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

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Abstract

I use an empirical model of school choice and competition to study how the structure of voucher policy design can influence the incentives schools have to invest in quality. I estimate a model of demand for schools using administrative microdata from Chile leveraging a significant policy change that eliminated out-of-pocket tuition fees for almost half of students at most schools. Demand estimates are combined with a model of for-profit school competition to highlight that a flat voucher with top-off fees leads to heterogeneity in competitive incentives and contributes to inequality in school quality. While the shift in voucher policy in Chile is shown to be associated with increased academic achievement and a reduced gap between rich and poor, the model also indicates that the large change has general equilibrium effects that preclude rigorous policy evaluation. Counterfactual simulations using the estimated model indicate that the policy shift to a targeted voucher with no top-off fees implemented in Chile diminished local market power of schools in poor neighborhoods and contributed to a supply side driven increase in the academic achievement of underprivileged students.

Keywords: Voucher Policy, School Competition, Targeted Vouchers, School Choice.

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1. INTRODUCTION

Introducing competitive market incentives in education has been a frequent topic in the policy debate over how to most efficiently improve the education system. Advocates have long argued that privatization will improve aggregate academic achievement and provide poor families with better educational opportunities. However, theoretical and empirical research has suggested that the context and policy details can matter quite a lot and the privatization of education markets could, in some cases, increase inequality and potentially worsen the outcomes of poor students (Bettinger, 2011; Epple, Romano, and Urquiola, 2017).[1]

In this paper, I develop an empirical model of school choice and competition to study how the structure of voucher policy design can affect the incentives schools face, and as a consequence, influence the distribution of academic achievement across socioeconomic groups. I first model families' choice of school in an environment where spatially differentiated schools compete for students by choosing their quality and prices.[2] This empirical demand model accommodates school unobservable characteristics, as well as observable and unobservable consumer heterogeneity at the census block level, providing a rich description of how families and schools interact. I estimate this empirical demand model for schools using micro-and macro-moments generated from administrative data from Chile following Berry, Levinsohn, and Pakes (2004) and Petrin (2002). I leverage a significant policy change that effectively eliminated out-of-pocket tuition fees for almost half of the students at most schools to generate credible instruments

[1]See early work by Neal (2002) and Ladd (2002), a review of international voucher programs in Chile, Colombia, and Sweden by Bettinger (2011), and recent comprehensive reviews by Urquiola (2016) and Epple, Romano, and Urquiola (2017).

[2]See literature estimating discrete choice models of school choice including recent work by Carneiro, Das, and Reis (2013); Walters (2014) and Dinerstein and Smith (2015).

to account for the endogeneity of prices and quality as in Berry (1994) and Berry, Levinsohn, and Pakes (1995).

I then develop a stylized model of school profit maximization which highlights the tradeoffs schools make when choosing quality and price in this context. Schools' first order conditions can be arranged to show how much quality will be marked down as a function of local market power, which in turn depends on the sensitivity of demand to changes in school quality, current price regulation, and voucher policy. The relevant quantities can be determined using demand estimates only and can be projected onto any census block to give a spatial description of competitive pressure across and within markets.

I show that in this empirical framework there is scope for voucher policy design to affect the degree of competition among schools. Demand estimates indicate that preferences for prices, distance, and quality are heterogeneous, and that poor households are particularly sensitive to price and distance to the school. Given the distribution of preferences and households across city blocks, schools in poor neighborhoods are found to have more local market power and thus mark down their quality more than schools in more affluent areas given the flat voucher structure initially in place in Chile. In other words, this first result shows that in the context of a flat voucher and no additional frictions specific to education markets, standard demand heterogeneity and product differentiation leads to significant inequality in the provision of school quality across socioeconomic groups due exclusively to differences in competitive pressure across and within markets. This type of inequality in school quality has been documented extensively in the education economics literature but has generally been attributed to education specific market frictions, not the consequence of heterogeneity of demand and product differentiation arising naturally with a flat voucher.[3]

[3]Education specific frictions such as peer effects and cream skimming tend to be

The voucher policy change in Chile provides a unique opportunity to evaluate the empirical relevance of this framework. After decades of flat vouchers and top-off fees, the *Subsidio Escolar Preferencial* (SEP) law was introduced in 2008, which raised the voucher amount for poor students and effectively eliminated tuition fees for approximately 40% of students at most voucher schools. It also mechanically provided more resources to public and private schools with poor students and established some additional regulation on the use of these funds. This is a large policy that affects almost half the population and inevitably has indirect effects on all students and schools in varying degrees depending on their exposure to changing market conditions. Descriptive evidence shows that after several years of almost no changes in student achievement, following the implementation of the targeted voucher policy, test scores of the poorest children rose significantly and the gap between that group and the rest of the population closed.[4] This represents a significant break in the evolution of average test scores and inequality in educational achievement in Chile. Results presented in the paper as well as other empirical research provide evidence that this increase in academic achievement was not the result of a massive reshuffling of students to more productive schools but driven by schools improving their quality. While it is impossible to know for sure how important sorting could have been over time if schools were not allowed to adjust their prices and quality, counterfactual simulations based on the estimated demand model confirm that the

commonly mentioned to explain the lack of competition between private and public schools. See for example Hsieh and Urquiola (2006) for early empirical work and Epple and Romano (1998) or Epple and Romano (2012) for theoretical and quantitative work highlighting the potential impact of education-specific frictions.

[4]The overall positive effects of this policy have been noted in contemporaneous research as well as in the popular press. International test score results also show gains adding credence to the claim that the program was effective, see the Online Appendix for more details.

improvement of achievement is driven mostly by the supply side reaction to the policy.

The strong supply side response is interesting to study because there are several aspects of the policy frequently mentioned in the education economics literature that could have led to improved school quality. One obvious candidate is that the increased quality could partly be rationalized by an increase in resources due to the larger voucher for poor students. While this is possible and surely part of the story, past experience in developing countries, and Chile in particular, have shown that increases in resources do not always lead to improvements in achievement (Glewwe, Hanushek, Humpage, and Ravina, 2011). In a context of a large for-profit sector such as Chile, this seems even less likely.[5] A second potential reason for improved outcomes is that the policy mandated increased oversight on the one hand and increased administrative support on the other. Though this seems like a promising avenue of pursuit to better understand the relevance of policy design details, it is unlikely to explain all of the observed results given the lack of capacity to implement these guidelines within the government, especially during the initial period of the policy.[6]

The second main result of the paper is that moving from a flat voucher with top-off fees to a system with targeted vouchers with no top-off fees leads to increased competition in the poorest neighborhoods. This result can help rationalize the success of the policy, especially when trying to understanding the increase in quality found at private for-profit voucher

[5] The overall increase in resources spent per capita on primary education increased at a similar rate during the years prior to the reform but yielded minimal improvements in test scores. See the Online Appendix for more details.

[6] While the policy describes several penalties for not complying with guidelines for the use of funds or for not reaching stated goals, minimal consequences were faced by schools during the period under study.

schools. The estimates of mark downs are shown to change with the policy, both at impact and once schools have had time to adjust. In addition, the changes in quality at the school level correlate with the estimated changes in quality markdowns.

These results are important because they suggest avenues for the efficient improvement of current voucher systems as well as insight into empirically relevant policy design aspects to consider in the design of future voucher systems. The main result emphasizes the important role of the supply-side responses to voucher policy design and how targeted subsidies can affect the distribution of quality in a market-oriented school system by changing incentives to compete on quality. The explicit modeling of price and quality highlights empirically that the details of the regulatory environment matter substantially for the incentives schools face and the resulting equilibrium outcomes.

While the SEP policy implemented in Chile has many interesting facets worth studying further, this analysis suggests that one channel through which price regulation and targeted vouchers improved outcomes is by increasing competition in neighborhoods where incentives to invest in quality are weakest.

2. INSTITUTIONAL CONTEXT AND THE CHANGE IN VOUCHER POLICY

The voucher market in Chile was first created through reforms to the organization and financing of the education system in 1980, beginning with a flat voucher and not additional fees were allowed.[7] In the early 1990s,

[7]The reader is directed to many excellent reviews of the Chilean voucher reform such as Gauri (1999), Beyer, Larraín, and Vergara (2000) and Espínola, de Moura Castro, and de Desarrollo (1999). Of particular interest is Prieto Bafalluy (1983) which is authored by the minister of education that implemented the reforms, and provides a clear description of the context and arguments that motivated the reforms.

schools were allowed to charge fees in addition to the voucher with the establishment of the *Financiamiento compartido, Ley 19.247*. Over the next two decades, the government steadily raised the real value of the voucher and made significant financial efforts to help the most vulnerable schools through programs like the *P-900* and *Programa MECE*. Nevertheless, basic features of the voucher program did not change dramatically over the 28 years. In 2012, over 60% of students entering first grade are matriculated in the private sector.[8]

In 2008, the *Ley de Subvenciòn Escolar Preferencial* (SEP), *Ley 20.248*, was put into place and established a new targeted voucher that would transfer significantly more resources to schools for each eligible student matriculated. This effectively eliminated out of pocket tuition paid by eligible students at participating schools because it forced schools to not add any additional top-up fees.[9] This represents the first major change to the voucher policy program since top-off fees were allowing in the early 1990s.

