students in 4th grade who took the test. I use Equation 13 to decompose this difference into changes in shares across groups due to student sorting and due to changes in school quality. First, I hold fixed the school quality of the pre-policy period (2007), but use the shares observed in the post-policy period data (2011) and find that there is a reduction in the gap in school value added of $-0.04$. Second, I hold shares observed in the pre-policy period (2007) fixed but take the post-policy estimated school quality to recalculate the differences and find a change in the gap in value added of $-0.10$. Since the total effect in the reduction of the gap across types of students is approximately 0.12, this exercise suggests that the majority of the observed changes in academic achievement observed by 2011 are driven by changes to school quality and not by students sorting to different types of schools.

## 6. POLICY EFFECTS OF THE TARGETED VOUCHER ON ACADEMIC QUALITY

### 6.1. *School Exposure to SEP and Academic Quality*

The model indicates that exposure to the targeted voucher policy will likely be mediated by the concentration of eligible students near the schools. This insight suggests that one can estimate the causal impact on school quality with a difference-in-differences estimator that uses the heterogeneity in the predetermined proportion of eligible students near each school as a measure of policy exposure.[32]

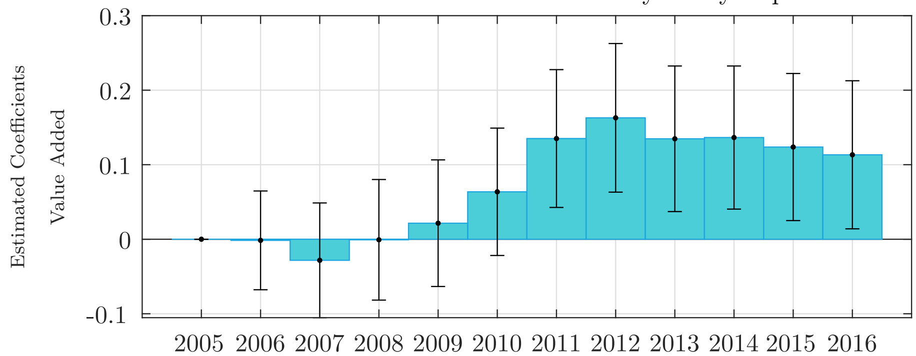
Specifically, I run a difference-in-differences regression described in Equation 14, exploiting time and cross-sectional variation across schools in neighborhoods with the highest fraction of eligible students and schools in neighborhoods with the lowest fraction of eligible students (see Section 4). I keep schools in the top and bottom quintile of exposure to SEP eligible students and estimate the difference-in-differences model where the dummy variable High Exposure$_j$ takes the value 1 if school $j$ is in the top quintile and 0 if school $j$ is in the bottom quintile. $\mathrm{D}_y(t)$ is a dummy variable that takes the value of 1 if $y = t$ and 0 otherwise. $\psi_{2,t}$ is the difference between high and low exposure to the policy in each year relative to 2005 which I fix as the baseline year. The coefficients $\psi_{3,t}$ denote year fixed effects for 2006 to 2016.

$$\hat{q}_{j,t} = \psi_0 + \psi_1 \cdot \text{High Exposure}_j + \sum_{y=2006}^{2016} \mathrm{D}_y(t) \cdot \text{High Exposure}_j \cdot \psi_{2,y} + \sum_{y=2006}^{2016} \mathrm{D}_y(t) \cdot \psi_{3,y} + \varepsilon_{j,t}, \tag{14}$$

[32]This spatial strategy is similar to the research design in Card, Dooley, and Payne (2010), where school choice was made available to Catholic schools, so that exposure to the competitive effects of the policy were associated with the share of Catholic students near a school prior the policy.

I find that exposure to the policy has a persistent and significant effect on school quality when comparing the poorest to the richest neighborhoods. Along with the overall increase in the distribution of school quality, this helps bolster the argument that the policy increased school quality, particularly in the poorest neighborhoods.

FIGURE 4.—Differences in Differences Estimates by Policy Exposure




Note: This figure shows the estimated coefficients from a difference-in-differences regression on school quality $\widehat{q}_{jt}$ (Value Added). The treatment group corresponds to the highest quintile of school level exposure to eligible students, and the control group corresponds to the lowest quintile. The measure of exposure to the policy is calculated as the share of SEP eligible students that live within a 0.5 km radius of the school. The full set of results are available in Section 5 of the Online Appendix.

### 6.2. *Average Revenue, Exposure to SEP and Academic Quality*

One potential reason that schools in poorer neighborhoods are improving is simply that the policy increased resources. To evaluate this mechanism, I leverage school level transfer data to estimate a school fixed effects model that includes a measure of neighborhood exposure in addition to government transfers. Because revenue is endogenous to the school's reaction to the policy, I use the composition of the school in 2005 but adjust the values of the different vouchers to simulated the average transfer each school would receive over time. $\Delta$ *Avg transfers simulated* corresponds to the difference in the weighted average of transfers to the school, holding fixed the share of eligible and non-eligible students from the pre-policy period. To estimate this school-level fixed effects model, I interact policy exposure with time. I present the results in Table II for two measures of quality including school value-added and also an indicator for having been awarded the SNED prize for academic achievement relative to similar schools. The results show evidence that resources drive some of the observed improvement. However, the results also indicate that when private voucher schools have more exposure to eligible families, they improved quality even after taking into account increased resources and individual school fixed effects. Public schools seem to react to increasing resources but not to the exposure measure.

