Voucher-School Competition, Incentives, and Outcomes: Evidence from Chile*

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Abstract

I investigate the effects of voucher-school competition on educational outcomes. In my model, parents decide between public schools and voucher schools (that is, private schools that receive a voucher for each enrolled student). The public schools have no direct incentive to produce quality, beyond meeting a minimum enrollment level. The voucher schools face explicit competitive incentives. The model produces three empirical predictions: 1) voucher-school competition improves student outcomes; 2) the competition may put stronger pressure on public schools to increase quality; and 3) voucher-school competition has stronger effects when the minimum enrollment level is more binding. Since voucher school competition is endogenous to public school quality, I exploit the interaction of the number of Catholic priests in different areas in 1950 and the institution of the voucher system in 1981 as a potentially exogenous determinant of the supply of voucher schools. I document that the number of priests is determined historically and, while priests have been involved in schools since the voucher system was established, before 1981 their involvement in schools for middle- and lower-class students was negligible. Consistent with this, I document that the number of priests per capita has little effect on educational outcomes before the reform and a positive effect after the reform. Next, using priests in 1950 as an instrument for voucher-school entry in a cross-section of students in 2002, I confirm the main predictions of my model: 1) the entry of a voucher school into a market has a positive effect on tests scores—equivalent to about 0.14 standard deviations; 2) the effects are similar for students attending public and voucher schools; and 3) the effects are smaller for public schools with less binding minimum enrollment levels.

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1 Introduction

Creating competition between schools is a cornerstone of voucher school proposals. Proponents have argued that by creating competition, vouchers create stronger incentives for public schools to increase quality. However, critics counter that school competition may increase student segregation and harm poor students. In parallel, a line of research on the effects of inter-school competition on student outcomes has not reached a consensus on the causal effects on academic outcomes. While some papers find positive and significant effects of school competition and school choice (e.g., Bayer and McMillan, 2005; Hoxby, 1994, 2000, 2005; Lavy, 2005; and Sandstrom and Bergstrom, 2005), other papers do not find significant effects (e.g., Hsieh and Urquiola, 2004; Rothstein, 2004, 2005).

This paper contributes to the literature by studying the effects of inter-school competition on the academic outcomes of Chilean students who attend publicly subsidized schools. Chile is the only developing country that has operated the complete K-12 sector under a "quasi-voucher" system for a long period of time (since 1981). Voucher schools (that is, private schools that receive a voucher for each enrolled student) currently serve roughly 40% of all students. However, voucher school enrollment varies widely across areas. While in 10% of the educational markets the voucher enrollment is more than 50%, about 20% of Chilean municipalities have no voucher schools in operation.

This paper first presents a Hotelling-type model (Hotelling, 1929), in which parents have heterogenous preferences for different schools, to analyze the effects on student outcomes of having two types of schools in a market: public schools with no direct incentives to produce quality beyond meeting a minimum enrollment level; and voucher schools that face explicit competitive incentives. In this context, the model predicts positive effects of voucher school entry on the quality offered by both voucher and public schools (level effects). The model also predicts that the size of the response of public schools to voucher school entry depends on the minimum enrollment level needed by a public school to operate and on the size of the school age population (interaction effects). Finally, the model suggests that voucher-school competition may put stronger pressure to improve quality on public schools than on voucher schools.

As a potentially exogenous determinant of voucher school competition in different markets, I exploit the interaction of the number of Catholic priests per person in 1950 in different areas of Chile with the establishment of the voucher system in 1981. I show that the number of priests per person is historically determined; and, while Catholic priests have been involved in Catholic schools since these schools started receiving vouchers,

their involvement in schools for middle- and lower-class students before 1981was negligible. Moreover, before the 1981 reform Catholic school competition had no financial effects on public schools. Consistent with this, I also document that the number of priests per person had little effect on educational outcomes prior to 1981 and has a positive effect on outcomes after the voucher system was established. In other words, the potential validity of my identification strategy relies on the assumption that Catholic priests were present in the pre-voucher period, but that their effects on educational outcomes only became evident during the period when the voucher system was established. The evidence supports this view.

I estimate the *level effects* of the ratio of voucher-to-public schools on test scores in an educational market for a cross-section of students in 2002. This sample of students allows me to test the predictions of my theoretical model using data for the *post*-reform period. Because my reduced-form results imply that priests had little effect on educational outcomes before 1981, I use the number of priests in different areas in 1950 as a potentially valid source of exogenous variation in the supply of voucher schools during the *post*-reform period. I find that once I instrument for the ratio of voucher-to-public schools in different educational markets, the entry of a voucher in a market increases tests scores by about 0.14 standard deviations. The results are similar for students attending both public and voucher schools and do not differ from the results after controlling for educational outcomes before 1981. In contrast, the OLS estimates do not show a strong effect of voucher-school competition on test scores.