Eligibility to the program was reserved for approximately the poorest 40% of the population. Eligibility is determined in several ways, but the two most common ways are for the student to be accredited as belonging to the lowest 33% of the income distribution according to the government's rank-

[8]The Online Appendix contains a detailed time line of education policy changes related to school funding in Chile, as well as more information regarding the evolution of the public and private market shares over time and relevant policies that occurred.

[9]Several authors have suggested deviating from a flat voucher environment to one that conditions the voucher amount on student characteristics such as income Nechyba (2000); Epple and Romano (2008), and in the case of Chile in particular, González, Mizala, and Romaguera (2002) and Gallego and Sapelli (2007) argue in favor of a targeted voucher system similar to the implementation that was carried out in 2008. An expansive review of the details of the SEP policy can be found in (de Politicas Publicas, 2012) as well as many studies documenting the different aspects of the policy and its implementation. A growing literature on the SEP policy and its effects is described in the Online Appendix.

ing of socioeconomic status called *Ficha de Proteccion Social* or to belong to the social program for poor families called *Chile Solidario*. These two criteria accounted for over 86% of all participants in the SEP program in 2010.[10] The same law that introduced the SEP targeted voucher also introduced an additional voucher subsidy for schools that had a high percentage of poor students. This additional subsidy is called the *Subvención por Concentración* (SC) and was much smaller in size than the SEP voucher. The additional targeted vouchers would be available to all public schools, as well as for voucher schools that signed up for the policy. It also required schools to not charge eligible students any tuition fees and not to select students on the basis of their previous academic performance. Schools also needed to provide a plan (*Plan de Mejoramiento Educativo*) regarding how the additional resources were going to be used. Schools joined the policy in large numbers, and by 2011 75% of schools receiving vouchers had been accredited, including virtually all public schools and two-thirds of private voucher schools.[11] In 2011, the SEP subsidy amount was further increased by 21% and additional modifications were implemented. The policy also had a series of other implementation design details that are very interesting. Schools receiving the additional voucher were asked to provide plans regarding how they would use the additional funds, asking schools to set goals and guidance and support to implement these plans was provided as well as the threat of losing their accredited status in theory. In practice it is hard to know how the policy details such as these were implemented and this paper focuses on the incentives that come directly from the change in voucher structure

[10] Additional avenues to be considered eligible are that the students' parents show that they are poor, of very low education or part of the lowest socioeconomic group in the public health system.

[11] Additional regulation was implemented with the *Ley General de Educación (LGE)*, *Ley 20.370*, including the creation of an agency in charge of regulating and informing on the quality of schools. These policies were not directly related to the SEP policy.

and I abstract away from these relevant implementation design features of the policy. This study focuses on the first period between 2005 and 2011 where the regulatory environment system was relatively stable except for the SEP law in 2008. Implementation of regulatory norms regarding the details of the policy such as setting and meeting goals were also seemingly not enforced during this period as there are no schools that were punish for not complying with the accompanying bureaucracy associated with schools participating in the SEP policy.[12]

2.1. *Stylized Facts*

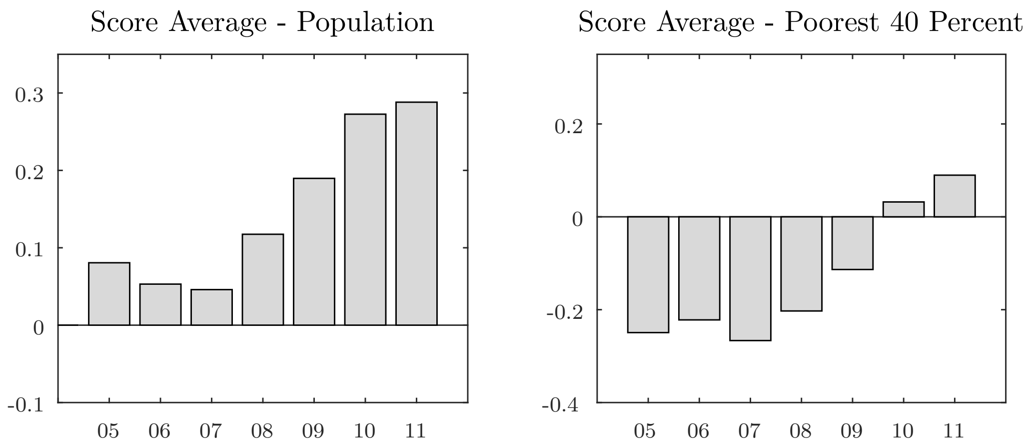
In this section I document a series of stylized facts about the Chilean education system and how they have changed. The first stylized fact is that official state mandated test score outcomes improved in the aggregate after the implementation of the SEP policy, breaking with eight years of stagnation. Test scores are standardized relative to a baseline test in 1999 so that scores are comparable across time. The left panel of Figure 1 shows the evolution of the average test score for students in 4th grade (averaged over both math and language). From 1999 to 2007, the growth in the average test score was almost negligible, while the next six years saw growth of almost 0.3σ. The right panel of Figure 1 shows this growth pattern was also seen among the poorest students in the country.[13]

The second relevant feature is that the large gap between the academic achievement of students with different socioeconomic backgrounds has closed over the last six years. Prior to 2008, the average test score of students from the 40% poorest households ranged between -0.15σ and -0.3σ depending

[12]The Online Appendix provides further background information about the policy implementation and background regarding the implementation of the policy.

[13]Several different ways of measuring achievement are presenting in the Online Appendix, all providing similar conclusions regarding the rise in aggregate test scores.

FIGURE 1.— Evolution of Academic Achievement



Note: Average scores had not changed since 1999 and the left panel of this figure shows how average test scores in 4th grade evolved over time since 2005. Test scores are comparable across years and are standardized relative to the baseline test in 1999. The average test score indicates the average across math and reading test scores of all students in a given year. The right panel of this figure shows average test scores for students in the 40% poorest households.
Source: Ministry of Education MINEDUC.

on the year and the exact definition of poor.[14] However the average student in the richest 60% had an average of approximately 0.4σ over the same time period. Since 2005, these differences have diminished from 0.6σ to approximately 0.4σ. In 2011, students of the 40% poorest families obtained an average of 0.08σ while the average of the rest of the students was 0.48σ which represents a closing of the gap by 0.2σ which represents approximately one third of the original gap. Deciding how to divide rich and poor in this exercise is of course arbitrary and different definitions of income will

[14]Poverty status is determined by calculating the per capital income percentile using household surveys that tested students parents fill out. Alternative methods of imputing poverty status for students with used applied based on a rich set of demographics about the student and parents available through administrative health and education records. The Online Appendix presents different definitions of poverty used in robustness checks throughout the paper.

have different coverage and different magnitudes in terms of the evolution of the test score gap. Revelent for this paper is that the poorest students in the distribution caught up with their richer counterparts during the period under study. These improvements have persisted and remained relatively stable to 2016.

These aggregate results have not gone unnoticed; the improvements in test scores and the reduction of the gap between socioeconomic groups has been mentioned in the press and in the policy debate. News pieces in the popular press as well as in other parallel academic work done in Chile have identified the targeted voucher policy as being an important contributor to the observed results. [15]

International evaluations such as the PISA and TIMSS evaluations also show evidence that is consistent with these findings. Comparing TIMSS and PISA tests prior 2008 and after 2011 show clear evidence that academic achievement grew substantially and the gap across socioeconomic groups was reduced.[16]

The policy of targeted vouchers and limiting top-off fees implemented in 2008 was intended to help students from poor backgrounds and the stylized facts presented above suggest the policy was successful in this regard. We

[15]For example MINEDUC (2012),Neilson (2013),Raczynski, Muñoz, Weinstein, and Pascual (2013),Correa, Parro, and Reyes (2014),Mizala and Torche (2013),Carrasco (2014),Valenzuela, Allende, Gómez, and Trivelli (2015) and others provide different empirical strategies to find evidence suggesting the SEP policy had positive effects, while differing in the mechanisms that are highlighted. Recent work corroborating these earlier findings include Murnane, Waldman, Willett, Bos, and Vegas (2017) and Mizala and Torche (2017). In contrast, Feigenberg, Rivkin, and Yan (2017) argue that there is no policy effect. The Online Appendix surveys the policy evaluation literature on the SEP policy.