TABLE II
INCOME AND EXPOSURE TO POLICY - SCHOOL FE

| | Voucher | | | Public | | Private |
|---|---|---|---|---|---|---|
| | Quality | Has SNED | Price | Quality | Has SNED | Quality |
| High Exposure x Policy | 0.04 (0.01) | 0.04 (0.02) | 0.09 (0.00) | 0.01 (0.01) | -0.03 (0.02) | -0.06 (0.09) |
| $\Delta$ Avg Transfers (sim) | 0.05 (0.00) | 0.01 (0.00) | -0.08 (0.00) | 0.07 (0.01) | 0.03 (0.01) | |
| Constant | -0.24 (0.02) | 0.30 (0.02) | 0.70 (0.01) | -0.73 (0.05) | 0.04 (0.07) | 0.36 (0.01) |
| Year and School FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| $R^2$ | 0.64 | 0.45 | 0.95 | 0.50 | 0.36 | 0.66 |
| N Obs | 21,942 | 22,260 | 22,260 | 14,571 | 14,648 | 4,348 |

Note: This table shows the results for the exposure to the policy on quality measures and price at schools grouped by the geographic exposure of schools to SEP eligible students.

These results are consistent with increased competitive incentives playing a role beyond the increase in transfers for private for profit schools. While this result is consistent with competitive incentives playing a role above and beyond the increase in resources, but it does not rule out other mechanisms correlated with neighborhood poverty such as increased regulation/support for the poorest schools as emphasized by Murnane, Waldman, Willett, Bos, and Vegas (2017).

To quantify the role for resources and market power in explaining *why* many schools improved their quality, I now estimate the demand model which provides a micro-foundation for the exposure to the policy. The estimated model allows for the detailed measurement of how changes in incentives and resources affect each individual school and how they contributed to the observed changes in the overall distribution of school quality. This allows me to empirically evaluate the relevance of competitive incentives and resources as mechanisms explaining school behavior. In particular, once exposure to the policy through these mechanisms has been accounted for, there is no reason in the model for exposure to poverty to have an effect per se and provides a straightforward test of the model.

# 7. ESTIMATING DEMAND FOR SCHOOLS

## 7.1. *The Estimation Strategy*

I estimate demand parameters $\theta = \{\alpha, \beta, \lambda, \sigma, \xi\}$ using a method of moments estimator that is a standard application of demand estimation from the empirical industrial organization literature.[33] The estimation strategy looks for a vector of parameters that will match the aggregate market shares of each school exactly while still respecting orthogonality conditions generated by a set of instruments and getting as close as possible to replicating the average choices for each type of family in the microdata. The aggregate share-matching moments are described as follows:

$$\bar{g}^{SM}(\theta) = \bar{s}_{j,t} - s_{j,t}(\theta) \quad \text{share-matching moments} \tag{15}$$

I construct moments taking advantage of the additional information that comes from microdata on choices made by individual families. This strategy is similar to Petrin (2002), with the exception that I use administrative data on the population of market participants. I define three types of micromoments based on the average academic quality $q_{j,t}$, out-of-pocket price $\text{op}_{k(i),j}$, and driving distance $d_{\text{loc}(i),j,t}$ each type of family chooses in each market and in each period.[34]

$$\bar{g}^{x,m}_{k,t}(\theta) = \frac{1}{S^m_{k,t}} \sum_{i \in S^m_{k,t}} x_{i,t} - \sum_{n}^{N_m} \sum_{j}^{F^m_t} w^m_{\text{loc},k} \cdot s^{nk}_{jt}(\theta) \cdot x_{j,t} \quad \text{micro-moments for } x_{j,t} \tag{16}$$

The third group of moments are defined by a set of orthogonality conditions which require the instruments, $Z_{j,t}$, to be independent from $\xi_{j,t}$. $Z_{j,t}$ include exogenous own characteristics, cost shifters and policy variation interacted with prior market structure. Let $\bar{g}^{IV}(\theta)$ denote the full vector of IV moments and $\bar{g}^{MM}(\theta)$ the full vector of micro-moments adding markets, time periods and family types,

$$\bar{g}^{IV}(\theta) = \frac{1}{N} \sum \xi_j(\theta) \cdot Z_j \qquad \text{IV moments} \tag{17}$$

---

[33] See Berry and Haile (2016) for a recent review of the related literature and a discussion on identification. See Nevo (2000) and Conlon and Gortmaker (2020) for a description of empirical strategies following Berry, Levinsohn, and Pakes (1995). The Online Appendix presents more details.

[34] Recall that in market $m$, at time $t$, $F^m_t$ is the number of schools and $S^m_{k,t}$ is the number of students. I have population microdata on choices of $q_j$ and $\text{op}_{k(i),j}$. I have driving distance to school for 50% of the population.

Stacking micro-moments into $\bar{g}^{MM}(\theta)$, the estimator can be written as:

$$\hat{\theta}^* = \underset{\theta}{\operatorname{argmin}} \begin{bmatrix} \bar{g}^{MM}(\theta) \\ \bar{g}^{IV}(\theta) \end{bmatrix}' \begin{bmatrix} W_{MM} & 0 \\ 0 & W_{IV} \end{bmatrix} \begin{bmatrix} \bar{g}^{MM}(\theta) \\ \bar{g}^{IV}(\theta) \end{bmatrix} \qquad \text{s.t. } \bar{g}^{SM}(\theta) = 0,\ \xi^m_{0,t} = 0\ \forall\, t, m. \tag{18}$$

Following Berry (1994), the aggregate market shares are treated as constraints that will hold exactly in the model. For each guess of the non-linear parameters affecting demand, one can recover mean utilities by inverting these market shares through the use of a nested fixed algorithm and then instrument using two-stage least squares to recover the linear parameters affecting demand and $\xi_{j,t}$ for each school. Note that I set $\xi^m_{0,t} = 0$ for one public school in each market and time period.[35]

I compute first-step estimates using the identity weighting matrix and then construct the optimal two step weighting matrix that accounts for the correlation between moments. The IV and micro moments are assumed independent so the variance-covariance matrix is block diagonal. Standard errors are constructed according to the standard GMM formula where the asymptotics are in the number of observed firms.

