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

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Abstract

I develop a model of supply under imperfect competition and demand for differentiated-products to study the primary education market in Chile. I use this framework to analyze how voucher policy affects incentives for schools to supply quality. First, I provide evidence that introducing a voucher targeted at poorer students led schools to improve quality, especially in the poorest neighborhoods. Next, I estimate demand and use the estimates to quantify the mechanisms that incentivized for-profit schools to improve. My estimates indicate that schools use market power to mark down quality below the competitive benchmark, where this markdown is larger in poorer areas. In my model, the new targeted voucher policy induced changes to observed school quality by reducing market power and increasing marginal revenue. My results indicate that targeted voucher policy improved academic achievement and equity not only by providing more resources to schools, but also by increasing competition among schools in the poorest neighborhoods.

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

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1. INTRODUCTION

It has been debated whether school choice and competition will be the tide that lifts all boats Hoxby (2003), or if they will lead to segregation and worse outcomes for poor students Hsieh and Urquiola (2006).[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 a voucher policy. I develop a model of supply under imperfect competition and demand for differentiated-products and use it to analyze the effects of a new school voucher targeted for the poorest students. First, I develop a structural econometric model and estimation framework to evaluate the impact of the new policy, explicitly accounting for equilibrium spillover effects from competition. Second, I use the estimated model to explain the observed changes in school value-added as a function of the main mechanisms in the model: changes to both marginal revenue and local market power.

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. In 2008, a new policy eliminated these fees for approximately 40% of the poorest students at most schools and significantly increased transfers to participating schools for each eligible student. I call this new system the "targeted voucher policy". This represented the largest change to the voucher policy in over 25 years.

[1]See reviews Neal (2002), Hoxby (2007), Rouse and Barrow (2009), Urquiola (2016), Epple, Romano, and Urquiola (2017).

I use detailed administrative data on a decade of student standardized test scores to estimate yearly school value-added (academic quality) and describe how these vary across schools and neighborhoods. I provide descriptive evidence that for-profit schools with greater resources tend to invest more in inputs and achieve higher value-added. Moreover, both poorer and richer students benefit equally from attending higher value-added schools. Schools in richer neighborhoods have higher value-added even when they have similar out-of-pocket fees to schools in poorer neighborhoods. In this context, out-of-pocket fees and residential segregation could both be contributing to the observed inequality.

The new targeted voucher policy aimed to increase the academic achievement of poorer students by expanding their access to higher quality schools and providing schools with more resources. I present evidence that this policy increased student achievement and improved equity. I show that the effects were driven primarily through the improvement of schools' value-added in the poorest neighborhoods rather than students sorting to better schools. In addition, while the increased resources introduced by the policy were important, overall, this mechanism does not seem to explain the entire increase in quality at private voucher schools in the poorest neighborhoods. This finding is consistent with equilibrium spillover effects stemming from increased competition as suggested by my model.

Building on these empirical findings that highlight the 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 under imperfect competition and demand for differentiated-products that incorporates relevant institutional details about the voucher policy in Chile. I allow consumers to 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 (1994); Berry, Levinsohn, and Pakes (1995)). On the supply side, the model of school profit maximization highlights the trade-offs that schools make when they choose quality and price, and how these trade-offs change in response to the voucher policy.

My model provides three important insights. First, much like firms that mark up prices when they have market power, for-profit schools will mark down quality as a function of local market power. The second insight is that the change in equilibrium prices and qualities after the introduction of the new policy, is determined by a combination of changing marginal revenue and changing market power. The third insight is that due to increased competition, all schools will be affected by the policy regardless of whether they participate in the voucher program. 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. To evaluate the relevance of these mechanisms in the presence of equilibrium spillover effects, I estimate the demand side of my model using detailed administrative data on 53 urban education markets containing 80% of the primary enrollment in Chile.

My demand estimates indicate that preferences for price, distance, and academic 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 these areas to reduce quality more than those in wealthier neighborhoods. 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, rather than to differences in resources or additional education specific market frictions.

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. 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. Importantly, while revenue increases contribute to improvements to quality in general, changing market power is the most important driver of improvement at the schools with the greatest increases in value-added.

These findings are important for several reasons. First, the results show 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. In this application, the estimated model shows that competitive effects are important and even 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. Prior work has emphasized that a targeted voucher can help disadvantaged students make the most of a market-oriented education system by expanding access to better schools.[3] However, my results indicate that the equilibrium supply-side reaction explained 60%-80% of the observed gains in equity. I show that the flat voucher benchmark was characterized by inequality across poorer and higher income neighborhoods that was due in part 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 addressed both factors driving inequality: increasing resources and increasing competitive incentives.

[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).

[3]For example, see Nechyba (2000), Epple and Romano (2008), Bettinger (2011). Early evidence on vouchers expanding poorer students access to better schools includes Rouse (1998) in the U.S. and Angrist, Bettinger, Bloom, King, and Kremer (2002) in Colombia.

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. Chile has subsidized the private provision of educational services in both primary and secondary schools for almost 40 years.[4] 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). 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$1,000 in 2007 for first grade). There are several additional vouchers that are based on the geography and students' 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$1,000. The median price at unsubsidized private elementary schools was US$5,000 in 2012 (110% of the minimum wage).

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 2007, the average per capita government transfer to urban schools was just under US$1,000, of which the baseline voucher accounted for over 80%. Per capita revenue among private voucher schools was heterogeneous due to out-of-pocket fees, ranging from US$970 to over US$2,200. Research has suggested that, while out-of-pocket fees increased investment in education by drawing resources from parents, it also

[4]See Prieto (1983), Gauri (1999) and Beyer, Larraín, and Vergara (2000) for more reviews on the Chilean voucher reform.

contributed to increased segregation and a wider achievement gap between richer and poorer students (Hsieh and Urquiola, 2006).

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

In 2008, the *Ley de Subvención Escolar Preferencial* (SEP), established a new voucher for the poorest 40% of students in Chile. This additional voucher eliminated out-of-pocket fees for poorer students and compensated schools by transferring more resources for each eligible student (∼US$ 500 in 2008). The SEP policy was motivated by the idea that a targeted voucher would expand choice by removing fees as a barrier to access better quality schools.[5] The two most common eligibility criteria for the SEP voucher (85% of participants in 2010) were to be in the lowest 33% of the income distribution, or to belong to the social program for poor families called *Chile Solidario*.

The program was open to all public and private voucher schools, and participation grew rapidly, particularly in poorer neighborhoods. By 2011, 73% of voucher-receiving schools had joined the targeted voucher program, with participation reaching 90% among subsidized schools in the highest quintile of poverty.

There are two aspects of the SEP voucher policy that are important to clarify. First, eligible students do not pay 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$1,000) and their out-of-pocket payment (between US$0 and US$1,900). After 2008, these students trigger the additional SEP voucher subsidy so that the school receives a larger subsidy from the government but cannot charge them the out-of-pocket fee.[6]

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[5] See Gallego and Sapelli (2007), Gallegos and Romaguera (2010), Epple and Romano (2008).

[6] The law also introduced an extra subsidy (of US$100) for schools where over 60% of students were poor. The policy also included support and accountability measures (González, Mizala, and Romaguera, 2002). However many of the auxiliary aspects of the policy were not implemented until several years later (Muñoz, Irarrázaval, Keim, Gaete, Jiménez, and Quezada, 2020).