[16]The Online Appendix describes the evolution of international test scores over the time period under study which again are also consistent with increased academic achievement and reduced gaps across socioeconomic groups during this period.

have seen that this group of students, broadly defined, have been catching up with their peers from higher income families over the time period after the SEP policy was implemented. To some extent it is not that surprising that something happened given the large change in additional resources spent on the education of the poorest students. However, it is important to note at this point that to correctly disentangle the effects of the policy a researcher faces several challenges. The first is that participation in the policy is endogenous for students as well as schools. Eligibility by poverty status also requires the family to have a poverty score, something that had been increasing in coverage over the time period under study and to some extent is endogenous to the benefits for families to sign up. Data availability and quality is likely changing over this time period as well. A second challenge is that the policy inherently has spill over effects since school improvements are likely to affect not only the beneficiaries of the additional voucher but also other non beneficiaries attending the same school. Moreover, the large change is likely to have general equilibrium effects if schools compete with each other, such that students who are not eligible and attend schools that are not eligible might also benefit from the policy.

This section has described several empirical facts regarding the evolution of measures of academic achievement that have been associated to the change in voucher policy implemented in 2008. I have also discussed that it can be difficult to use these statistics to develop a rigourous policy evaluation and quantify the mechanisms given the general equilibrium nature of the effects of the policy and the institutions surrounding the implementation of the policy. To make headway into what mechanisms may have been important and to better characterize the potential general equilibrium effects of the policy in the next sections I develop an empirical model of supply and demand in this market for schools. I ask first whether there is any empirical content to the supply side considerations in explaining the outcomes we see.

Then I explore where there is any empirical content in the idea that part of the changes observed were due to changing nature of competition in this market. While the model developed in the paper will inevitably be stylized and leaves out important aspects of the SEP policy, its meant to capture the main forces at play and allow for an empirical exercise quantifying the relative importance of different channels through which the policy affected outcomes.

3. EMPIRICAL MODEL OF SCHOOL CHOICE AND SCHOOL INCENTIVES

3.1. *Market Definition and Student and School Data*

3.1.1. *Schools and Students*

Administrative records on all schools in the country are available from the Ministry of Education of the Chilean government (MINEDUC). This lists the type of school, the aggregate matriculation by grade level, and the address of the school along with other school characteristics. I concentrate on regular elementary schools between the years 2005 and 2011 and exclude schools that focus only on special-needs children or only on high school students. Using the address information on each school, I associate schools with the previously defined markets if the school is within the boundaries of the market, with a small buffer zone to avoid excluding schools on the edge of the cities. This gives a total of 4,809 schools. Market shares are constructed using the aggregate information on matriculation for all schools in the market for each year by grade. Most markets are characterized by a small number of schools. There are only a few large urban areas that have over 100 schools, while the capital of Santiago has over 1,400 schools.

Detailed individual level data is useful to describe the choices that families make and to estimate school quality. I use administrative panel data from 2005 to 2011 on all students in the country from the Ministry of Education of the government of Chile. These data record the school attended for each student for every year as well as information on grades and basic demographics. It also includes individual level eligibility for the *Subvencion Escolar Preferencial* (SEP) targeted voucher which started after 2008. I use these data to document choices given the type of student. This dataset also contains address information for a subset of students for the years 2010 and 2011, which I use to estimate the joint distribution of program eligibility and mothers' education across census blocks. A second source of data is from birth records from the Ministry of Health of the government of Chile. This database covers all births in the country after 1992 and contains information on the health conditions of a child at birth such as birth weight, birth length and gestation. It also contains information regarding the mother and father, such as education level and marriage status. The original source data also contains the mother's id number which allowed for the identification of siblings and the possibility to link other administrative educational information from the mother at the Ministry of Education. A third source of data on students are test scores from the SIMCE test and an accompanying survey for the population of 4th and 8th grade students. The survey contains detailed information about the household composition, demographics and income. A fourth source of data comes from college entrance exams which covers all applicants to college from 1980 forward and are linked to students mothers.[17] Since the sample of students entering 1st grade in 2005 would have been born in 1998 or 1999, virtually all mothers who took the test would be included in the data.

These datasets are linked at MINEDUC using individual level identifiers which are masked, and the resulting database is stripped of any individual

[17]Data on college entrance exams prior to 2000 was originally collected from archival records as part of the *Proyecto 3E* (Beyer, Hastings, Neilson, and Zimmerman, 2015; Hastings, Neilson, and Zimmerman, 2015), a joint research effort with DEMRE, the institution that administers the college entrance exam in Chile.

level identification. Geographic location is associated with a census block and address information is also eliminated. From this sample, I link students to markets through the school they attend. The resulting sample dataset of elementary school students contains almost 12 million student-year observations, which accounts for 86% of the system during that period. Census block level geographic information is available for approximately 5 million (or 45%) of this sample.[18]

3.1.2. *Urban Markets in Chile*

Defining the market is a difficult task in many settings when physical distance is a relevant characteristic. It is generally not easy to find a boundary where one market ends and one begins in broad urban areas. Papers that study retail markets typically have used political or administrative boundaries to define markets such as cities or counties (Davis, 2006). In some cases, such as small isolated communities, this works well. However, in large urban areas consumers close to the border of a county might also be close to firms in the next county. In these cases, it is possible for consumers to choose to cross market lines to buy from firms in neighboring markets. In my application, I take advantage of the relatively sparse distribution of the population in Chile where communities tend to be far from each other. This creates a natural definition of a market based on the idea that consumers in one city will not travel very far across rural areas to go to school in another city.

In practice, I use the Chilean census maps of all urban areas in the country to define markets. I join all urban areas that are five kilometers apart or less at their closest point. The union of all connected urban areas is defined as one market under the assumption that students could feasibly travel within this set of urban areas due to their proximity. Using this method across the

[18]The Online Appendix explains the data processing in detail.

entire country defines over 300 urban markets, but many of these markets are very small. I focus on markets with at least 500 students and at least five elementary schools with first grade students leading to a setting with approximately 60 markets that contain over 80% of all students in first grade.[19]

The Chilean census also provides detailed block-level data on every urban area and thus on every market as defined in this analysis. Block-level census data is used to describe the distribution of student characteristics in the market across a grid of N_m nodes. I group census blocks into squares approximately five blocks wide to define a node and aggregate the block level information to this five-block level. I use the most recent available census data from 2012 together with a sample of geocoded students to estimate w_{nk}^m, the distribution of family types across each node within the market. I use current microdata on all students in the market to determine the aggregate participation of each type of family Π_k^m in the market. In the empirical application, Π_k^m varies with time from 2005 to 2011 but w_{nk}^m does not. It is important to note that this structure allows for the rich description of heterogeneity within markets, even without knowing the exact location of each student.[20]

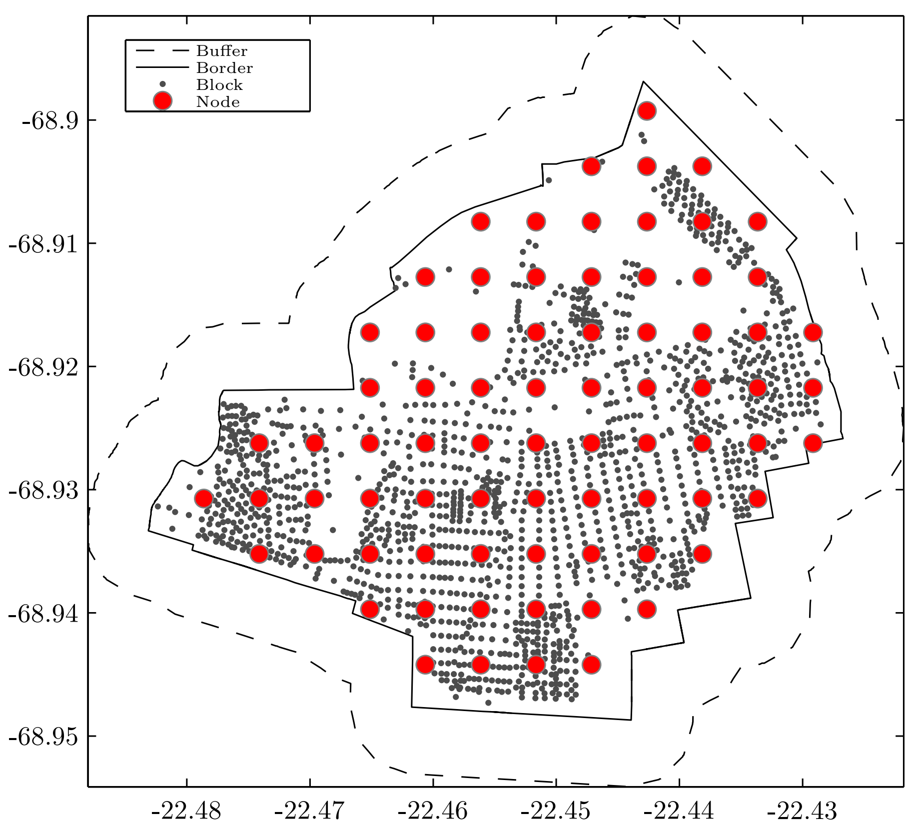
To be concrete and to introduce some notation, in this application a market is defined by six features. The first is a geographic boundary (a polygon) described by B^m. The second is a set of schools F^m that operate within B^m at any point in time. The third is set of N^m nodes spread evenly within the boundaries B^m of the market. The fourth is a set of S^m students of K observable types that can live at any of the N^m nodes inside the market. The

[19]Details of the distribution of market characteristics are presented in the Online Appendix.