The data also support the existence of *interaction effects* of voucher school competition, as predicted by my theoretical model. Public schools located in areas with larger school-age populations or that receive above-the-median non-voucher transfers from the government do not react strongly to voucher-school competition. These results constitute a more demanding test of the predictions of my model and cannot be explained by alternative theoretical models that may explain the level effects of inter-school competition. Some of these alternative theories are as follows: (1) There may be direct effects of competition on parents' or other schools' information; i.e., parents or schools use the information provided by competitors to improve quality (Hoxby, 1994). (2) There may be reputation effects: yardstick competition among teachers who care about their performance in comparison to other teachers (Juerges et al. 2004); this effect may be more relevant in markets with more comparison points.(3) There may be poaching: good teachers signal their unknown characteristics and good (voucher) schools learn and hire these good teachers. My results on the existence of the interaction effects of voucher-

school competition are hard to reconcile with these alternative explanations and support the work of my model stressing the role of incentives on the behavior of public school agents.

The reminder of the paper is organized as follows. Section 2 briefly describes the Chilean education sector. Section 3 presents a theoretical model for framing the empirical analyses of the paper. Section 4 presents the data used in this paper. Section 5 describes the identification strategy. Section 6 presents the results of difference-in-difference regressions using data on educational outcomes before and after 1981. Section 7 presents estimates of the level effects of voucher-school competition on student outcomes using a cross-section of primary students in 2002. Section 8 presents estimates of interaction effects and section 9 briefly concludes. An appendix presents the proofs of the main theoretical results of the model.

2 Institutional Setting: Primary and Secondary Education in Chile

Before 1981, the government in Chile was involved in the funding and provision of education, the supervision and regulation of curricula, the handling of human resources, and investment.[1] The 1981 educational reform: transferred public education from the central to the local governments (municipalities); established a per-student subsidy (voucher) to be received by voucher and public schools depending on enrollment; allowed parents to choose among any publicly-financed school; and allowed would-be schools to enter the market.[2]

Three types of schools emerged: publicly owned schools (managed by local governments), voucher schools (owned by private agents), and non-voucher schools.[3] The first two types of schools receive vouchers; the non-voucher private schools do not receive public funds, charge high tuitions, and serve upper- income students. In 2002, voucher schools enrolled about 40% of students in 2002 up from an enrollment rate of 15% in 1981. Public school enrollment dropped from 78% in 1981 to 50% in 2002. The remaining enrollment corresponds to non-voucher private schools, which I do not include in my sample.

Public and voucher schools present important differences in terms of their incentive structures and the amount of non-voucher resources they receive. Voucher schools tend

[1] While the reform was formally enacted in 1981, Aedo-Richmond (2000) suggests that the reform began to be implemented *de facto* around 1978.

[2] Sapelli (2003) presents a more detailed description of the Chilean voucher system.

[3] A small group of free private schools did operate before the 1981 reform. These schools enrolled around 5% of the school-age population and were financed with small public subsidies and private donations (Aedo-Richmond, 2000).

to behave like competitive firms, receiving revenues proportional to enrollment. While some voucher schools are operated by for-profit firms, other voucher schools are operated by non-profit organizations that raise additional funds in a relatively competitive market for donations to be spent in schools (Aedo, 1998). In contrast, public schools work under "softer" budget constraints: when needed, public schools that are losing students receive transfers, above and beyond the vouchers to pay their expenses (Sapelli, 2003). In addition, while vouchers were the only public intervention in the K-12 sector during the 1980s, governments during the 1990s channeled additional resources to "vulnerable" schools and increased non-voucher spending. In terms of teacher regulations, the public school teachers face flat wage schedules and cannot be removed easily from their positions (Mizala and Romaguera, 2004). The number of teachers per student is 25% higher in public schools than in voucher schools (CENDA, 2002). And, public schools are highly unionized.[4] I use these differences in the institutional environment that voucher and public schools face in the model in Section 3.

The closing of public schools is a second institutional feature of the Chilean system that I study in the model. The data suggest that about 8% of public schools stopped reporting test scores during the 1990s. The most likely reason for this is that these schools were closed or merged with other public schools. The closed schools tended to have fewer students than other public schools and to under-perform relative to other public schools. Interestingly, the teachers' union is now actively lobbying against the closing and merging of public schools. Moreover, the opinions of teachers reported in Bellei et al. (2003) suggest that teachers do not want to be moved from one public school to another. This evidence, in conjunction with the evidence on fixed wages, suggests that public school teachers earn significant rents from working in public schools.

3 Motivating Theory

I present a simple theoretical model for studying the potential effects of voucher-school competition on school quality. The model incorporates three groups of agents: parents deciding among different schools, voucher school owners, and public school agents.