2.3. *The Evolution of Academic Achievement*

I document two stylized facts regarding the evolution of academic achievement during the period I study. First, average official state-mandated 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 until 2007, but improved by nearly 0.3σ 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. Before 2008, students from the poorest 40% of households scored between -0.2σ and -0.3σ below the baseline average, depending on the year and exact definition of poor. The average student in the wealthiest 60% of households scored between 0.3σ and 0.4σ above the baseline average over the same period. In 2012, students from low-income households scored 0.12σ above baseline, compared to 0.51σ for high-income students—implying that most of the gap reduction was driven by gains among the poorest students.

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.[7] 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. I contribute to this debate by providing further evidence that the SEP policy increased test scores among the poorest students and reduced achievement gaps. International evaluations, such as PISA and TIMSS, also provide evidence that learning and inequality declined in Chile during this period.[8]

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

[8]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 (see Online Appendix).

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. 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 demand side, my goal is to characterize how families trade off academic quality, prices, and other attributes when selecting a school. On the supply side, my objective is to characterize how spatially differentiated for-profit schools choose price and academic quality under different voucher policy regimes. The challenge is to flexibly capture substitution patterns and school incentives while retaining tractability for the empirical application. In the empirical model, the price and academic quality are the two endogenous variables schools can modify. These are at the center of the demand model, which incorporates heterogeneous preferences for distance, academic quality, and prices. My framework will also capture preferences for other persistent school traits that matter to parents, but are not easy to measure, such as the school's values and prestige.

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 $k \in \{1, 2, ..., 6\}$.[9] 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.

Parents have common preferences over observable school characteristics that are fixed over time, denoted by 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 another indicator if it is only observed in the post period. To capture additional unobserved reasons families may systematically prefer school j over others in their market, I include a common preference term ξ_j. This term reflects school attributes that are fixed during the study period and are unobserved by the econometrician but influence school choice directly—independently

[9]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.

of any impact they may have on student learning, which is captured by q_j. Examples include a school's prestige or the quality of its infrastructure.[10]

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

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

The heterogeneity of preferences is given by $\beta_i = \sum_{k=1}^{K} \mathbb{1}(k(i) = k)\beta_k + \nu_i$ 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 ν_i is standard normal with a zero mean and a variance of σ^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.[11] 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

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

[10]Under this framework, if parents have preferences over student body composition they are captured by q_j if they enhance student learning, and are assumed to be homogeneous and absorbed into ξ_j if they influence school choice without affecting learning outcomes. As student composition was stable while test scores changed during the study period, I do not explicitly model peer preferences. See Allende (2020) for a related approach with social interactions.

[11]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 the Online Appendix that this assumption is reasonable in a developing country education market characterized by private for-profit schools.

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.

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^{loc} so that $\sum_{\text{loc}}^{L^m} w_k^{\text{loc}} = 1$, while the total proportion of students in the market who are of type k is given by Π_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 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 made irreversible decisions such as their location, choice of technology, and participation in the government voucher policy.

I begin by assuming that every privately owned and administered for-profit school is an independent decision-maker, and that they 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 $\text{MC}(q_j)$.

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. 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. In this setting, these definitions are independent of the student type k.[12] The profit function for school j is the sum of the net profit derived from each type of student given the sticker price, quality, and voucher policy

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

Now, 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

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

[12] 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 $\frac{\partial v_b^m}{\partial p_j} = 0$.

The first term represents the price under perfect competition. In absence of 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.

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 denoted by the vector ω_j^g, so the marginal cost of school j can be expressed as $\text{MC}(q_j) = c^m + \sum_g c_g \omega_j^g + c_q q_j$. 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 provide quality with a "markdown" relative to perfectly competitive quality because they have market power[13]

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

A school's market power depends on the set of competitor characteristics, including price, academic quality, and their unobservable ξ. 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

[13] 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 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.

always equal to marginal revenue since they receive no subsidies from the government. 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. Empirically, these differences in market power stem from the spatial distribution of families, 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. Finally, 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 denoted by V^{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_{sep} for poor students so that out-of-pocket expenses are $\mathrm{op}_j = 0$ for $k = \mathrm{E}$, and $\mathrm{MR}(p_j, k, V) = p_j + v_b^m$ 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 μ_j^p and quality markdowns μ_j^q would be altered for all schools, whether they participate in the policy or not, for two reasons.

First, the policy changes demand for *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 $\mathbf{op}(\mathbf{p}_0^{\mathrm{e}}, V^{\mathrm{flat}}) \to \mathbf{op}'(\mathbf{p}_0^{\mathrm{e}}, V^{\mathrm{target}})$. 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 (public, private subsidized or private non-subsidized), 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 $p^*_j(\mathbf{q}^{\mathrm{e}}_1, \mathbf{p}^{\mathrm{e}}_1, \mathbf{op}^{\mathrm{e}}_1)$ and qualities $q^*_j(\mathbf{q}^{\mathrm{e}}_1, \mathbf{p}^{\mathrm{e}}_1, \mathbf{op}^{\mathrm{e}}_1)$ at all schools, which will again affect price markups μ^p_j and quality markdowns μ^q_j.

The actual implementation of targeted vouchers in Chile is slightly different, as it transfers an additional amount v_{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 under 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, under the SEP policy, marginal revenue is fixed at $\text{MR}(p_j, k, V) = v^m_b + v_{\text{sep}}$ for $k = \text{E}$ and continues to be $\text{MR}(p_j, k, V) = p_j + v^m_b$ for all $k = \cancel{\text{E}}$. 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. The new equation for p^*_j is $p^*_j(\mathbf{q}^{\mathrm{e}}_1, \mathbf{p}^{\mathrm{e}}_1, \mathbf{op}^{\mathrm{e}}_1)$ and $q^*_j(\mathbf{q}^{\mathrm{e}}_1, \mathbf{p}^{\mathrm{e}}_1, \mathbf{op}^{\mathrm{e}}_1)$ under the new SEP policy below

$$p^*_{j,1} = \left[c^m + \sum_l c_l \omega^l_j + c_q q^*_{j,1} - v^m_{b,1}\right] - s_{j,\cancel{\text{E}}}(\mathbf{q}^{\mathrm{e}}_1, \mathbf{op}^{\mathrm{e}}_1) \left[\frac{\partial s_{j,\cancel{\text{E}}}(\mathbf{q}^{\mathrm{e}}_1, \mathbf{op}^{\mathrm{e}}_1)}{\partial p_{j,1}}\right]^{-1}. \tag{8}$$

The key difference in the pricing Equation (8) 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 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_{sep},

$$q^*_{j,1} = \left[\frac{1}{c_q}\left(v^m_{b,1} + v_{\text{sep}} - c^m - \sum_l c_l \omega^l_j\right)\right] - \mu^q_j - \left[\frac{v_{\text{sep}} - p_{j,1}}{c_q}\right]\left[\frac{\partial s_{j,\cancel{\mathbb{E}}}}{\partial q_{j,1}}\right]\left[\frac{\partial s_j}{\partial q_{j,1}}\right]^{-1}. \tag{9}$$