### 7.2. *Instruments*

My estimation framework is standard in the empirical industrial organization literature. While Berry and Haile (2014) describe nonparametric identification results using only aggregate data, these results carry over to the case with microdata. Relevant to this application, Berry and Haile (2020) show that micro data can aid identification and reduce reliance on instruments for identification. This type of empirical model of demand has two features that pose a challenge for identification. First, consumers have heterogeneous preferences due to unobserved tastes for quality. Second, the demand model accommodates school level unobservable characteristics $\xi$ that are correlated with price and quality. The main requirement for identification is to have instruments that are independent from $\xi_{j,t}$ and provide independent variation in the endogenous

[35]This normalization implies the inclusion of market and time fixed effects in first stage regression and the demand model.

variables price, quality and market share. I assume that $\xi_{j,t}$ is made up of a fixed component $\xi_j$ and a period-specific idiosyncratic demand shock $\Delta\xi_{j,t}$. This demand shock is realized only after setting prices and quality, therefore is uncorrelated to them.[36]

The first source of exogenous variation is the timing of the implementation of the targeted voucher policy interacted with schools varying exposure to the policy. Similarly to the policy exposure variable used in the difference in differences model in Equation 14, I use the sudden change in voucher policy interacted with the concentration of eligible students near the school. A related instrument generated by the policy variation is the change in the average transfer each school gets as a function of the policy. This is the same simulated transfer that was used in the fixed effects model Table II. To construct this instrument, I fix school student composition to their 2005 level before the policy and then calculate the difference between the simulated trajectory for government transfers over time with and without the SEP policy. These instruments are based on the assumption that $\xi_j$ is exogenous to the timing of the voucher policy implementation and broader neighborhood characteristics.

The second type of instrument is a proxy for labor costs faced by schools in different geographic locations. School balance sheet data shows that the median voucher school spends 80% of its total expenditure on college educated workers. I measure a proxy for compensating differentials across labor markets locations and time. I use worker-firm linked earnings data across all industries from the Chilean tax registry that is linked to college entrance exams, industry, sector and location of employment to estimate earnings regressions controlling for worker characteristics (denoted for worker $i$ as $wx_i$). I define $\omega_{\ell(i),t}$ as a time $t$ and geographic area $\ell$ fixed effect which absorbs the average earnings deviation for high skilled workers in the same geographical area as follows: $\text{earnings}_{i,t} = wx_i\phi^w + \omega_{\ell(i),t} + \mathrm{e}_{i,t}$,[37] where $\mathrm{e}_{i,t}$ is an idiosyncratic shocks to

[36] Alternatively, the deviations from $\xi$ can be attributed to measurement error in school value added and thus also uncorrelated with prices and quality chosen.

[37] The worker is associated to a geographic location defined here as a "*Comuna*". 128 of the most urban *comunas* are included in the markets used in this study. These are similar to small and mid-sized cities in the US. Markets can include one or many *comunas*.

earnings. Here $\omega_{\ell,t}$ represents the additional cost of employing high skilled workers at location $\ell$, and time $t$. Similarly to the policy instruments, the variation over time and space captured by $\omega_{\ell,t}$ is a valid instrument given $\xi_j$ is assumed to be fixed and not systematically correlated with broader location characteristics.

Finally, I include schools' own exogenous characteristics as instruments. These are the same school characteristics that are predetermined and influence demand in Equation 1, including whether the school was private, for profit, religious, if it has K-12 grades and whether it has been open since 1995.

Table III presents linear regressions of the endogenous variables (price, quality and shares), on the exogenous variables, including the excluded instruments. I include two columns for each endogenous variable; one column runs the regression on the entire panel and the other only uses the estimation sample (i.e. years 2007 and 2011). In both cases I obtain high F-statistics and the coefficients generally have the expected signs given the model. For example, increased exposure to the policy interacted with the policy timing increases quality. Higher labor costs lead to lower quality and higher prices at private voucher and non voucher schools. Increased transfers from the government increase quality and lower prices.