3.1 Agents

$\bar{L}$ parents are uniformly distributed over a linear neighborhood of length 1. The location of parents along the linear neighborhood refers to their preferences for public and voucher

[4]The teachers' union has strong political power and actively lobbies for additional benefits and against policies aimed at providing performance incentives.

schools, which are located at the extremes of the city. In particular, let x denote location along the linear neighborhood, public schools are located at $x = 0$ and voucher schools at $x = 1$. This modelling approach formalizes the notion that public and voucher schools not only offer formal instruction (i.e., measured in test scores), but also instruction in other areas, such as religious education and civic values. I assume that parents have heterogeneous preferences about these school characteristics and that schools cannot choose their location along the linear city (i.e., public and voucher schools have intrinsic differences in the non-formal instruction they provide).

The utility of a parent located at x is given by:

$$U_{jx} = q_j - td_{jx}, \tag{1}$$

where q_j is quality offered by the school j and d_{jx} is the distance from parents located at x to school j. d captures the discrepancy between parents' preferred instruction and the instruction provided by school j. Therefore, t is a "transportation cost" that measures the disutility per unit of distance of sending children to a school that is not located at x. Parents choose the school that maximizes (1). If two voucher schools offer the same quality, then parents randomize among them.

There is only one public school in each neighborhood, but the number of voucher schools (N) is endogenously determined in the model, given some number of would-be voucher schools in an area (N^P). The number of would-be voucher schools may be limited, because school quality is a good whose reputation is important. School quality is provided after students are enrolled; therefore, voucher schools may "hold up" parents and not fulfill their initial offers of quality. In a context of incomplete contracts, only voucher schools with good reputation or that can signal that they are not opportunistic agents are able to enter the market and generate a positive demand. In addition, cultural and social factors may constrain the number of acceptable voucher schools.[5]

Owners of voucher schools decide simultaneously whether they enter the market and what quality they provide (q_V). Profits of voucher school i are given by:

$$\Pi_i = \left[(v - c^V(q_{V_i}))n_{V_i} - F\right], \tag{2}$$

where v is the per-student voucher, $c^V(\cdot)$ is the unitary cost of providing quality q_V, n_V

[5]Survey data from Chile suggest that, indeed, there are limitations in the supply of voucher schools. Lehmann and Hinzpeter (1997) report that in 1996 about half of the parents with children in public schools would like to have their children in voucher school. In 2001, while 39% of middle-income parents have or had their children in a voucher schools, 66% would have preferred a voucher school to a municipal. Results for low-income parents are similar: while 21% of these parents have or had their children in voucher schools, about 50% would have preferred a voucher school.

is the number of voucher school students, and F is a fixed cost. I assume $c^{V\prime}(\cdot) > 0$ and that quality offered by voucher schools has to be above a minimum level q_V^M.

In terms of public schools, mayors (who manage public schools in a municipality) face an agency problem; in contrast to voucher schools, public schools cannot use variable wages and other forms of explicit incentives to implement their optimal choices. Thus, public school agents (teachers) decide the quality that public schools provide (q_P) by maximizing:

$$\left\{y - c^P(q_P) + R\ \mathbf{1}\left[n_p \geq \bar{n}\right]\right\}, \tag{3}$$

where y is income of teachers, which is fixed, $c^P(\cdot)$ is the effort cost of providing quality q_P ($c^{P\prime}(\cdot) > 0$), $\mathbf{1}\left[n_P \geq \bar{n}\right]$ is an indicator function that takes a value of one if $n_P \geq \bar{n}$ and a value of zero otherwise, n_P is the number of public school students, $\overline{n}$ is the minimum enrollment level, and R is a positive constant that captures rents of public school agents that are lost if the public school closes. The public school closes when its enrollment is below the minimum enrollment level or its quality is below q_P^M.

The public school budget is:

$$\left[(v-o)n_P - F + NV\right],$$

where NV is a non-voucher transfer and o is a per student cost. I assume that only non-voucher transfers vary across public schools. The minimum enrollment level of each public school is the enrollment level associated with a balanced public school budget, which is given by:

$$\bar{n} = \frac{F - NV}{v - o}.$$

Since only NV varies across public schools, $\bar{n}$ is determined by changes in NV.

3.2 Equilibrium

The timing of events is as follows:

1. First, a finite number N^P of voucher schools simultaneously decide whether they enter the market and the quality they provide (q_V).

2. Next, public school agents decide the quality they provide (q_P).

3. Finally, parents decide to which school to send their only child.

The symmetric subgame perfect equilibrium of this model is characterized by values for q_P, q_{V_i}, N, n_P, n_V, and n_{V_i}, such that:

- Quality offered by all voucher schools is the same, i.e., $q_{V_i} = q_V \ \forall \ V_i$.
- Parents maximize (1) by selecting among available schools.
- Public school agents maximize (3) by selecting public school quality.
- $N \leq N^P$.
- $\Pi_i \geq 0$, and the N voucher schools that have entered the market maximize (2) by selecting voucher school quality.