Now comparing across two equilibria, $(\mathbf{q}^{\mathrm{e}}_0, \mathbf{p}^{\mathrm{e}}_0, \mathbf{op}^{\mathrm{e}}_0) \to (\mathbf{q}^{\mathrm{e}}_1, \mathbf{p}^{\mathrm{e}}_1, \mathbf{op}^{\mathrm{e}}_1)$, we can decompose the difference in the equilibrium quality provided at a school j as[14]

$$q^{\mathrm{e}}_{j,1} - q^{\mathrm{e}}_{j,0} = s_j(\mathbf{q}^{\mathrm{e}}_0, \mathbf{op}^{\mathrm{e}}_0)\left[\frac{\partial s_j(\mathbf{q}^{\mathrm{e}}_0, \mathbf{op}^{\mathrm{e}}_0)}{\partial q_{j,0}}\right]^{-1} - s_j(\mathbf{q}^{\mathrm{e}}_1, \mathbf{op}^{\mathrm{e}}_1)\left[\frac{\partial s_j(\mathbf{q}^{\mathrm{e}}_1, \mathbf{op}^{\mathrm{e}}_1)}{\partial q_{j,1}}\right]^{-1} + \tag{10}$$

$$\left[\frac{v^m_{b,1} - v^m_{b,0}}{c_q}\right] + \left[\left[\frac{v_{sep} - p^{\mathrm{e}}_{j,0}}{c_q}\right]\left[\frac{\partial s_{j,\mathbb{E}}(\mathbf{q}^{\mathrm{e}}_1, \mathbf{op}^{\mathrm{e}}_1)}{\partial q_{j,1}}\right] + \left[\frac{p^{\mathrm{e}}_{j,1} - p^{\mathrm{e}}_{j,0}}{c_q}\right]\left[\frac{\partial s_{j,\cancel{\mathbb{E}}}(\mathbf{q}^{\mathrm{e}}_1, \mathbf{op}^{\mathrm{e}}_1)}{\partial q_{j,1}}\right]\right]\left[\frac{\partial s_j(\mathbf{q}^{\mathrm{e}}_1, \mathbf{op}^{\mathrm{e}}_1)}{\partial q_{j,1}}\right]^{-1}.$$

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 $\Delta\mu = \mu(\mathbf{q}^{\mathrm{e}}_0, \mathbf{op}^{\mathrm{e}}_0) - \mu(\mathbf{q}^{\mathrm{e}}_1, \mathbf{op}^{\mathrm{e}}_1)$.

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 $(v_{sep} + v^m_b)$ and an ineligible student $(p_j + v^m_b)$ where $v_{sep} >= p_j$. The second line of Equation (10)

[14]See the Online Appendix for the decomposition of the difference in equilibrium prices.

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 $(v_{sep} - p^{e}_{j,0})$, 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, $(p^{e}_{j,1} - p^{e}_{j,0})$, again weighted by how sensitive demand from *ineligible students* is to quality.

In my framework, schools with zero out-of-pocket prices in the pre-policy period would likely increase their academic quality under SEP due to i) the increase in transfers from eligible students and ii) increased competition from more expensive schools with higher quality that have now become affordable. Both of these forces would likely be stronger in neighborhoods with a higher concentration of eligible students w_{E} and thus we should see the biggest changes in markdowns, marginal revenue, and increases in quality in poor neighborhoods. It is important to note that given competitive incentives are relative to the local equilibrium, there will likely be significant heterogeneity in the way market power changes and affects similar schools in the same location. In general the effect on quality and prices in the new equilibrium is ambiguous and is an empirical issue that depends on a variety of factors. In the next sections, I describe how to estimate demand parameters and use them to quantify market power both before and after the policy.

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. This data provides information on aggregate enrollment 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. This data indicates the source of funding and the amount transferred to each school for each month. Since voucher transfers depend on school characteristics, this data also includes information on the average out-of-pocket price charged to non-SEP students and whether the school is a recipient of an achievement prize for academic excellence (SNED[15]).

I use administrative panel data from 2005 to 2016 on all students in Chile. This data records the school each student attended each year, as well as information on grades and basic demographics. It also includes 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. This data contains information on the health conditions of a child at birth such as birth weight, birth length, and gestation. It also includes 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.

The final dataset at the student-year level includes nearly 2 million observations of first-grade students. I use this dataset to calculate market shares and to characterize student choices.[16] I use the same panel dataset to track students from first 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*

I define education markets using a combination of aggregate administrative data on schools, micro-data on the population of students, and individual-level census

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[15]SNED is a prize for schools that outperform a peer group of schools with similar composition of students.

[16]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 education their mother had achieved when she gave birth (32% less than high school, 43% high school, 12% 2 year postsecondary degree and 13% four year college degree or more, for first graders in 2011).

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 2 km 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.

I add a 1 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 are enrolled at. 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 micro-level 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^{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, conditional on mother's education and SEP eligibility.[17] This density at loc given student type k is w_k^{loc}, such that $\sum_{\text{loc}\in L^m} w_k^{\text{loc}} = 1$. I assume w_k^{loc} is fixed across time.

[17] 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.

The 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, with available geolocated student micro-data. 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.

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 0.5 km and classify 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.

5. DESCRIPTIVE EVIDENCE ON ACADEMIC QUALITY AND VOUCHER POLICY

5.1. *Estimating Measures of Academic Quality*

The following subsection outlines the value-added estimation strategy. Let the relationship between test scores $y_{i,j,t}$, student characteristics, and each school's ability to increase test scores, q_{jt}, be

$$y_{i,j,t} = q_{j,t} + X_{i,t}\gamma + e_{i,j,t}. \tag{11}$$

Where $X_{i,t}$ is a large vector of observable individual student characteristics and $e_{i,j,t}$ is a random i.i.d. 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's 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 is the estimated school value-added, and will capture unobserved school inputs such as teacher quality, infrastructure, and any other school-specific characteristics that raise the average test score.

Table 9 of the Online Appendix presents the estimates of Equation (11), which are consistent with those commonly found in the literature.[18] Socioeconomic status, parents' education, and health at birth are all important predictors of later outcomes including academic success (Currie and Almond, 2011, Bharadwaj, Eberhard, and Neilson, 2018). Students whose mothers ranked in the top decile of the college entrance exam scored between 0.16 and 4.6 standard deviations higher on their test scores.

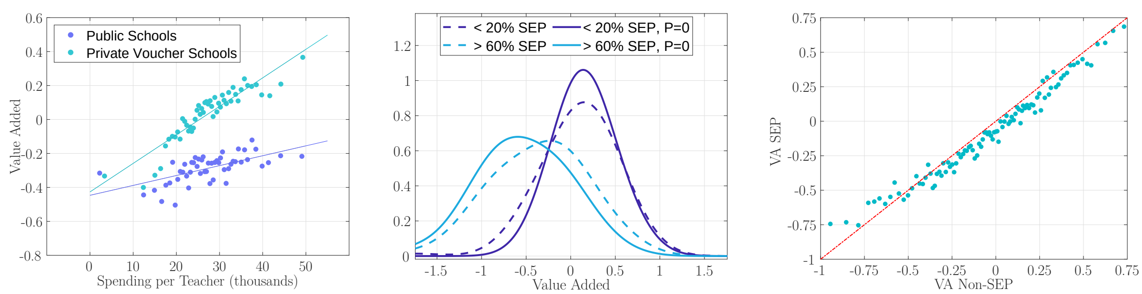
Private voucher schools have consistently higher estimated value-added than public schools, and private non-voucher schools have much higher value-added than either. More salient is the significant heterogeneity in estimated value-added within each type of school. In 2007, the difference between the 25th and 75th percentile of the estimated school value-added was 1.04σ among public schools and 1.23σ 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.