Table III

Regression of Endogenous Variables on Instrumental Variables

| | Academic Quality $q_{j,t}$ (1) | Academic Quality $q_{j,t}$ (2) | Price $p_{j,t}$ (1) | Price $p_{j,t}$ (2) | Shares $s_{j,t}$ (1) | Shares $s_{j,t}$ (2) |
|---|---|---|---|---|---|---|
| % Eligible E | | | | | | |
| x Public | -0.71 (0.03) | -0.78 (0.06) | 0.00 (.) | 0.00 (.) | 0.06 (0.00) | 0.06 (0.00) |
| x Voucher | -0.49 (0.03) | -0.58 (0.06) | -2.97 (0.06) | -2.74 (0.12) | 0.03 (0.00) | 0.02 (0.00) |
| x Public x Policy | 0.77 (0.04) | 1.10 (0.13) | 0.00 (.) | 0.00 (.) | 0.02 (0.00) | 0.02 (0.01) |
| x Voucher x Policy | 0.70 (0.03) | 0.77 (0.09) | 1.57 (0.07) | 1.66 (0.17) | 0.02 (0.00) | 0.02 (0.01) |
| Labor Costs $\omega_{\ell,t}$ | | | | | | |
| x Voucher | -0.11 (0.01) | -0.17 (0.03) | 0.38 (0.02) | 0.35 (0.06) | -0.02 (0.00) | -0.03 (0.00) |
| x Private | -0.17 (0.02) | -0.08 (0.06) | 1.24 (0.04) | 1.54 (0.11) | -0.02 (0.00) | -0.02 (0.00) |
| $\Delta$ Mg Transfers | | | | | | |
| x Public | -0.71 (0.03) | -0.85 (0.13) | 0.00 (.) | 0.00 (.) | -0.04 (0.00) | -0.04 (0.01) |
| x Public x %E | 0.06 (0.02) | 0.02 (0.06) | 0.00 (.) | 0.00 (.) | -0.01 (0.00) | -0.01 (0.00) |
| x Voucher | -0.80 (0.02) | -0.84 (0.08) | -1.45 (0.16) | -1.77 (0.00) | -0.01 (0.00) | -0.02 (0.01) |
| x Voucher x %E | 0.08 (0.02) | 0.13 (0.07) | 0.63 (0.04) | 0.62 (0.14) | -0.01 (0.00) | -0.01 (0.01) |
| Exogenous Own $x_j$ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| $R^2$ | 0.28 | 0.28 | 0.86 | 0.86 | 0.09 | 0.10 |
| F-stat Excluded IV | 285.86 | 42.45 | 1062.29 | 163.71 | 271.10 | 48.27 |
| N Obs | 40,758 | 6,880 | 26,742 | 4,526 | 41,329 | 6,987 |

Note: Price regressions do not consider public schools, since they don't charge any top-off fees. Columns (2) considers only 2007 and 2011. All columns include year fixed effects.

### 7.3. *Quantifying Heterogenous Demand for Schools*

I present the estimated demand parameters in Table IV. The main specification uses data from four years and 53 markets including the Santiago Metro area. Consistent with the evidence from surveys and prior work on school choice, I find that preferences are heterogeneous across socioeconomic groups. Poorer and less educated families value school academic quality, but they are very price sensitive and dislike distance more than richer and more educated families. Interestingly, mothers education is generally more relevant than poverty status as a driver preference heterogeneity. In addition to the substantial heterogeneity in preferences across observable family characteristics, I find an important role for unobserved heterogeneity in preferences for academic quality.[38]

TABLE IV
DEMAND MODEL ESTIMATES

| | | | |
|---|---|---|---|
| $\overline{\beta}^x$ - Common Preferences for School Characteristics $x_j$ | | Voucher | Non-Voucher |
| Type of Private | | -0.86 (0.04) | 2.49 (0.17) |
| Catholic | | 0.08 (0.04) | -0.02 (0.08) |
| Other Religious | | 0.11 (0.04) | 0.50 (0.08) |
| Has K-12 Grades | | 0.07 (0.02) | -0.98 (0.18) |
| Entered Prior 1995 | | 0.84 (0.02) | 0.70 (0.06) |
| Entered Post 2007 | | 0.64 (0.06) | 0.40 (0.15) |
| For Profit Voucher | | -0.55 (0.02) | |
| $\overline{\beta}^q$ - Common Preference for Academic Quality | 1.41 (0.02) | | |
| $\beta_k^x$ - Observable Heterogenity by Mother Education | Quality $\beta_k^q$ | Price $\alpha_k^{op}$ | Distance $\lambda_k^d$ |
| Less than High School ($\leq 12$) | | -2.72 (0.06) | -1.29 (0.01) |
| Mother Edu = 12 | 0.55 (0.02) | -0.56 (0.05) | -1.10 (0.01) |
| Mother Edu = 14 | 0.83 (0.03) | -0.25 (0.05) | -1.05 (0.01) |
| Mother Edu $\geq$ 16 | 1.10 (0.04) | 0.00 (0.05) | -0.96 (0.01) |
| $\beta_k^x$ - Observable Heterogenity by Poverty Status 40% | -0.31 (0.01) | -1.48 (0.03) | -0.05 (0.01) |
| $\sigma_q$ - Unobservable Heterogenity for Academic Quality | 0.80 (0.05) | | |

Note: Standard errors shown in parenthesis next to estimated coefficients.

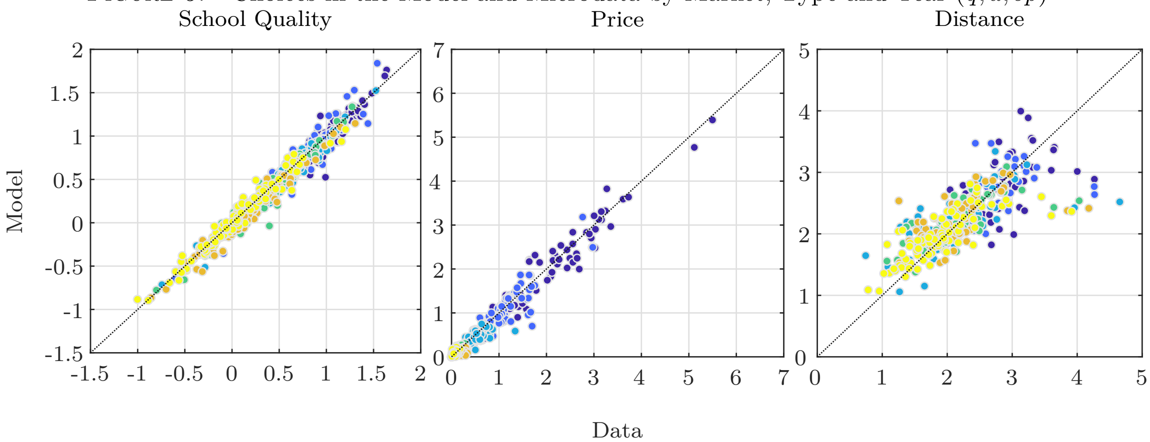
Figure 5 compares the data and the model simulations by plotting the average academic quality, distance and out-of-pocket cost $(\overline{q}, \overline{d}, \overline{op})$ for families of different types in each market and year. The model is able to capture variation across types