[20]More information on the construction of the distribution of consumers and their types is available in the Online Appendix.

fifth is a vector Π^m which is of length K containing the shares of each type of student in the market m and where we have that $\sum_k^K \Pi_k^m = 1$ for each market m and $\sum_k^K S_k^m = S^m$. Finally, the sixth aspect that defines a market is the distribution of student types across nodes within each market described by w_k^m which is a vector of length N^m containing the share of students of type k of the market m that are located at each node n. We have that $\sum_n^{N^m} w_{nk} = 1$ and $\sum_k^K \sum_n^{N^m} w_{nk}\Pi_k S_k^m = S^m$. This structure is useful for several reasons.

FIGURE 2.— Map of with Census Blocks and Nodes



Note: This figure shows the boundaries of the city of Calama.
Source: INE, Ministry of Education MINEDUC, own calculations.

The first is to allow very detailed within market heterogeneity. This can can be very important if households are very sensitive to distance when choosing a school as this would make competition very local. The second aspect is that this very microlevel structure allows for the detailed description of the market but does not require knowing where all families live. It is only necessary to estimate the joint distribution of family types conditional on block characteristics. Finally, the aggregation at the level of equidistant nodes as opposed to uneven sized blocks keeps the problem of estimation manageable by reducing the dimensionality and easier to interpret. Figure 2 shows one example of spreading nodes across the market to diminish the dimensionality of the demand side problem while still keeping a flexible and detailed description of varying demand across space.

3.2. *Model of School Choice*

In what follows I develop an empirical model of school choice that characterizes the way families trade off different characteristics of schools when making their choices. The objective of this empirical model is to quantify the behavior of families regarding their choice of school based on the underlying characteristics such as price, quality and distance, so as to be able to replicate credible counterfactual scenarios and characterize the incentives schools face when choosing prices and investment in quality. To this end, I develop a model of demand for elementary schools in an environment where spatially differentiated schools choose quality and prices to maximize profits. The model accommodates school unobservable characteristics as well as observable and unobservable family heterogeneity at the census block level, providing a rich description of how families and schools interact.

The specific context is a static choice model where families must choose exactly one provider of educational services from their market. Families are assumed to be able to attend any school in the market as long as they are willing to pay the price and travel to get there. Public and private schools are differentiated spatially and compete for students. Private schools can choose to charge a price above a subsidy given by the government for each student while public schools cannot. Both public and private schools can choose their quality, presumably through the hiring of more qualified teachers, materials and also by exerting more effort. In what follows I make these ideas more precise and derive some empirical implications from the model.

Families are indexed by i and are members of one observable family type k and have unobservable characteristic v_i. They derive utility from a school indexed by j at time t as a function of the school's observable and discrete characteristics x_{jt}, its price p_{jt}, quality q_{jt} and the proximity to the families home d_{ij}. Preferences over these characteristics are heterogenous across family observable discrete type k. Preferences for quality are also heterogeneous along an unobserved family characteristic v_i. Families share a common preference for unobservable characteristics of the school ξ_{jt}. Finally, family i has a random iid preference shock for school j at time t that is ϵ_{ijt}. A family i's utility derived from a school indexed by j at time t is the following:

$$U_{ijt} = \eta_k x_{jt} + \beta_k q_{jt} + \xi_{jt} - \alpha_k p_{jt} + \lambda_k d_{ij} + \beta^u v_i q_{tj} + \epsilon_{ijt} \tag{1}$$

The distribution of unobservable characteristics is assumed to be normal with a zero mean and a variance of σ^2 so that $v_i \sim N(0, \sigma)$. The distribution of the random preference shock ϵ_{ijt} is assumed to have a standard extreme-value distribution. Families live at a specific geographic location within the market which defines the distance to each school. The geographic location will be defined as a node on a grid of N_m nodes across the market, discussed further below.

Furthermore, families must choose one school out of the F_t^m schools in the market m at time t. Note that there is no outside option in this case. One particular school is chosen to be the reference in each market and we can normalize $\xi_{1t} = 0$ without loss of generality. Given the assumptions described above, we can calculate the share of families of type k who live at node n at time t who will select school j as follows:

$$s_{jt}^{nk}(\mathbf{q},\mathbf{p},\boldsymbol{\xi}) = \frac{1}{N_{vi}} \sum_{i=1}^{N_{v_i}} \left(\frac{\exp\left(\beta_k q_{jt} + \xi_{jt} - \alpha_k p_{jt} + \lambda_k d_{nj} + q_{jt} v_i\right)}{\sum_f^{F_t^m} \exp\left(\beta_k q_{ft} + \xi_{ft} - \alpha_k p_{ft} + \lambda_k d_{nf} + q_{ft} v_i\right)} \right) \tag{2}$$

In Equation 2, the bold symbols $(\mathbf{q},\mathbf{p},\boldsymbol{\xi})$ represent vectors of quality, price and unobservable characteristics of all schools in the market. The market is comprised of a total of N students who live on the discrete set of N_m nodes. The distribution of students of type k across nodes is given by the vector w_k^m with

$$\sum_n^{N_m} w_{nk}^m = 1 \qquad \forall \quad k \tag{3}$$

The proportion of the students in the market who are of type k is given by Π_k^m where we have:

$$\sum_{k=1}^{K} \Pi_k^m = 1 \tag{4}$$

The total market share of a given school j is:

$$s_{jt}(\mathbf{q},\mathbf{p},\boldsymbol{\xi}) = \sum_k^K \sum_n^{N_m} s_{jt}^{nk}(\mathbf{q},\mathbf{p},\boldsymbol{\xi}) \cdot w_{nk}^m \Pi_k^m \tag{5}$$

Several important assumptions have been made to derive this parsimonious model of school choice. One assumption is that parents do not bargain with schools over prices. Another important assumption is that students can attend any school that they are willing to travel to and pay for. This assumption avoids the explicit modeling of capacity constraints and allows for straightforward counterfactual exercises. To the extent prices are correlated with selectivity, ignoring supply-side selection will make poor students seem to behave as though they are more price elastic. In practice, strict capacity constraints don't seem to be relevant for the majority of school choice situations as no more than 4% of schools have enrollments in first grade that are binding to the legal class size limit. It is of course possible that schools have a desired class size that is lower than the legal limit which may still serve as a constraint. However, survey evidence from 4th grade parents shows they almost never say they have been rejected from the school they actually wanted to send their child to.[21] Finally, selection of any kind is prohibited by law at elementary schools that take vouchers, *Ley General de Educación (LGE), Ley N 20.370*.[22] These points suggest that, at least in elementary schools, selection on the part of schools is not the main driver of choice for the majority of students, and schools and prices and supply of nearby schools are more relevant.

Another important assumption is that families are aware of the location, quality and price of all options. There is some empirical evidence that suggests this is not always the case (Hastings and Weinstein, 2008). In this application, demand estimates need not be interpreted as parameters of indirect utility as there is no welfare analysis conducted. In this application, I also assume residential location is not a relevant dimension in the school choice problem. In the U.S. neighborhood-based public school sys-

[21] See the Online Appendix for further discussion and a list of reasons to attend a school.

[22] In the literature comparing voucher and public schools, some authors have emphasized that voucher schools screen their students and argue this is a reason that voucher schools perform better on average than public schools (Rounds, 1996; Contreras, Sepúlveda, and Bustos, 2010). These studies are based on survey evidence that application processes at some voucher schools request that parents provide documents such as marriage certificates, current employment, and in some cases, an academic evaluation. This is consistent with selection but not proof as schools can decide to let a paying student enroll just the same.

tem, modeling residential location is very important as argued in Nechyba (1999),Nechyba (2000),Nechyba (2003), and Bayer, Ferreira, and McMillan (2007). In the case of Chile and in many other voucher applications in the world, particularly in developing countries, the link between residential location and school choice is less important as it does not determine the school or choice set (Bettinger, 2011). Future empirical applications should extend this analysis to incorporate some of these additional features and see how they interact with voucher policy.