Heterogeneity in estimated school value-added is significantly correlated with differences in resources and inputs. Detailed data on school expenditures available since 2013, show that over 80% of expenses are teacher salaries. The second panel of Figure 1 uses this data to show a positive relationship between average spending on teachers and estimated value-added, especially for private voucher schools.

[18] I present robustness analyses in the Online Appendix using different samples and specifications, including controls for past test scores. I also apply standard Bayesian shrinkage procedures described in Kane and Staiger (2008). In each case, the results are very similar.

The variation in value-added is also explained by neighborhood characteristics. Even schools with no copay 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 eligible SEP students, had an average estimated value-added of -0.36σ in 2007. The same type of school in neighborhoods with less than 20% of eligible SEP students, had an average value-added of 0.09σ, representing a 0.45σ difference in standardized value-added depending on the location of the school. The middle panel of Figure 1 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 1.—Descriptive Evidence For Estimated School Quality q_j



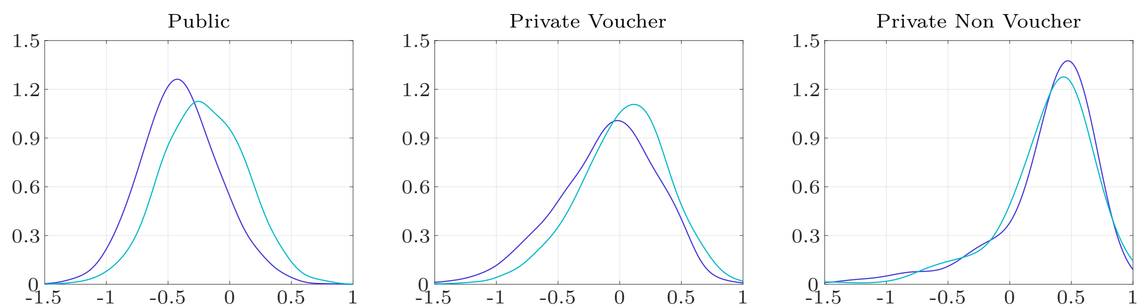
Note: The left panel shows a binscatter plot with average expenditure on teachers in 2014 on the x-axis and value-added on the y-axis. The middle panel shows the distribution of school value-added (2005-2007) for schools with a high percentage of eligible students $\mathtt{E}$ nearby and with very a low percentage of eligible students. The right panel compares value-added at schools in 2011 for $\not{\mathtt{E}}$ students (x-axis) and $\mathtt{E}$ students (y-axis).

Finally, to evaluate whether there is evidence that resources are targeted to students with a higher marginal revenue for the school, 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 1 shows a strong correlation between these two estimates of school academic quality, indicating that improvements in academic quality seem to have spillover effects on all students within the school, independent of how much revenue individual students are worth.

5.2. *Decomposing Sorting and School Improvement*

I find that on average, value-added increases in both public and private voucher schools, but there is no change in the non-voucher private sector. Public schools improved evenly across the distribution, with an average increase of 0.16σ. Private voucher schools increased their quality by 0.12σ on average, with the largest changes coming from the bottom of the quality distribution. Figure 2 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 2.—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 9 of the Online Appendix.

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 micro-data on the population of all students to measure shares. Letting $\Delta\overline{q}^{\not{\mathrm{E}},\mathrm{E}}(\mathbf{q}_1^{\mathrm{e}},\mathbf{p}_1^{\mathrm{e}},\mathbf{op}_1^{\mathrm{e}}) = \Delta\overline{q}_1^{\not{\mathrm{E}},\mathrm{E}}$ and $\Delta\overline{q}^{\not{\mathrm{E}},\mathrm{E}}(\mathbf{q}_0^{\mathrm{e}},\mathbf{p}_0^{\mathrm{e}},\mathbf{op}_0^{\mathrm{e}}) = \Delta\overline{q}_0^{\not{\mathrm{E}},\mathrm{E}}$, I group students by SEP eligibility and can write how the gap in average student achievement changes as

$$\Delta\overline{q}_1^{\not{\mathrm{E}},\mathrm{E}} - \Delta\overline{q}_0^{\not{\mathrm{E}},\mathrm{E}} = \sum_j^{F_m} \left[q_{1,j}^{\mathrm{e}}\left[s_{j,\not{\mathrm{E}}}(\mathbf{q}_1^{\mathrm{e}},\mathbf{op}_1^{\mathrm{e}}) - s_{j,\mathrm{E}}(\mathbf{q}_1^{\mathrm{e}},\mathbf{op}_1^{\mathrm{e}})\right] - q_{0,j}^{\mathrm{e}}\left[s_{j,\not{\mathrm{E}}}(\mathbf{q}_0^{\mathrm{e}},\mathbf{op}_0^{\mathrm{e}}) - s_{j,\mathrm{E}}(\mathbf{q}_0^{\mathrm{e}},\mathbf{op}_0^{\mathrm{e}})\right]\right]. \quad (12)$$

The narrowing of the gap in school value-added is very similar to the shrinking gap in student-level test scores across eligible and ineligible students (documented in the Online Appendix). 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 fourth grade who took the test. I use Equation (12) to decompose this difference into changes in shares across groups due to student sorting and due to changes in school quality. First, I hold the school quality of the pre-policy period (2007) fixed, 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 rather than 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*

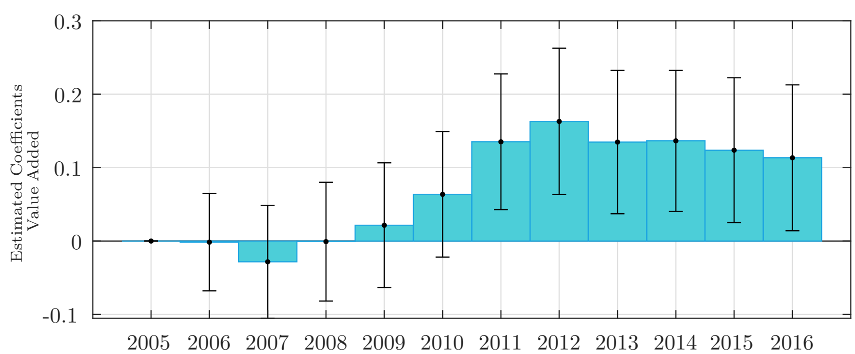
The model indicates that exposure to the targeted voucher policy will likely be mediated by the concentration of eligible students near the schools. This insight suggests that one can estimate the causal impact on school quality with a difference-in-differences estimator that uses the heterogeneity in the predetermined proportion of eligible students near each school as a measure of policy exposure, following the spatial strategy in Card, Dooley, and Payne (2010).