[38]See related models of school choice like Hastings, Kane, and Staiger (2009), Gallego and Hernando (2010), Carneiro, Das, and Reis (2016). I present a robustness analysis in Section 3 of the Online Appendix with different sets of instruments, markets and years. In every case I find the same broad patterns.

and markets, especially for quality and price where micromoments are constructed using the entire population.

The patterns found in the estimated preferences are consistent with the original motivation for the targeted voucher policy, since out-of-pocket fees are indeed a barrier for poorer families to gain access to schools with higher academic quality. These results suggest that poorer families choose higher quality schools when they are available at low prices and short distances. The fact that on average they attend schools with low academic quality indicates that more desirable (and affordable) schools are often not available. In other words, the estimates indicate out-of-pocket prices and distance are contributing to the observed inequality in access to higher quality schools. In addition, these results indicate that the policy has the potential to lead to sorting and producing competitive incentives, since families will become more quality-sensitive under the targeted voucher program. My next question is whether this competitive pressure is large enough to generate meaningful change.

FIGURE 5.—Choices in the Model and Microdata by Market, Type and Year ($\overline{q}, \overline{d}, \overline{op}$)



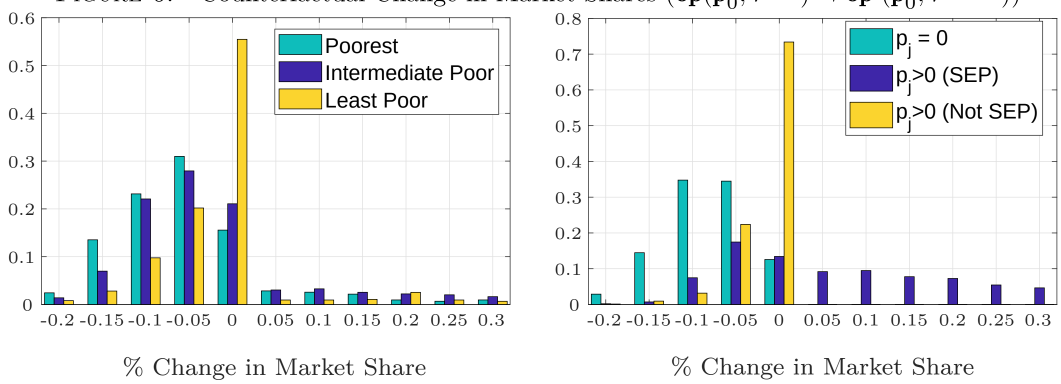

Note: Averages are calculated using microdata (x-axis) and simulated data from the estimated model (y-axis). Colors indicate family types from poorer, less educated (type 1 ■) to richer, more educated (type 6 ■).

# 8. QUANTITATIVE ANALYSIS OF VOUCHER POLICY AND EQUILIBRIUM QUALITY

## 8.1. *Counterfactual Sorting and Heterogeneous Competitive Incentives*

Before any schools adjust prices or quality, eliminating out-of-pocket fees for poorer students will make some schools less attractive as their competitors become more affordable. Other schools will see their demand increase as their higher prices are no longer relevant for some families. I quantify this heterogeneity by using the model to simulate the school choices that would result in 2007 if out-of-pocket prices were eliminated at participating schools while holding fixed the supply side quality.

FIGURE 6.—Counterfactual Change in Market Shares $(\mathbf{op}(\mathbf{p}_0^{\mathrm{e}}, V^{\mathrm{flat}}) \rightarrow \mathbf{op}'(\mathbf{p}_0^{\mathrm{e}}, V^{\mathrm{target}}))$




Note: The figures show the change in market share comparing 2007 to the counterfactual given by $(\mathbf{q}_0^{\mathrm{e}}, \mathbf{p}_0^{\mathrm{e}}, \mathbf{op}_0')$. The left panel shows changes to market share by neighborhood poverty. The right panel shows the same results broken down by preexisting out-of-pocket prices and whether the school participated in the targeted voucher program.

The left panel of Figure 6 contrasts the change in shares for schools by neighborhood poverty status. Schools in poorer neighborhoods would generally lose market share, but a few would actually see an increase. The right panel shows that schools with zero sticker prices never gain market share, since their competitors have become more attractive. Schools with positive prices that participate in the new policy see a variety of effects, with a large group seeing an increase in market share. Schools that do not participate in the policy never benefit, and 25% would see a loss of market share if they do not react to the policy to make their school more attractive.