3.3. *Supply Side Incentives*

I model private voucher schools' behavior as profit maximizing schools. The profit function for a school in a particular market with N students is given by the following equation:

$$\pi_{jt}(\mathbf{q}_t, \mathbf{p}_t, \boldsymbol{\xi}_t) = N s_{jt}(\mathbf{q}, \mathbf{p}, \boldsymbol{\xi}) \left(v + p_j - MC(q_j)\right) - F_j \tag{6}$$

We can replace Equation 5 in Equation 6 so that we can write profits as a function of the students of each type who attend the school from each node in the market:

$$\pi_{jt}(\mathbf{q}, \mathbf{p}, \boldsymbol{\xi}) = N \underbrace{\left(\sum_{k}^{K} \sum_{n}^{N_m} s_{jt}^{nk}(\mathbf{q}, \mathbf{p}, \boldsymbol{\xi}) w_{nk}^{m} \Pi_k \right)}_{s_j} \left(v + p_j - MC(q_j)\right) - F_j \tag{7}$$

Schools maximize profit by choosing price and quality. In choosing price, they compare the marginal gain from raising the price to the marginal cost of attracting fewer students. In practice, at high levels of p the voucher diminishes so that $v(p_j) + p_j$ is a concave function of p. For simplicity, I ignore this feature of the voucher payout scheme and I also assume that capacity constraints are not relevant in order to get a simple expression for price and quality.

The first order condition with regard to price is the following:

$$\frac{\partial \pi_j(\mathbf{q},\mathbf{p},\boldsymbol{\xi})}{\partial p_j} = N\frac{\partial s_j(\mathbf{q},\mathbf{p},\boldsymbol{\xi})}{\partial p_j}\left(v+p_j-MC(q_j)\right)+Ns_j(\mathbf{q},\mathbf{p},\boldsymbol{\xi}) \quad = 0$$

$$p_j^* = \underbrace{[MC(q_j)-v]}_{\text{MC after subsidy}} \underbrace{+s_j(\mathbf{q},\mathbf{p},\boldsymbol{\xi})\left[-\frac{\partial s_j(\mathbf{q},\mathbf{p},\boldsymbol{\xi})}{\partial p_j}\right]^{-1}}_{\text{Price Mark up}} \tag{8}$$

By reordering, we can get to an expression for price, assuming no corner solution at zero. The first part of the right hand side equation represents the pricing in perfect competition. The price should be equal to marginal costs minus the subsidy per student. The second term represents the "markup" relative to marginal costs that schools can charge because of their local market power. The price markup is smaller the more sensitive the school's share is when its own price changes. Note also that the markup depends on the prices and qualities of all other schools in the market.

Similar arguments can be made for the choice of quality. Schools choose quality by comparing the marginal benefit of attracting more students relative to the marginal increase in the costs.

$$\frac{\partial \pi_j(\mathbf{q},\mathbf{p},\boldsymbol{\xi})}{\partial q_j} = N\frac{\partial s_j(\mathbf{q},\mathbf{p},\boldsymbol{\xi})}{\partial q_j}\left(v+p_j-MC(q_j)\right)-Ns_j(\mathbf{q},\mathbf{p},\boldsymbol{\xi})\cdot\frac{\partial MC(q_j)}{\partial q_j} = 0$$

I further assume that $MC(q_j) = c_0 + (c_1 \cdot q_j)$. Rearranging, we get to the following expression for quality:

$$q_j^* = \underbrace{\left[\frac{v+p_j-c_0}{c_1}\right]}_{\text{Competitive Quality}} \underbrace{-s_j(\mathbf{q},\mathbf{p},\boldsymbol{\xi})\left[\frac{\partial s_j(\mathbf{q},\mathbf{p},\boldsymbol{\xi})}{\partial q_j}\right]^{-1}}_{\text{Quality Mark Down}} \tag{9}$$

The last equation shows that schools will provide quality that is lower than they would in perfect competition. Market power will allow schools to provide quality with a "mark down" relative to marginal costs. The market power again stems from the term $\frac{\partial s_{jt}(\mathbf{q},\mathbf{p},\boldsymbol{\xi})}{\partial q_{jt}}$, which shows how sensitive demand of the school is with respect to quality.

In both cases, the incentives of the firm depend on their local market power. This stems from the fact that schools are differentiated not only by price and quality, but by their location.

The market power that a school has will depend on its competitors and their characteristics including prices and their distances from households. It will also depend crucially on the types of students that live near the school and what characteristics they value most. The market power of a school can be characterized as a weighted average of the preferences of the families that live nearby and the characteristics of other schools:

(10)

$$\frac{\partial s_{jt}(\mathbf{q},\mathbf{p},\boldsymbol{\xi})}{\partial q_{jt}} = \sum_{k}^{K}\sum_{n}^{N_m}\left(\beta_k \cdot w_{nk}^{m}\Pi_k^m\right)\cdot\left(\frac{1}{N_{vi}}\sum_{i=1}^{N_{v_i}}\cdot\left[s_{jti}^{nk}(\mathbf{q},\mathbf{p},\boldsymbol{\xi})(1-s_{jti}^{nk}(\mathbf{q},\mathbf{p},\boldsymbol{\xi}))\right]\right)$$

To the extent that rich and poor households have differences in preferences, schools may face very different incentives if they are located in more or less wealthy neighborhoods. In addition, it is intuitive to think the policy of targeted vouchers would modify the competition in poor neighborhoods. This is because poor families are expected to be more price sensitive and thus the targeted voucher is likely to affect their choices more although this also depends on what alternatives are available nearby. There are additional incentives to compete as students are also worth more to schools with this higher voucher, but this effect is not directly captured by the mark down expression.

In what follows, I estimate the parameters of the demand system and use these to quantify the quality markdown. I then show how this markdown changed systematically with the introduction of the policy and how this is distributed across neighborhoods and whether it was associated with changes in estimated school quality.

3.4. *Estimation Strategy*

3.4.1. *Estimating Measures of Quality*

The model describes preferences over schools as a function of distance, price and school academic quality, as well as unobserved school attributes. Previous work estimating discrete models of school choice have used average school test scores as a measure of school academic quality as in Hastings, Kane, and Staiger (2009) and Bayer, Ferreira, and McMillan (2007).[23] This empirical strategy has the benefit of being straightforward, but it also confounds the schools' contribution to learning with the students' own characteristics. It also makes constructing counterfactual test score distributions very difficult. I will argue that while average test scores are a good proxy for school quality in some applications, a school's contribution to learning (i.e. value added) is a closer proxy to what families should consider when comparing schools on quality. The estimation of the empirical model of school choice will then determine whether families' choices take into account school quality or other characteristics as some research has indicated in the past (Rothstein, 2006; Mizala and Urquiola, 2013).

In this application, I assume quality is not directly observable to the econometrician in the data. However, families recognize the school's ability to improve students scores. The assumed relationship between observable test scores y_{ijt} and quality q_{jt} is defined in Equation 11, where X_{it} is a large vector of observable individual student characteristics the and v_{ijt} is an random iid shock to observable test scores.

$$y_{ijt} = q_{jt} + X_{it}\gamma + v_{ijt} \tag{11}$$

The vector of characteristics used in my empirical estimation is unusually large relative to the literature and includes detailed administrative infor-

[23] See also applications to school choice in Chile by Gallego and Hernando (2010) and Chumacero, Gomez, and Paredes (2011).

mation on the student's family background. The estimated value of q_{jt} is the school fixed effect and is the component of the average test score in the school that is not explained by the individual characteristics of the students. This will capture the school inputs such as teacher quality, infrastructure and any other school specific characteristic that raises the average test score. To the extent that the demographic composition of the schools' students matter for test scores, these effects will also be included in the school fixed effect quality measure.

Important assumptions are made in the estimation of school quality. I do not model peer effects directly and I assume that v_{ijt} is orthogonal to q_{jt} which precludes selection on unobservable characteristics. These assumptions are restrictive but provide a parsimonious model that can produce counterfactual test score distributions in a tractable way. In practice, estimation will be carried out with a large vector of family observable characteristics and robustness analysis suggests a limited role for selection on unobservables driving the estimates (Altonji, Elder, and Taber, 2005). Moreover, the growth is broad based, aggregate test scores across a large group of the population documented is not likely to be driven by selection effects or peer effects. This suggests that these assumptions will not be critical for the results in the paper and are discussed further in Secton 4.

3.4.2. *Estimating Demand for Schools*

I estimate parameters $\theta = \{\alpha, \beta, \lambda, \sigma, \xi\}$ from Equation 1 by using a method of moments estimator. I combine aggregate, IV and micro moments following Berry (1994), Berry, Levinsohn, and Pakes (1995), Petrin (2002) and Berry, Levinsohn, and Pakes (2004). Aggregate moments discipline the model estimates making it fit the market participation of schools observed in the data. The estimation of a year and firm specific term ξ allows the model to match school level shares perfectly. The rich microdata define a set of type specific moments so that the estimation routine chooses θ so as to approximate the heterogeneity in behavior across different types of families. Noting that ξ is correlated with both q_j and p_j, I solve the endogeneity problem using an IV strategy following Berry (1994). I define instruments taking advantage of the variation of costs across markets and changes to policy over time. I develop each set of moments below.