Specifically, I run the difference-in-differences regression described in Equation (13), 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, as detailed in 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_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,

$$\hat{q}_{j,t} = \psi_0 + \psi_1 \text{High}_j + \sum_{y=2006}^{2016} \mathrm{D}_y(t)\text{High}_j \cdot \psi_{2,y} + \sum_{y=2006}^{2016} \mathrm{D}_y(t)\psi_{3,y} + \varepsilon_{j,t}. \quad (13)$$

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 3.—Difference-in-Differences Estimates by Policy Exposure



Note: This figure shows the estimated coefficients from Equation (13). The Online Appendix presents additional details.

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 simulate the average transfer each school would receive over time. Δ*Avg transfers simulated* corresponds to the difference in the weighted average of transfers to the school, holding the share of eligible and ineligible students from the pre-policy period fixed. To estimate this school-level fixed effects model, I interact policy exposure with time. I present the results in Table I for two measures of quality, school value-added, and an indicator for having been awarded an academic excellence prize (SNED). The results show that increased 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 I
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)
Δ 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 (school value-added and awarded SNED) and price at schools grouped by the geographic exposure of schools to SEP eligible students.

These findings indicate that competitive incentives play a role beyond the increase in transfers to private for-profit schools. While this supports the idea that competition has an impact beyond the additional resources, it does not exclude other factors correlated with neighborhood poverty, such as heightened regulation and support for the most disadvantaged schools, as highlighted 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 the demand parameters $\theta = \{\alpha, \beta, \lambda, \sigma, \xi\}$ using a method of moments estimator, a standard approach in demand estimation within the empirical industrial organization literature, following Berry (1994), Berry, Levinsohn, and Pakes (1995) and building on the discrete choice framework pioneered by McFadden (1974).[19] The estimation strategy looks for a vector of parameters that will lead the model to match the aggregate market shares $\overline{s}_j$ for each school j, while still respecting orthogonality conditions generated by a set of instruments Z_j. In addition, the empirical strategy will attempt to get as close as possible to replicating the average choices for each type of family in the micro-data. The aggregate market shares moments are

$$\bar{g}^{SM}(\theta) = \overline{s}_{j,t} - s_{j,t}(\theta) \quad \text{market share moments.} \tag{14}$$

I construct moments taking advantage of the additional information that comes from micro-data on choices made by individual families as in Petrin (2002). I define three types of micro-moments 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

[19]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 (1994), Berry, Levinsohn, and Pakes (1995). The Online Appendix presents more details.

market and in each period. Recall that in market m, at time t, F_t^m is the number of schools and $S_{k,t}^m$ is the number of students of type k.[20] Thus, for each $x = \{q, \text{op}, d\}$ we can define micro-moments as follows

$$\bar{g}_{k,t}^{x,m}(\theta) = \frac{1}{S_{k,t}^m} \sum_{i \in S_{k,t}^m} x_{i,t} - \sum_{n}^{N_m} \sum_{j}^{F_t^m} w_{\text{loc},k}^m \cdot s_{jt}^{nk}(\theta) \cdot x_{j,t} \qquad \text{micro-moments for } x = \{q, \text{op}, d\}\,. \tag{15}$$

The third group of moments are defined by a set of orthogonality conditions that require the instruments, $Z_{j,t}$, to be independent of $\xi_{j,t}$, which is the per-period empirical analogue of ξ_j. $Z_{j,t}$ include exogenous 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,

$$\bar{g}^{IV}(\theta) = \frac{1}{N} \sum \xi_j(\theta) \cdot Z_j \qquad \text{IV moments.} \tag{16}$$

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

$$\hat{\theta}^* = \underset{\theta}{\operatorname{argmin}} \begin{bmatrix} \bar{g}^{MM}(\theta) \\ \bar{g}^{IV}(\theta) \end{bmatrix}' \begin{bmatrix} W_{MM} & 0 \\ 0 & W_{IV} \end{bmatrix} \begin{bmatrix} \bar{g}^{MM}(\theta) \\ \bar{g}^{IV}(\theta) \end{bmatrix} \qquad \text{s.t. } \bar{g}^{SM}(\theta) = 0,\ \xi_{0,t}^m = 0\, \forall\, t, m. \tag{17}$$

Following Berry (1994), aggregate market shares are treated as constraints that hold exactly in the model. For each guess of the non-linear parameters affecting demand, mean utilities are covered by inverting these market shares through 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 $\xi_{0,t}^m = 0$ for one

[20] I observe the population micro-data on choices of q_j and $\text{op}_{k(i),j}$ but each of these will be measured with error. I have the approximate driving distance to school for 50% of the population which is also an approximation and measured with error.

public school in each market and time period. This normalization implies the inclusion of market and time fixed effects in first stage regression and the demand model.

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. I construct standard errors 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 following Berry, Levinsohn, and Pakes (1995). As is common in this literature, the empirical model of demand presented 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 ξ that are correlated with price and academic quality. The key identification condition is to have instruments that are independent of $\widetilde{\xi}_{j,t}$ and provide independent variation in the endogenous variables price, quality, and market share.[21]

In my model, schools can adjust both prices and their academic quality each period. However, I assume their other characteristics, including non-academic quality ξ, are fixed and exogenous. To accommodate the panel aspect of the data, I assume that the estimated $\widetilde{\xi}_{j,t}$ is made up of two components. The first is a schools' fixed non-academic attribute ξ_j. This component was motivated in Section 3 as measuring non-learning attributes such as the charisma of the principal or how families perceive the values and culture at the school. The second component of $\widetilde{\xi}_{j,t}$ is a period-specific idiosyncratic shock $\Delta\xi_{j,t}$, which can represent unexpected demand shocks or measurement error in school academic quality that do not influence the choices of price and academic quality. $\widetilde{\xi}_{j,t}$ can be described as $\widetilde{\xi}_{j,t} = \xi_j + \Delta\xi_{j,t}$. By making this distinction,

[21] While Berry and Haile (2014) describe non-parametric identification results using only aggregate data, these results carry over to the case with micro-data. Relevant to this application, Berry and Haile (2020) show that micro-data can aid identification and reduce reliance on instruments for identification.

I effectively allow for schools to adjust their test score value-added in addition to the usual assumptions in BLP applications where only prices are endogenous and not quality. However, it remains necessary to assume the absence of other endogenous characteristics. This assumption implies that any efforts to increase demand are fully reflected in either measured changes in school value-added or adjustments to prices.

Another important feature of this application is that there is no outside option so I normalize $\widetilde{\xi}_{j,t}$ in each market and period by $\widetilde{\xi}^{m}_{0,t}$. This effectively serves as a market and time fixed effect that absorbs any shocks at the market and period level.