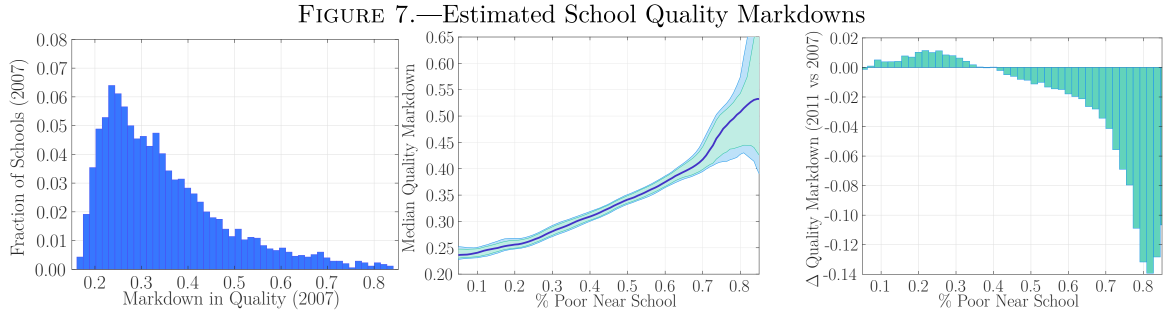
These ex-ante predicted changes in market share are significantly correlated with actual changes in quality ex-post for private voucher schools. Consistent with the existence of equilibrium spillovers from competition, schools that did not participate in the targeted voucher program and obtained no additional revenue improved more ex-post when they would have lost more market share had they not improved.

Using the counterfactual allocation of students to schools, I can calculate $\Delta\bar{q}^{\not{\mathrm{E}},\mathrm{E}}(\mathbf{q}_0^{\mathrm{e}}, \mathbf{p}_0^{\mathrm{e}}, \mathbf{op}_0')$ and compare it to the pre-policy gap $\Delta\bar{q}^{\not{\mathrm{E}},\mathrm{E}}(\mathbf{q}_0^{\mathrm{e}}, \mathbf{p}_0^{\mathrm{e}}, \mathbf{op}_0)$. I find that the gap between richer and poorer students closes, but reaches only 20% of the actual reduction documented above for the post-policy targetd voucher equilibrium. Repeating the exercise forcing all voucher schools to participate, the gap closes by 40% of the final reduction. In both cases, expanding choice on its own would have had much smaller effects without the supply side adjustment.

### 8.2. *Measuring Market Power Under Flat and Targeted Vouchers*

The model suggests that local market power is one important determinante of the school quality provided by for-profit schools. Moreover, the targeted voucher policy could modify schools' ability to mark down quality and potentially drive part of the changes observed in the data. Using the estimated parameters $\widehat{\theta}$, I measure $\mu^q_{j,t}(\widehat{\theta})$ for each school and I find that market power is sizable and varies across schools in the context of the Chilean flat voucher policy in 2007. The left panel of Figure 7 shows the distribution of $\mu^q_{j,07}(\widehat{\theta})$ for voucher schools. While the lowest values are 0.1, the median is 0.35 and the top quintile has a median of 0.45.

FIGURE 7.—Estimated School Quality Markdowns




Note: The left panel shows the distribution of quality markdowns in 2007 at voucher schools. The middle panel shows the median markdown by poverty rate near the school in 2007, with 95% and 99% bootstrap CIs. The panel on the right shows the change in markdown by poverty rate near the school.

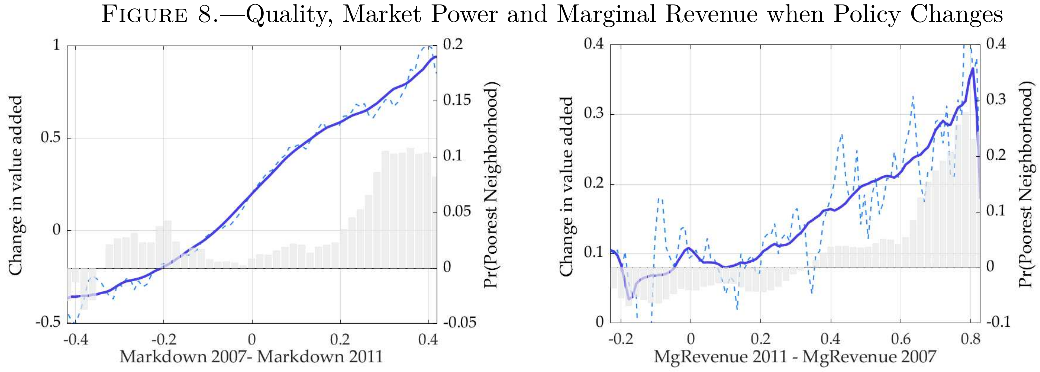
The middle panel shows that local market power is positively correlated with the rate of poverty near the school in 2007. There is a 0.2 difference in the mean quality across neighborhoods with 0.1 % poor and 0.8% poor. This relationship between market power and poverty is a new source of structural inequality in this context. These differences are due only to the market power produced by heterogeneous preferences and differentiated products.

Finally, in the panel on the right I show the average change in the markdown at each school from 2007 to 2011 by nearby poverty. On average, schools in the poorest neighborhoods lost more market power ex-post. This result indicates that changing competitive incentives could be a relevant mechanism through which the policy affected the distribution of quality at schools, especially those in the poorest neighborhoods.

### 8.3. *Quantifying the Role of Competitive Incentives*

The estimates and counterfactuals presented above suggest the change in voucher policy in Chile could have heterogeneous effects on schools depending on nuanced differences in local market conditions. The policy will shift both the marginal revenue associated with attracting an additional student as well as the market power the school may have to reduce quality. The estimated model and data on the equilibrium before and after the policy can be used to study how the changes to market power and marginal revenue are related to the observed change in academic quality.