For each school and time period I ask the estimation routine to choose θ such that the model replicates the share of the market that the school has in the administrative data. I refer to this set of moments as aggregate moments. This defines one moment for each firm and time period. $\mathbb{N}^{f\times t} = \sum_t^T N_{m,t}^f$

$$G^1(\theta) = s_{jk} - s_{jt}(\theta) \tag{12}$$

I then define the micro moments of interest to be the expected quality, price and distance each type of family chooses in each market in each period.

$$E(d\big|k,t,m); \quad E(p\big|k,t,m); \quad E(q\big|k,t,m) \qquad \forall\, t,m \quad \text{and } k$$

The model parameters are chosen so as to match the empirical counterpart of these expressions. From the microdata I have N_{kt}^m observations in market m of students identified as type k at time t. Each of these observations has chosen an option with a q, p and d associated to it, thus I can generate empirical averages to approximate the expectations of interest. Given a set of parameters and the distribution of students across the market (census blocks) I can construct moments implied by the model to compare with the empirical ones given by the microdata. This defines $\mathbb{N} = \sum_{m\in M} N^m x K x T$ moments for price, quality, and distance.

$$G_d^2(\theta) = \frac{1}{N_{kt}^m} \sum_{i \in N_{kt}^m} d_{ik} - \sum_n^{N_m} \sum_j^{N_{m,t}^f} s_{jt}^{nk}(\theta) \cdot w_{nk}^m \cdot d_{jn} \tag{13}$$

$$G_q^2(\theta) = \frac{1}{N_{kt}^m} \sum_{i \in N_{kt}^m} q_{ik} - \sum_n^{N_m} \sum_j^{N_{m,t}^f} s_{jt}^{nk}(\theta) \cdot w_{nk}^m \cdot q_{jt} \tag{14}$$

$$G_p^2(\theta) = \frac{1}{N_{kt}^m} \sum_{i \in N_{kt}^m} p_{ik} - \sum_n^{N_m} \sum_j^{N_{m,t}^f} s_{jt}^{nk}(\theta) \cdot w_{nk}^m \cdot p_{jt} \tag{15}$$

where $N_{m,t}^f$ schools in each year t and market m.

Finally, I define a last set of moments as a set of orthogonality conditions. Specifically, to identify the school demand parameters, I need instruments that are related to price and quality but not related to the unobserved quality of the school ξ. I define moments that are of the following type

$$G^3(\theta) = \xi \cdot IV' \tag{16}$$

The instruments include cross market cost shifters such as teacher wages in each market. I use the baseline voucher which varies across time. I also use the variation in prices that is induced by the SEP policy. This policy effectively eliminated prices at a significant number of schools for almost half of all students. The change in prices induced by this policy affect equilibrium prices and quality for all students through schools first order conditions. This equilibrium effect occurs differentially across neighborhoods that have higher or lower concentrations of eligible students.[24]

To implement the estimation described above, the main challenge is the size and density of the problem. To make the problem more manageable,

[24]The Online Appendix lists the instruments used and presents IV regression results.

the model was estimated with a pre and post year 2007 and 2011 and using a subsample (smaller 50%) and the solution is used as a starting point to solve for the entire sample. A Nested Fixed Point algorithm described in Berry (1994) was found to be more robust initially but slower dealing with larger markets so a slight modifications of an MPEC approach as described in Dubé, Fox, and Su (2012) was implemented using a warm-start precalculated for smaller markets. Details regarding the implementation of both methods are presented in the Online Appendix.

4. RESULTS AND ANALYSIS

4.1. *Quality Estimates*

School quality is estimated by OLS according to Equation 11. The school quality is the school and year fixed effect in a regression of students' test scores that controls for a large vector of student characteristics including household income, detailed parental educational levels, mothers' math and language college entrance exam scores, demographic composition of the families, and early childhood health indicators.

We find that both parents' education have significant and relatively large coefficients. Students whose mother took the college entrance exam also did significantly better, adding almost 0.3σ to the student's test scores. Mothers who did better on the college entrance exam also had children who did better on 4th grade evaluations. A mother who scored one standard deviation above the mean test score in language had children who scored 0.3σ better. Interestingly, mothers' performance on math tests are much less important in magnitude than language test scores by a factor of four.[25]

Health at birth has been shown to be a important predictor of later life outcomes.[26] The results here also show that birth weight, birth length and weeks of gestation are all significantly related to test scores, even after controlling for school and year fixed effects as well as many other demographic characteristics.

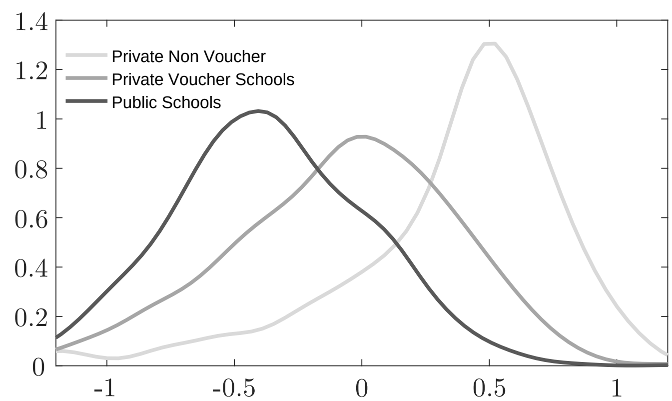
The resulting school and time fixed effect estimates for school quality are too numerous to present in a table. I summarize the main results that stem from

[25]Results are presented in Appendix Table A2 and all estimates include school and year fixed effects.

[26]See Behrman and Rosenzweig (2004),Currie and Almond (2011), and Almond and Currie (2011) for examples. Bharadwaj, Loken, and Neilson (2013) and Bharadwaj, Eberhard, and Neilson (2017) show that health outcomes at birth are systematically correlated with academic outcomes in the case of Chile.

this analysis. The first is that, consistent with the results from the literature on school quality in Chile summarized in Drago and Paredes (2011), voucher schools have higher quality than public schools on average and private non voucher schools have much higher quality than either. An additional result that is less emphasized in the literature is that school quality as measured in this application is very heterogeneous within types of schools as can be seen in Figure 3.[27]

FIGURE 3.— School Quality by School Type in 2011



Note: This figure shows the distribution of quality estimated for schools in 2011 using Equation 11 with estimated school quality on the x-axis. Regression coefficients are presented in Table A2.

Another result is that school quality rose both in the aggregate and within public and voucher schools, but did not change in the non voucher private sector which did not participate in the SEP policy. Public schools improved evenly across the distribution, while lower performing voucher schools improved the most. Public schools improved their student-weighted average quality by 0.16σ with larger improvements at the higher quality part of the

[27]Recent work has begun to document the heterogeneity in school quality across school types, for example Henríquez, Lara, Mizala, and Repetto (2012) show evidence of high performing low cost schools.

distribution. Voucher schools increased their quality by 0.12σ on average with the largest changes coming from the bottom of the quality distribution.

One natural check is to look at the relationship between estimated school quality and the school's inputs that we think affect the quality of the school and I present some of these results in the Appendix and further exploration in the Online Appendix where I show evidence of a positive relationship between school quality and prices charged by voucher schools. Another test is to regress estimated school quality on school inputs like measures of teacher quality.[28] The estimates of value added control for a very long list of observable student characteristics, much more than is usual in the education production function literature. The change in observable demographics in the population is controlled for and is smooth in evolution making it hard to argue that the observed effects are the product of changing students and not changing schools. What set of strategies schools implement to improve is beyond the scope of this paper but deserves further study.

4.2. *Parameter Estimates and Demand and Supply Decomposition*

Using the estimated school quality together with the microdata moments and instruments described above, I estimate the model and present the results in Table A3. The first result is that preferences are strikingly heterogeneous across socioeconomic groups and follows findings by several authors such as Hastings, Kane, and Staiger (2009) or Gallego and Hernando (2010). Families of lower income and less educated mothers tend to put more weight on price and distance. Differences are less pronounced regard-

[28]This measure has been shown in other work to be related to teacher quality measured in several ways Gallegos and Neilson (2017) including wages, teacher video evaluations, job prospects and student test scores.

ing school quality. [29]

Given schools and students are changing their behavior in response to the policy at the same time it is impossible to rigourously determine what the demand side response would have been in isolation. Simple observation of switching patterns in the data suggest the demand response was limited in equilibrium. However students in school prior the policy face switching costs that new entrants do not. In addition schools response to the policy is inherently endogenous to the students potential to switch. In this paper I use the estimated demand model presented in the previous section to study the quantitative extent to which sorting of students to better schools could have explained the observed effects of the targeted voucher policy in isolation of any supply side considerations. The first exercise is to hold the set of schools and their quality fixed and apply the targeted voucher policy which changes prices in the baseline year. This will isolate the increase in aggregate test scores that is attributable to only demand side sorting when the policy is in place. The second counterfactual is to let families in the model sort to schools and use the schools available in 2011 with their characteristics.[30] This last situation measures the full policy impact within a consistent framework in the model.