The key assumptions I make regarding $\widetilde{\xi}_{j,t}$ are that i) ξ_j is fixed and orthogonal to the instruments $Z_{j,t}$, ii) the period-specific idiosyncratic shocks $\Delta\xi_{j,t}$ are independent of prices and academic quality chosen by the school, and also iii) $\Delta\xi_{j,t}$ is independent of the instruments $Z_{j,t}$. The first assumption is the usual orthogonality condition. The second and third conditions are needed to ensure $\widetilde{\xi}_{j,t} \perp Z_{j,t}$ and are likely to be met if $\Delta\xi_{j,t}$ represents classical measurement error in the observed academic quality or if it represents an idiosyncratic shock to demand that schools do not know, do not expect, or otherwise ignore, when choosing prices and quality each period. These assumptions would be violated if schools could quickly invest in their non-academic quality or if they could set prices and academic quality as a function of $E(\Delta\xi_{j,t}) \neq 0$. Under these assumptions, this IV strategy provides consistent estimates of the parameters, even in the presence of measurement error in school academic quality. [22]

The first source of exogenous variation is based on the policy variation described in the previous sections. Specifically, I use the timing of the implementation of the targeted voucher policy interacted with schools' varying exposure to the policy. Like the policy exposure variable used in the difference-in-differences model in Equation (13) and Card, Dooley, and Payne (2010), I use the sudden change in voucher policy interacted with the concentration of eligible students near the school. A related in-

[22] An alternative approach would be to use a shrinkage procedure to adjust value-added estimates. I choose not to use Bayesian procedures that assume a prior that does not stem directly from the equilibrium model of demand and supply. While there is an optimal level of shrinkage for this kind of model, it is a non-trivial question that is beyond the scope of this paper.

strument generated by the policy variation, is the change in the average transfer each school gets as a function of the policy. Table I presents the fixed effects model that uses this same simulated transfer. To construct this instrument, I fix school student composition at their 2005 level before the policy, and then calculate the difference between the simulated trajectory for government transfers over time both with and without the SEP policy. These instruments are based on the assumption that ξ_j is exogenous to the timing of the voucher policy implementation and broader neighborhood characteristics. As with a difference-in-differences model, there are several ways this instrument could be invalid. For example, if residential choice is a margin that can quickly adjust to the policy change, the concentration of eligible families near a school could change as a result of the policy. On this margin there is no evidence of significant urban change during the relevant period before or after the policy change.

The second type of instrument is a proxy for labor costs faced by schools in different geographic locations. Schools' balance sheet data show 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 ℓ fixed effect which absorbs the average earnings deviation for high skilled workers in the same geographical area as follows: $\text{earnings}_{i,t} = wx_i\phi^w + \omega_{\ell(i),t} + \text{e}_{i,t}$,[23] where $\text{e}_{i,t}$ is an idiosyncratic shock to earnings. Here $\omega_{\ell,t}$ represents the additional cost of employing high skilled workers at location ℓ, and time t. Like the policy instruments, the variation over time and space captured by $\omega_{\ell,t}$ is a valid instrument given ξ_j is fixed and not systematically correlated with broader location characteristics.

[23]The worker is associated to a geographic location defined here as a "*Comuna*". 128 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*.

Finally, I include schools' own exogenous characteristics as instruments. Table II 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 2006, 2007, and then 2011, 2012). 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 II

REGRESSION OF ENDOGENOUS VARIABLES ON INSTRUMENTAL VARIABLES

	Academic Quality $q_{j,t}$		Price $p_{j,t}$		Shares $s_{j,t}$	
	(1)	(2)	(1)	(2)	(1)	(2)
% Eligible E						
x Public	-0.71 (0.03)	-0.74 (0.04)	0.00 (.)	0.00 (.)	0.06 (0.00)	0.06 (0.00)
x Voucher	-0.49 (0.03)	-0.59 (0.04)	-2.97 (0.06)	-2.74 (0.09)	0.03 (0.00)	0.03 (0.00)
x Public x Policy	0.77 (0.04)	1.03 (0.09)	0.00 (.)	0.00 (.)	0.02 (0.00)	0.01 (0.01)
x Voucher x Policy	0.70 (0.03)	0.82 (0.06)	1.57 (0.07)	1.69 (0.12)	0.02 (0.00)	0.02 (0.00)
Labor Costs $\omega_{\ell,t}$						
x Voucher	-0.11 (0.01)	-0.16 (0.02)	0.38 (0.02)	0.38 (0.04)	-0.02 (0.00)	-0.03 (0.00)
x Private	-0.17 (0.02)	-0.07 (0.04)	1.24 (0.04)	1.36 (0.07)	-0.02 (0.00)	-0.02 (0.00)
Δ Mg Transfers						
x Public	-0.71 (0.03)	-0.71 (0.07)	0.00 (.)	0.00 (.)	-0.04 (0.00)	-0.03 (0.01)
x Public x %E	0.06 (0.02)	0.05 (0.04)	0.00 (.)	0.00 (.)	-0.01 (0.00)	-0.00 (0.00)
x Voucher	-0.80 (0.02)	-0.72 (0.05)	-1.45 (0.04)	-1.59 (0.10)	-0.01 (0.00)	-0.02 (0.00)
x Voucher x %E	0.08 (0.02)	0.08 (0.05)	0.63 (0.04)	0.54 (0.09)	-0.01 (0.00)	-0.01 (0.00)
Exogenous Own x_j	✓	✓	✓	✓	✓	✓
R^2	0.28	0.27	0.86	0.86	0.09	0.09
F-stat Excluded IV	285.86	77.99	1062.29	322.53	271.10	88.64
N Obs	40,758	13,701	26,742	9,015	41,329	13,931

Note: Price regressions do not consider public schools, since they do not charge any out-of-pocket fees. Columns (2) considers years 2006, 2007, 2011, and 2012. All columns include year fixed effects. Quality regressions have fewer observations (571 school-by-year observations considering all years) because schools with less than 10 students with test scores or information on birth records are excluded. The number of observations varies between the estimates of Academic Quality and Shares because not all schools have observable quality measures, whereas share data is available for all schools.

Similar to concerns in difference-in-differences models, the instruments derived from policy changes might be invalid if external factors influenced the assumed exogeneity. For instance, if families adjust their residential choices in response to the voucher policy, this could alter the concentration of eligible students near schools, thereby affecting the instrument based on policy exposure. An examination of the composition of neighborhoods and schools before and after the policy suggests that changes in neighborhood composition played a very limited role.[24] Moreover, the absence of differential pre-trends in average test scores between the two groups strengthens the credibility of the identification strategy, as shown in Figure 3.

7.3. *Quantifying Heterogenous Demand for Schools*

Table III presents the estimated demand parameters. The main specification uses data from four years and 53 markets including the Santiago Metropolitan 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, mother's education is generally more relevant than poverty status as a driver of 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.[25]

Figure 4 compares the data and the model simulations by plotting the average academic quality, distance, and out-of-pocket cost $(\overline{q}, \overline{d}, \overline{\mathrm{op}})$ for families of different types in each market and year. The model is able to capture variation across types

[24] See Figure 8 of the Online Appendix for supporting evidence.

[25] See related models of school choice like Hastings, Kane, and Staiger (2009), Gallego, Hernando, Flabbi, and Tartari (2008), Carneiro, Das, and Reis (2016). I present a robustness analysis in the Online Appendix with different sets of instruments, markets, and years. In each case I find the same broad patterns.

and markets, especially for quality and price where micro-moments 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 poor students 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.