FIGURE 8.—Quality, Market Power and Marginal Revenue when Policy Changes




Note: The left y-axis shows the average change in value-added from 2007 to 2011, calculated in bins of $\pm 0.02$ (dashed lines ). The right y-axis shows the demeaned probability that a school is *High Exposure* (gray bars ). Dark blue lines show a moving average using 10% of the sample ( ). The left panel shows the negative of the change in estimated markdown $-\Delta\mu_j^q$. The right panel shows the change in marginal revenue as defined by the second line of Equation 10 including the weighted average of marginal revenue coming from SEP and non SEP eligible students. Only SEP voucher schools are included.

In the left panel of Figure 8, the left axis shows the conditional mean of the change in academic quality given the change in markdowns, presented as $-\Delta\mu_j^q = \mu_{j,07}^q\left(\widehat{\theta}\right) -$

$\mu^q_{j,11}\left(\widehat{\theta}\right)$. On the right axis, I plot the demeaned probability of a school being in the poorest neighborhoods (referred to as High Exposure) given the change in markdowns. Schools that had a bigger markdown in 2007 relative to 2011 are on average also schools that had larger gains in academic quality and are more likely to be in the poorest neighborhoods. The right panel presents similar statistics conditioning on the change in marginal revenue. I find that the relationship between marginal revenue and the change in academic quality is again positive, and schools with bigger changes in marginal revenue are also more likely to be in the poorest neighborhoods.

The model describes an explicit relationship between the change in quality and the change in market power and marginal revenue in Equation 10. Assuming academic quality $\hat{q}_j$ is measured with error, I estimate the empirical analogue of Equation 10 described in Equation 19 and evaluate whether the observed change in quality is systematically related to the variation in the measured markdowns and the change in marginal revenue across policies.

$$\Delta\hat{q}_j = \beta^{\mu,07}\mu^q_{j,07}(\widehat{\theta}) + \beta^{\mu,11}\mu^q_{j,11}(\widehat{\theta}) + \beta^{\text{MgRev}}\Delta\text{MgRev}_j(\widehat{\theta}) + \epsilon^q_j \tag{19}$$

Table V shows that the coefficients accompanying $\mu^q_{j,07}(\widehat{\theta})$ and $\mu^q_{j,11}(\widehat{\theta})$ are near the expected values of one and negative one.

The expected coefficient on changing marginal revenue is $1/c_q$, which is positive but of an unknown magnitude. The estimated coefficient of approximately 0.1 implies that increasing the value of the marginal student by one thousand dollars increases school academic quality by $0.1\sigma$.

To further test whether the model is capturing relevant heterogeneity in the data, I repeat the estimation of Equation 10 adding the *High Exposure* variable that is not in the model but had been found to be significantly related to improvements in school quality. Columns 3 and 4 report coefficients are largely unchanged and the exposure to poverty indicator is no longer significant. This suggests that the main mechanisms that were correlated with neighborhood poverty are being appropriately captured by the model estimates.

I use the estimated coefficients from column (1) of Table V to describe the relative contribution that competitive incentives and marginal revenue have had in explaining the changes in academic quality. The targeted voucher policy increased marginal revenue for most participating voucher schools so in general contributed positively, but by varying amounts. The contribution to the predicted growth in quality was 0.01, 0.03 and 0.05 for the 25th, 50th and 75th percentiles. On the other hand, the change in markdowns can contribute positively or negatively depending on the policy effect at each school, and I find empirically that the median contribution to changing value-added is approximatly zero. At the same time, the change in markdowns is the primary mechanism that explains changes in predicted value added among the subset of voucher schools with above median growth in value-added. Here I see that while having a muted role on average, the change in market power explains two thirds of the predicted increase in quality at the median school that had positive growth ex-post. This is also true in the poorest neighborhoods in spite of the fact marginal revenue increases by twice as much in poorer areas than in areas with average poverty (up to $US900 relative to the average change of $US300). Further focusing on the schools in the poorest neighborhoods that improved the most (top quintile) I find that four fifths of the predicted change is attributed to changing market power. In other words, while increasing marginal revenue was relevant across most schools, the changes in market power were the main drivers behind the largest changes in observed school quality, especially those in poorer neighborhoods.

TABLE V

QUALITY MARKDOWN AND THE CHANGE IN SCHOOL QUALITY

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Quality Markdown 2007 $\mu^q((\mathfrak{q}_0^e, \mathfrak{p}_0^e, \mathfrak{op}_0^e))$ | 1.29 (0.04) | 1.29 (0.03) | 1.30 (0.04) | 1.29 (0.05) |
| Quality Markdown 2011 $\mu^q((\mathfrak{q}_1^e, \mathfrak{p}_1^e, \mathfrak{op}_1^e))$ | -1.26 (0.05) | -1.28 (0.04) | -1.26 (0.05) | -1.28 (0.05) |
| $\Delta$ MgRevenue | 0.10 (0.02) | 0.10 (0.01) | 0.09 (0.02) | 0.09 (0.01) |
| Intercept/Market FE | 0.14 (0.02) | ✓ | 0.14 (0.02) | ✓ |
| High Exposure | | | 0.03 (0.02) | 0.03 (0.02) |
| $R^2$ | 0.51 | 0.53 | 0.51 | 0.53 |

Note: This table presents the results of estimating Equation 10, where I assume value added has classical measurement error. Each regression has 1337 observations that are weighted by the pre-policy size.