[29] Using the estimated model parameters, we can show how well the model fits the empirical features we are interested in replicating. The distribution of school quality in aggregate fits perfectly given that the model must replicate the aggregate share of each school perfectly. The Online Appendix shows the fit of the model by the mothers' educational group, showing a relatively adequate fit given moments include only means across markets.

[30] The potential role of the extensive margin of entry/exit is not explicitly explored in this paper. There does not seem to be a large increase of new entrants but it is important to note that the threat of entrants of higher quality could have played a role in raising investment and pushing up quality at existing schools, and this mechanism is not considered in these counterfactuals. The role of the threat of entry/exit and the extensive margin in general are left for future work.

To isolate the demand side contribution I fix the schools available to be the ones available in 2007, but the prices are adjusted assuming the targeted voucher policy is in place as it is in 2011. The model then assigns students to schools and the distribution of test scores, school quality, and changes in these quantities can be calculated relative to the baseline year of 2007. This produced an increase in average test scores of 0.08σ for students in the poorest 40% of the distribution.

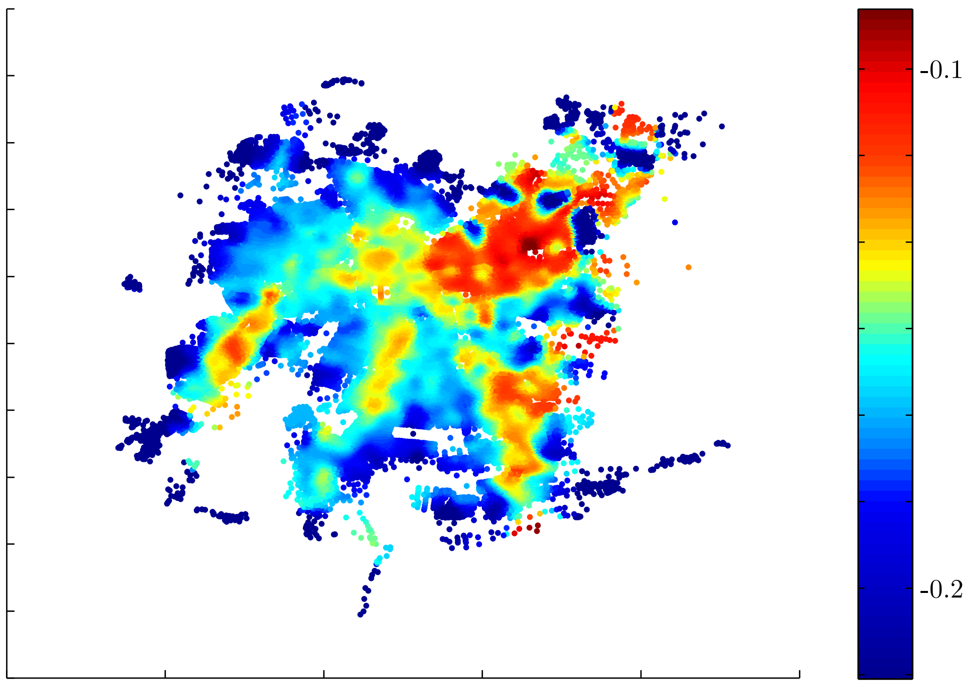
The next counterfactual is reassign students according to estimated preferences using the schools' characteristics in 2011. This generates an aggregate increase of 0.23σ suggesting that the growth in school quality at existing schools explains almost two-thirds of the total effect.I now turn to the study of the incentives schools had to improve quality once the targeted voucher policy was in place. To do this, I use the demand estimates to quantify the schools' local market power and how this changes with the implementation of the policy.

4.3. *Targeted Vouchers and Competitive Incentives*

From the demand estimates we know that poor, less educated families are more price sensitive and are less inclined to travel far from their homes to attend school. This leads to high markdowns in poor neighborhoods as better, more expensive schools are not close substitutes given the families' high price elasticities. The fact that schools in poor neighborhoods have more local market power to markdown their quality partially helps understand the inequality in outcomes. Figure 4 shows the heterogeneity in calculated markdowns within a market. The northeast section of the market is home to richer families while the outskirts of the city are populated by less wealthy and educated households. Markdowns track these patterns although there is heterogeneity across neighborhoods.

The SEP policy that targets more resources to poor students and lowers

FIGURE 4.— School Quality Markdown - Santiago

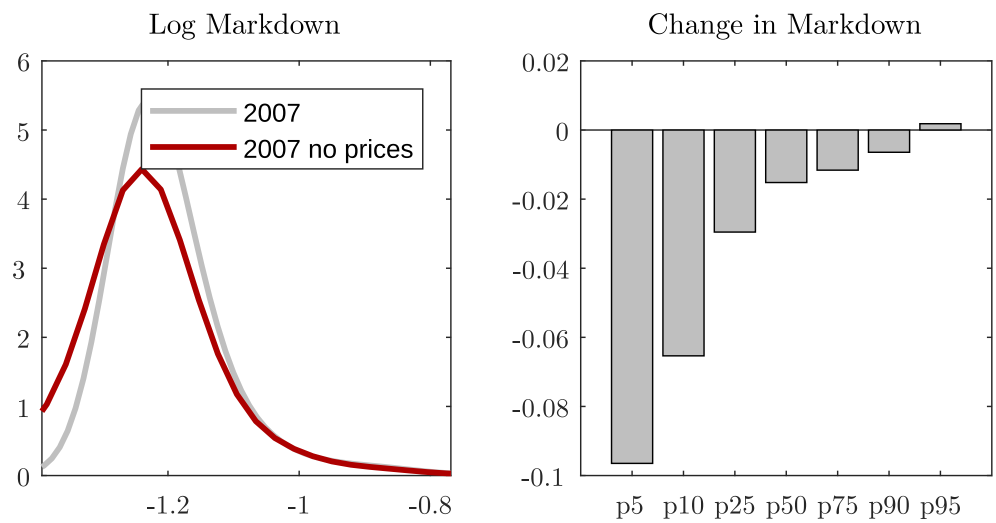


Note: This figure shows the distance weighted average markdown from Equation 10 evaluated at each census block centroid in the city of Santiago, which is the largest market.

their out-of-pocket expenses can intuitively be expected to diminish schools' local market power. More expensive schools of good quality will become more attractive to poor families and this will increase the effective competitive pressure schools in poor neighborhoods face. In Figure 5 we see that this is indeed the case; the entire distribution of school markdown shifts, in particular at the lower tail of the distribution.

One prediction that comes from the model is that schools that have more market power as measured by the quality markdown will have lower quality. Moreover, schools who suffer bigger changes after the implementation of the policy should also see systematically larger increases in their quality now

FIGURE 5.— School Quality Markdown - Before and After Policy



Note: The left panel of this figure shows the distribution of school level markdowns calculated in 2007 with and without the policy Equation 10. The right panel shows the percent change in the distribution of markdowns at specific percentiles.

they have lost market power. While there are many different aspects to the SEP policy, these empirical implications of the model would lend credence to the significance of the competitive pressure channel of targeted vouchers. The following table presents the empirical results of both these tests in the sample of schools with estimated markdowns.

The regression relating a change in competitive pressure (quantified via estimated markdowns) to changing school quality (quantified via estimated value added) after several years have passed can be seen as a micro-founded version of reduced form regressions common in the applied education literature studying the role of competitive pressure and student achievement. For example Figlio and Hart (2014) studies the effect of tax deductions for expenses on private schooling on public school achievement by comparing the increase in test scores across markets with more or less private schools before

TABLE I

Quality Markdown and School Quality

Levels of School Quality and Baseline Markdowns

Parameter	Coef.	Std. Error
Markdown 2007	-0.257	0.016
Constant	-0.014	0.019

2011-2007 Changes in School Quality and Changes in Markdowns

Parameter	Coef.	Std. Error
Change in Quality Markdown	-0.150	0.011
Constant	0.184	0.013

Note: $R^2 = 0.1540, N = 980$

This table presents the results of two regressions. The top panel presents the results of regressing the estimated mark down for schools in 2007 and the quality estimates in the same year. The bottom panel presents the results of regressing the difference in school quality and the difference in estimated mark downs. Both results are consistent with the empirical models predictions and lend support for competitive pressure to play some degree of importance in this market.

the policy was implemented. Another example is Card, Dooley, and Payne (2010) where the policy increases choice and the empirical strategy looks at how achievement changed across markets with more or less options available. In both cases the empirical strategy is to use an indicator for more or less competitive market structure that turns on after the policy is in place. The framework presented here shows how to make these ideas precise by quantifying the degree to which competitive environments are changing with policy by explicitly modeling the tradeoffs faced by schools and families.