TABLE III

DEMAND MODEL ESTIMATES

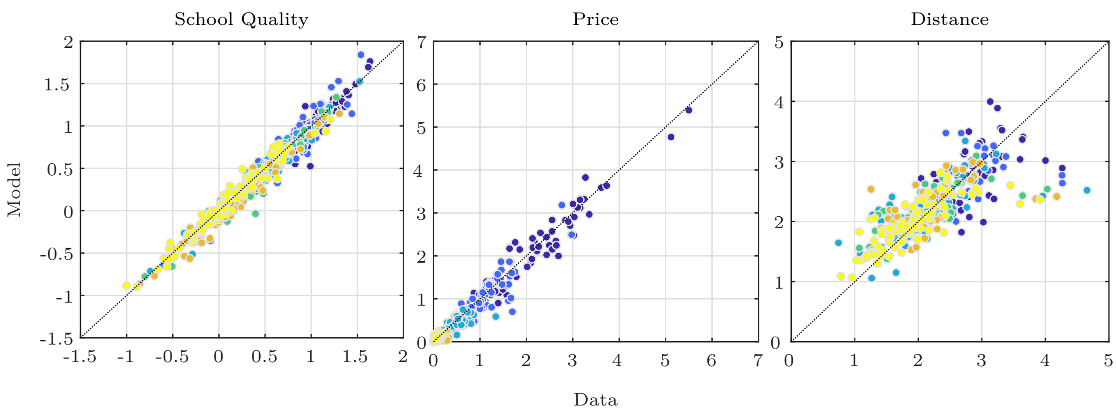
$\overline{\beta}^x$ - Common Preferences for School Characteristics x_j		Voucher	Non-Voucher
Type of Private		-0.86 (0.04)	2.49 (0.17)
Catholic		0.08 (0.04)	-0.02 (0.08)
Other Religious		0.11 (0.04)	0.50 (0.08)
Has K-12 Grades		0.07 (0.02)	-0.98 (0.18)
Entered Prior 1995		0.84 (0.02)	0.70 (0.06)
Entered 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)		
β_k^x - Observable Heterogenity by Mother Education	Quality β_k^q	Price α_k^{op}	Distance λ_k^d
Less than High School (≤ 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)
β_k^x - Observable Heterogenity by Poverty Status 40%	-0.31 (0.01)	-1.48 (0.03)	-0.05 (0.01)
σ_q - Unobservable Heterogenity for Academic Quality	0.80 (0.05)		

Note: Standard errors are presented in parentheses next to estimated coefficients. The first panel presents estimates for aggregated preferences on school characteristics. The second panel presents the estimate for aggregated preference on academic quality. The third panel presents estimates on preferences by mother education. The fourth panel presents estimates on school quality, price, and distance by poverty status. The last panel presents the estimate for unobservable heterogeneity for academic quality.

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. In the following section I examine whether the intensity of competitive pressure is sufficient to drive substantial changes.

I conduct several robustness exercises and present results in the Online Appendix. The first test estimates the model excluding the largest market (Santiago). The results are similar with a slightly higher estimated standard deviation on unobserved preferences for quality. I then test a specification that includes fixed effects to control for public school management, which is at the *Comuna* level. This did not produce meaningful changes. Finally, I evaluate the effects of limiting the IVs to only those coming from the policy (and time) variation. I find that demand estimates remained similar, although preferences for school academic quality were found to be higher.

FIGURE 4.—Choices in the Model and Micro-data by Market, Type, and Year $(\overline{q}, \overline{d}, \overline{\text{op}})$



Note: Averages are calculated using micro-data (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).

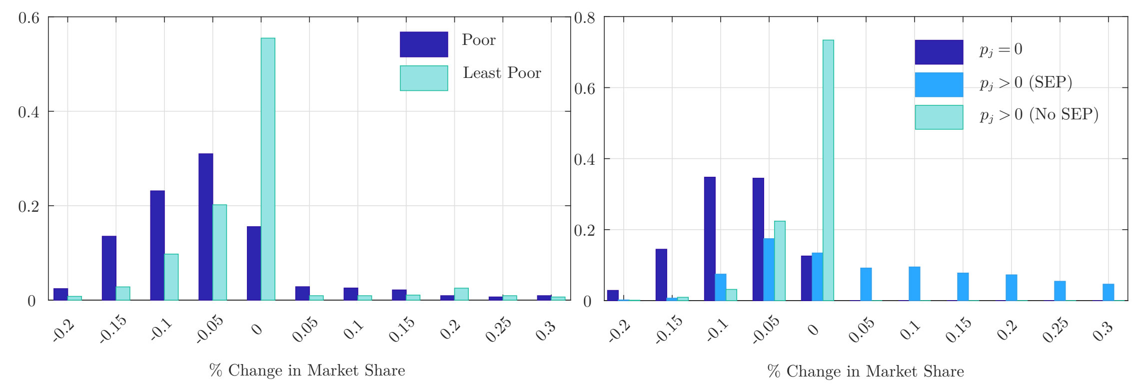
8. QUANTITATIVE ANALYSIS OF VOUCHER POLICY AND EQUILIBRIUM QUALITY

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 quality and sticker prices fixed.

The left panel of Figure 5 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.

FIGURE 5.—Counterfactual Change in Market Shares $(\mathbf{op}(\mathbf{p}^{\mathrm{e}}_0, V^{\text{flat}}) \rightarrow \mathbf{op}'(\mathbf{p}^{\mathrm{e}}_0, V^{\text{target}}))$



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

Aggregating over the counterfactual allocation of students to schools, I can calculate the overall policy effect when only out-of-pocket prices are changed $(\Delta\overline{q}^{\not{\mathrm{E}},\mathrm{E}}(\mathbf{q}^{\mathrm{e}}_0, \mathbf{p}^{\mathrm{e}}_0, \mathbf{op}'_0)$ and compare it to the pre-policy gap $(\Delta\overline{q}^{\not{\mathrm{E}},\mathrm{E}}(\mathbf{q}^{\mathrm{e}}_0, \mathbf{p}^{\mathrm{e}}_0, \mathbf{op}_0))$. This comparison shows that the gap between richer and poorer students closes when out-of-pocket prices fall at participating schools $(\mathbf{op}(\mathbf{p}^{\mathrm{e}}_0, V^{\text{flat}}) \rightarrow \mathbf{op}'(\mathbf{p}^{\mathrm{e}}_0, V^{\text{target}}))$. However, this counterfactual that leaves out changes in academic quality, represents only 20% of the actual reduction in the post-policy targeted voucher equilibrium. Repeating the exercise, forcing all voucher schools to participate, closes the gap by 40% of the final reduction, showing that the limited effect from only demand side sorting is not driven by the extensive margin adoption of the policy. In both cases, expanding choice on its own would have had much smaller effects without the supply side adjustment.