## 9. CONCLUSION

In this paper, I study the industrial organization of the primary education market in Chile and focus on the equilibrium supply side response to government policy. I begin by evaluating the effects of a targeted voucher policy that significantly increased the value of the voucher for the poorest 40% of students. I show that this policy led to significant improvements in school value-added, among both public schools and private for-profit schools. Improvements to school quality were largest in the poorer neighborhoods where a higher percentage of students became eligible for the larger voucher. Evidence suggests that for-profit schools in poorer neighborhoods increased quality by more than the additional resources alone can explain.

Given the importance of the supply-side response, I focus on providing a quantitative answer to the question: *why* did these for-profit voucher schools improve? To answer this question, I develop a model of consumer demand and supply with imperfect competition among schools that incorporates the most relevant aspects of the voucher policies implemented in Chile. On the demand side, the model estimates indicate that preferences for school characteristics are heterogeneous across socioeconomic groups, in particular with regard to out-of-pocket prices and distance. On the supply side, modeling schools' choice of price and quality reveals that schools mark down their quality as a function of their local market power. Combining the two sides of my model, I show that schools in neighborhoods with a large concentration of poor families, who are more sensitive to price and distance, have more local market power, and tend to provide lower quality under a flat voucher system. As a result, I show empirically that a flat voucher system with out-of-pocket fees contributes to inequality, not just due to differential access to resources or sorting, but also due to differences in market power. My findings suggest a previously undocumented cause of structural inequality in education markets: the empirical relationship between school market power and neighborhood poverty. This relationship leads to more inequality of access to quality education, even in the absence of education-specific frictions like peer effects or cream-skimming.

Introducing a larger subsidy for poor students through a targeted voucher policy ameliorates the inequality generated by the flat voucher policy in two ways. First, it expands the set of schools that are affordable to poorer families, allowing them to enroll in more desirable and potentially higher-quality schools. The policy also changes schools' incentives to provide quality. On the one hand, the policy provides more resources for each poor student and eliminates out-of-pocket fees. This generally increases the marginal revenue schools receive from poor students, especially at schools that originally had low out-of-pocket fees. On the other hand, the policy diminishes schools' local market power by eliminating out-of-pocket fees as a dimension of differentiation and increasing competition.

Using the estimated model, I quantify how market power and marginal revenue at each school changed after the policy. These school specific measurements show that schools faced very different policy effects, but these effects are correlated with prior market structure and neighborhood characteristics such as poverty. Using these two components, I show that the schools that improved substantially did so due to both an increase in marginal revenue and a reduction of market power. While both mechanisms are relevant, changes in market power account for two-thirds of the increasing quality among schools with above median growth in school quality. This result holds in the poorest neighborhoods, where schools receive much larger increases in marginal revenue.

This paper presents one of the first empirical analyses of voucher policy that explicitly considers both demand and supply in a market-oriented school choice system.[39] My empirical model and estimation strategy closely follow the empirical industrial organization literature applied to markets with spatial product differentiation. This flexible empirical framework is useful because it allows for the measurement of detailed substitution patterns that are important in characterizing the trade offs individual schools face when choosing price and quality.

[39] Ferreyra (2007) studies the potential aggregate effects of vouchers in the US context and is the first paper to estimate a model of school choice with equilibrium supply side considerations. In related empirical work, Bayer and McMillan (2010) show that the estimated elasticity of demand is correlated with school effectiveness in the US. In this paper, I show that the change in market power leads to changes in school value-added.

The main contribution of my empirical model is that it allows for nuanced measurement of the mechanisms driving schools' incentives to provide quality. Being able to quantify these mechanisms provides new insights regarding how voucher policy can influence the distribution of school quality, especially highlighting spillovers due to competitive effects. Furthermore, the estimated model produces measures of market power and marginal revenue that completely capture the influence of neighborhood poverty in explaining the observed change in school quality. These mechanisms thus provide a microfoundation for the program evaluation strategy based on exposure to neighborhood poverty. At the same time, they provide a way to quantify the importance of each underlying mechanism. Finally, it is worth noting that the empirical success of this parsimonious model suggests that future work can build on this framework to further study how rules and regulations in the education sector can affect market allocations.

Private for-profit schools play a large role in many education markets, especially in developing countries where governments can have limited capacity to provide high quality services directly. It is therefore important for research to engage with the empirical study of how government policy affects the incentives of private providers and the equilibrium supply-side reaction to such policies. The success or failure of a given policy can ultimately be determined by how the supply-side responds in equilibrium to changes in incentives. The targeted voucher policy studied in this paper is one example where a policy that only expanded choice with no supply-side reaction would have only reached 20% to 40% of the observed gains in equity. The reason why the supply side is so important is very intuitive. Families in poorer urban areas face many disadvantages in their access to higher-quality schools. Beyond their ability to afford out-of-pocket tuition fees, I find that these families are also located further from higher-quality schools and are more sensitive to distance. These results reinforce the point that policies that incentivize schools in the poorest neighborhoods to improve are crucial to reducing structural inequality in access to education.

The emphasis on the supply-side and the role of for-profit providers does not negate the relevance of other important aspects of the policy. For one, my results show that resources matter, and increasing transfers improves quality at private for-profit schools as well as at public schools. Furthermore, I am unable to attribute the entire increase in quality to any particular mechanism in my model, so there is ample room for other complementary hypotheses associated with the policy to be relevant beyond the competitive incentives mechanism emphasized here.

Finally, it is important to note that I make several simplifying assumptions regarding the education production function and how families choose which school to attend. I argue that these simplifying assumptions are warranted in this case given the context and the specific research question. However, future work that aims to study a wider range of policy questions and counterfactual situations should consider these limitations and develop ways to enrich the model to include more traditional education-specific frictions.

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