5. CONCLUSION

This paper develops a model of school choice and competition to study how the structure of voucher policy can influence the distribution of school quality through its effects on competitive incentives. I estimate the model parameters leveraging detailed administrative data and an important voucher policy change in Chile. The explicit modeling of schools' choice of price and quality allows for a detailed analysis of how voucher policy can change the nature of competition in across neighborhoods. On the demand side, the model estimates indicate that preferences for school characteristics are heterogeneous across socioeconomic groups, in particular with regard to prices and distance traveled to school. From the supply side, modeling schools' choice of prices and quality reveals that schools mark down their quality as a function of their local market power. Taken together, I show that schools located in neighborhoods with a large concentration of poor families, who are more price sensitive and are less willing to travel, will face demand that is less sensitive to changes in quality and will consequently have more local market power to markdown quality. This result implies that flat voucher designs with top-off fees generate inequality across socioeconomic groups without the need to appeal to additional education specific market failures.

I use this framework to study how the a shift in school funding from a flat voucher with top-off fees to a targeted school voucher with no out-of-pocket fees affected school incentives in Chile and contributed to the observed increase in academic achievement. The larger voucher for poor students undoubtedly provided more resources for schools and this can be one of several reasons for the increase in estimated school quality. However given past experience, more resources do not generally lead to higher performance and in the context of for-profit private schools it is not direct that more resources would be translated into higher quality. In particular, the increase in performance of for-profit private schools is interesting to study given that generally transfers would not necessarily be passed on to students via higher quality. To approach this question, this paper uses the empirical model to better understand why for-profit schools' incentives to invest in quality may have changed.

The empirical results show that the introduction of a larger voucher for poor students diminishes schools' local market power in poor neighborhoods. Part of this result is on impact by allowing poor students to consider attending better schools that would have been too expensive without the voucher program. Part of this result is due to the overall increase in school quality of competitors. The model estimates indicate that the introduction of targeted vouchers effectively raised competition in these neighborhoods by reducing the role of prices in limiting the choices of these families and increasing school quality in poor neighborhoods. In addition, schools that suffered changes to their market power after the policy also produced larger increases to their quality, supporting the idea that the competitive channel played a role in the observed rise in school achievement.

These results add to the literature emphasizing that voucher policy design can have important consequences. Seminal work by Epple and Romano (1998, 2008) explored the theoretical aspects of how competition between schools may or may not work well for poor students. This work is also related to reduced form empirical work studying how policy changes that increase school choice improve outcomes depending on market structure (Card, Dooley, and Payne, 2010; Figlio and Hart, 2014). This paper presents one of the first empirical analyses to explicitly consider both demand and supply incentives in a market-oriented school choice system and presents a simple framework to do comparative statics in this environment. The mechanisms shown to be at work are novel to the education literature and highlight how even in the absence of additional education specific market frictions, inequality can arise across socioeconomic groups. A standard empirical approach common in the industrial organization literature is enough to generate insights on how voucher policy can affect incentives to compete and can shed light on the optimal design of new policy. The evidence presented highlighting the importance of considering the supply side is consistent with recent experimental work by Andrabi, Das, and Khwaja (2017) which shows that providing information on school prices and quality in Pakistan had effects on aggregate academic achievement driven mainly by schools improving their quality. Also related is Dinerstein and Smith (2015) that presents empirical evidence of unintended supply side consequences of increasing public school funding. The empirical framework presented in this paper can be used in both of these contexts to help study mark downs and how these may change with policy without the need to explicitly estimate cost structures.

The results presented in this paper are broadly important beyond the context of Chile because they provide insight into how design of voucher policy can influence school incentives and the distribution of quality in equilibrium. Future work should build on the empirical framework presented, leveraging insights from empirical industrial organization to study the range of incentive effects different regulatory environments can have on the distribution of school quality such as entry, exit, and location decisions as well as incentives for dynamic investment in infrastructure and innovation. These issues are more relevant than ever given that voucher policy of some form is currently being crafted in countries all over the world, including the United States, where tax deductions under the new *Tax Cuts and Jobs Act* will play a similar role to vouchers, but only for those rich enough to use them.

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APPENDIX

TABLE A1

Poor students catch up

Coefficient	Average Test Scores		Mathematics Test Scores		Language Test Scores	
Constant	0.324	(0.011)	0.262	(0.012)	0.386	(0.010)
Poor	-0.590	(0.012)	-0.629	(0.013)	-0.552	(0.011)
$Time_1$	0.019	(0.008)	0.008	(0.008)	0.029	(0.007)
$Time_2$	0.048	(0.008)	0.082	(0.008)	0.015	(0.008)
$Time_3$	0.038	(0.008)	-0.007	(0.008)	0.082	(0.007)
$Time_5$	0.087	(0.008)	0.082	(0.009)	0.092	(0.008)
$Time_6$	0.199	(0.008)	0.115	(0.009)	0.283	(0.008)
$Time_7$	0.129	(0.008)	0.127	(0.009)	0.132	(0.008)
$PoorxTime_1$	-0.001	(0.009)	0.028	(0.010)	-0.031	(0.010)
$PoorxTime_2$	-0.004	(0.010)	0.006	(0.010)	-0.014	(0.010)
$PoorxTime_4$	0.026	(0.009)	0.018*	(0.010)	0.035	(0.009)
$PoorxTime_5$	0.066	(0.010)	0.065	(0.011)	0.067	(0.010)
$PoorxTime_6$	0.099	(0.010)	0.083	(0.011)	0.115	(0.010)
$PoorxTime_7$	0.227	(0.010)	0.240	(0.011)	0.214	(0.010)
R^2	0.08		0.07		0.07	
N obs	1214579		1214579		1214579	

Note: This table shows the results of a regression of test scores of 4th grade students on time and dummy variables indicating belonging in the 40% poorest of 4th grade students. The regression also includes interactions between time and poverty status.

TABLE A2

School Quality Estimation Regression

	Coef.	StdErr	Coef.	StdErr
Constant	0.082	(0.002)	-1.699	(0.058)
Mother More High School	0.316	(0.003)	0.213	(0.003)
Mother High School	0.201	(0.002)	0.190	(0.002)
Father More High School	-	-	0.213	(0.003)
Father High School	-	-	0.101	(0.002)
Mother Took PAA	-	-	0.301	(0.007)
Mother PAA Math D2	-	-	0.081	(0.004)
Mother PAA Mat D3	-	-	0.099	(0.005)
Mother PAA Math D4	-	-	0.112	(0.007)
Mother PAA Math D5	-	-	0.101	(0.008)
Mother PAA Lang D2	-	-	0.139	(0.004)
Mother PAA Lang D3	-	-	0.229	(0.005)
Mother PAA Lang D4	-	-	0.319	(0.007)
Mother PAA Lang D5	-	-	0.252	(0.010)
Poor	-0.122	(0.002)	-0.093	(0.002)
Male	-0.035	(0.002)	-0.049	(0.002)
Married	-	-	0.003	(0.002)
Birth Weight	-	-	0.000	(0.000)
(Birth Weight)^2	-	-	-0.000	(0.000)
Birth Gestation	-	-	0.012	(0.001)
(Birth Gestation)^2	-	-	-0.000	(0.000)
Birth Length	-	-	0.031	(0.002)
(Birth Length)^2	-	-	-0.000	(0.000)
Single Birth	-	-	-0.026	(0.027)
Number of siblings	-	-	-0.029	(0.001)
Twin	-	-	-0.083	(0.027)
Birth Father Age	-	-	0.002	(0.000)
Birth Mother Age	-	-	0.004	(0.000)
R^2	0.30		0.32	
N obs	1380255		1380255	

Note: This table presents regression results for estimates of test scores on a large vector of individual student level characteristics. School quality is estimated as the school and year fixed effect and have not been presented in this table.

TABLE A3

Demand Model Estimates

Parameter θ_2	Coef.	Std. Error
Quality	1.3663	0.4316
Voucher School	0.1473	0.3597
Public School	-1.8032	0.3588
For Profit School	-0.8226	0.3444
Religious School	-0.3201	0.2123
Quality x HS Mom	0.1979	0.3233
Quality x College Mom	0.5239	0.5290
Quality x SEP	-0.2927	0.3465
Price x NHS Mom	-9.899	2.2836
Price x HS Mom	-2.8413	1.9002
Price x College Mom	-0.0001	0.4922
Price x SEP	-3.3190	1.3484
Distance x NHS Mom	-0.9928	0.1097
Distance x HS Mom	-0.7027	0.0625
Distance x College Mom	-0.3844	0.0626
Distance x SEP	-0.2178	0.0769
Sigma Preference - Quality	0.1361	0.6093

Note: Table presents results from the estimation using twenty nine markets (smallest half) and the simulation of 500 v_i^q. Changing the sample leads to similar results as estimates are reasonably stable. Overall the consistent finding is that more educated families value price and distance less while poorer less educated families value them more. School quality is consistently significant and valued by all. Random coefficients tend to have a limited role, usually not significantly different from zero and small suggesting that the modeling at the block level with micro-moments across six types absorbs most of the relevant heterogeneity in preference for quality.