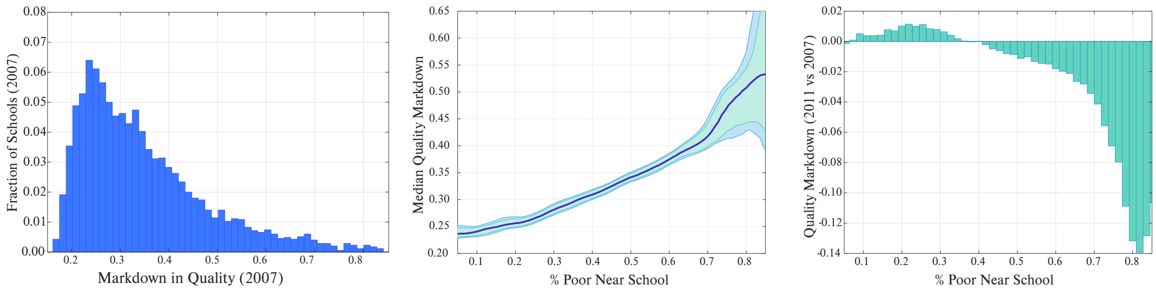
Finally, it is important to note while this counterfactual is only possible to construct with the estimated demand model, the predicted changes in market shares are significantly correlated with actual changes in quality ex-post for private voucher schools. In particular, schools that are predicted to lose more students in the counterfactual above are found to improve their value-added more after the policy is implemented. Interestingly, this finding is also true for schools that did not participate in the targeted voucher program. These schools obtained no additional revenue, but improved more ex-post when the model estimates indicate they would have lost market share had they not improved. This result is consistent with the existence of equilibrium spillovers from competition.

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

The model suggests that local market power is one important determining factor 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 6 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.

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.

FIGURE 6.—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.

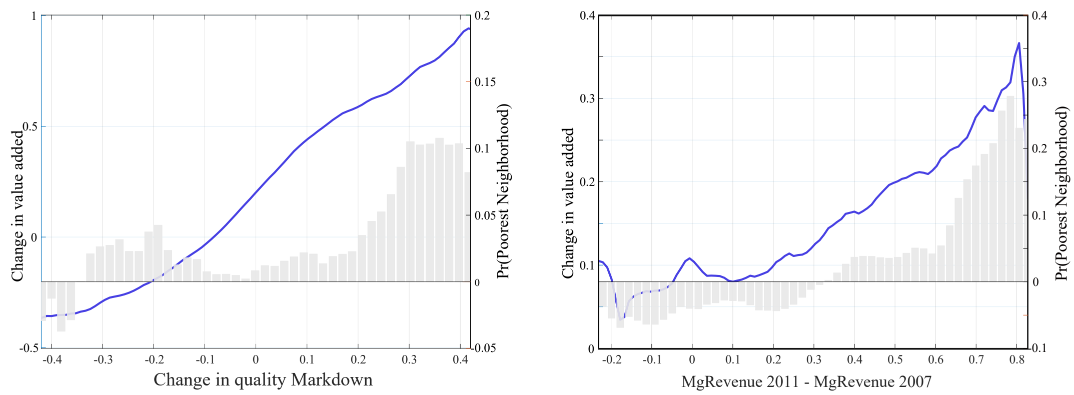
Finally, in the panel on the right I show the average change in the markdown at each school from 2007 to 2011 by nearby poverty. On average, schools in the poorest neighborhoods lost more market power ex-post. This result indicates that changing competitive incentives could be a relevant mechanism through which the policy affected school value-added 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 would shift both the marginal revenue associated with attracting an additional student and the market power the school may have to reduce quality. The estimated model and data from the equilibrium before and after the policy can be used to study how the changes to market power and marginal revenue are related to observed changes in academic quality.

In the left panel of Figure 7, the left axis shows the conditional mean of the change in academic quality given the change in markdowns, presented as $-\Delta\mu_j^q = \mu_{j,07}^q\left(\widehat{\theta}\right) - \mu_{j,11}^q\left(\widehat{\theta}\right)$. 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 experienced a greater markdown in 2007 compared to 2011, tend to show larger gains in academic quality and are more likely to be located in the poorest neighborhoods. The right panel presents similar statistics, now conditioned on changes in marginal revenue. The results suggest a positive relationship between changes in marginal revenue and improvements in academic quality, with schools experiencing greater increases in marginal revenue more likely to be located in the poorest neighborhoods.

FIGURE 7.—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 ± 0.02.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 Equation (10).

The model explicitly defines the relationship between changes in quality, market power, and marginal revenue, as shown in Equation (10). Assuming academic quality $\hat{q}_j$ is measured with error, I estimate the empirical analogue of Equation (10) described in Equation (18) 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,

$$\Delta\hat{q}_j = \beta^{\mu,07}\mu^q_{j,07}(\widehat{\theta}) + \beta^{\mu,11}\mu^q_{j,11}(\widehat{\theta}) + \beta^{\mathrm{MgRev}}\Delta\mathrm{MgRev}_j(\widehat{\theta}) + \epsilon^q_j. \tag{18}$$

Table IV 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 US$1,000 increases school academic quality by 0.1σ.

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, which is not in the model but was significantly related to improvements in school quality. Columns (3) and (4) report coefficients that 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.

TABLE IV

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)
Δ 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.

I use the estimated coefficients from column (1) of Table IV to describe the relative contribution that competitive incentives and marginal revenue have had in explaining the changes in academic quality. The targeted voucher policy generally increased marginal revenue for most participating voucher schools, though to varying degrees. The contribution to the predicted growth in quality was 0.01, 0.03, and 0.05 for the 25th, 50th, and 75th percentiles, respectively.

Changes in markdowns had mixed effects, with a median contribution to value-added of approximately zero. However, markdowns were the primary driver of quality improvements in schools with above-median growth in value-added. Here I see that 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 where marginal revenue increases by three time as much (up to $US900 relative to the average change of $US300). 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.

9. CONCLUSION

This paper examines the primary education market in Chile, focusing on how private for-profit schools responded to targeted vouchers. Using a demand-and-supply model with imperfect competition, I analyze the key mechanisms driving their improvement under this policy.

The main contribution of this empirical model is that it enables precise measurement of the mechanisms driving school quality incentives. Quantifying these effects reveals how voucher policy shapes school quality, particularly through competitive spillovers. Furthermore, the estimated model produces measures of market power and marginal revenue that capture the influence of neighborhood poverty in explaining the observed change in school quality. These mechanisms thus provide a micro-foundation for the program evaluation strategy based on exposure to poverty. At the same time, they provide a way to quantify the importance of each underlying mechanism.

My findings suggest a previously undocumented cause of structural inequality in education markets under a flat voucher: a link between school market power and neighborhood poverty. This relationship leads to more inequality in access to quality education, even in the absence of additional frictions specific to education markets.

A targeted voucher policy with larger subsidies for poor students reduces inequality from the flat voucher system 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 changes schools' local market power by eliminating out-of-pocket fees as a dimension of differentiation and increasing competition. Using the estimated model, I show that the schools that improved substantially did so due to both an increase in marginal revenue and a reduction of market power.

The targeted voucher policy expanded choice, but I show that without the equilibrium supply-side reaction, it would have only reached 20% to 40% of the observed gains in equity. The reason is 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 families' school selection process. These assumptions are justified in the current context, given the specific research question and empirical setting and discussed further in the Online Appendix. However, future work aiming to address a broader set of policy questions and counterfactual scenarios should consider these limitations and explore ways to enrich the model to incorporate education-specific frictions. In this direction, Allende (2020) provides a promising extension by incorporating social interactions and peer effects into both the demand side and the education production function, enabling the analysis of more complex policy environments.

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