To solve the symmetric subgame perfect equilibrium of the model, I use backwards induction, starting from parents' choices. Parents choose a school to maximize (1). Aggregating their decisions, I derive the demand for public and voucher schools, as stated in Result 1 (proofs of the theoretical results are presented in the Appendix):

Result 1 *Enrollment in the public school and voucher schools is, respectively:*

$$n_P = \begin{cases} \bar{L} & \text{if } N = 0 \\ \bar{L}\left(\frac{q_P - q_V}{2t} + \frac{1}{2}\right) & \text{if } N > 0 \end{cases},$$

$$n_{V_i} = \begin{cases} 0 & \text{if } N = 0 \\ \frac{\bar{L}}{N}\left(\frac{q_V - q_P}{2t} + \frac{1}{2}\right) & \text{if } N > 0 \end{cases} \quad \forall \ V_i.$$

School quality is determined by maximizing utility of public school agents, given Result 1. Note that maximization of Equation (3) implies that either the minimum quality or the minimum enrollment constraint is binding in equilibrium. Condition 1 states the case in which the minimum enrollment constraint binds.

Condition 1 (Minimum Enrollment Constraint Binding)

$$\left(\frac{\bar{n}}{\bar{L}} - \frac{1}{2}\right) \geq \frac{q_P^M - q_V}{2t}.$$

Condition 1 is quite intuitive and states that the minimum enrollment level is more likely to be binding when the minimum enrollment is high relative to the population and the difference between minimum public school quality and voucher school quality is large.

Result 2 presents the optimal public school quality.

Result 2 *1. If Condition 1 holds, optimal public school quality is given by:*

$$q_P = \begin{cases} q_P^M & \text{if} \quad N = 0 \\ 2t(\frac{\bar{n}}{\overline{L}} - \frac{1}{2}) + q_V & \text{otherwise} \end{cases},$$

and, enrollment in public schools is given by:

$$n_P = \begin{cases} \overline{L} & \text{if} \quad N = 0 \\ \bar{n} & \text{otherwise} \end{cases}.$$

2. If Condition 1 does not hold, optimal public school quality is given by:

$$q_P = q_P^M,$$

and, enrollment in public schools is given by:

$$n_P = \begin{cases} \bar{L} & \text{if } N = 0 \\ \bar{L}\left(\frac{q_P^M - q_V}{2t} + \frac{1}{2}\right) & \text{if } N > 0 \end{cases}.$$

The intuition of this result is that only one of the two constraints is binding in equilibrium. Thus, if there is no voucher school in the market, then public school agents offer the minimum quality, q_M^P. The same result emerges if the minimum enrollment level is not binding. In contrast, if the minimum enrollment constraint binds, then public school agents have to produce a (higher) quality level, such that the public school has exactly the number of students needed to satisfy the minimum enrollment level.

Finally, regarding the behavior of voucher schools, I first determine the number of voucher schools that have non-negative profits if they produce the minimum quality level (q_V^M), assuming no restriction on the number of would-be voucher schools. I denote this number of schools as N^*. I analyze below the case in which there are a limited number of would-be voucher schools.

Result 3 *1.* $N^* = 0$ *if* $n_V(v - c^V\left(q_V^M\right)) < F$.

2. $N^* > 0$ *if* $n_V(v - c^V\left(q_V^M\right)) \geq F$. N^* *is given by:*

$$N^* : \frac{n_V}{(N^*+1)}(v - c^V\left(q_V^M\right)) < F \leq \frac{n_V}{N^*}(v - c^V\left(q_V^M\right)).$$

This result highlights an important property of the model. Namely, that N^* depends positively on the total enrollment in voucher schools which, in turn, depends negatively on public school quality (See Result 1). Therefore, this model predicts that the better the public schools in an area are, the lower is the number of voucher schools operating

in that area. This result is important for the empirical implementation of the model because it suggests that there may be reverse causality from public school quality to the number of voucher schools in an area. Therefore, OLS estimates of the effect of voucher-school competition are downward biased. This bias suggests using instrumental variables to identify the causal effect of the number of voucher schools on public school quality.

Next, the actual number of voucher schools depends on the availability of would-be voucher schools in a market.

Result 4 *The number of voucher schools operating in a market is:*

$$N = \min\left(N^*, N^P\right).$$

Finally, the next result determines the optimal quality level offered by each voucher school.

Result 5 *If Condition 1 holds, quality offered by voucher schools is*:

$$q_V = \begin{cases} q_V^M & \text{if } N = 1 \text{ and } N^P = 1 \\ c^{V^{-1}}\left(v - \frac{NF}{L-\bar{n}}\right) & \text{if } N \geq 1 \text{ and } N^P \geq 2 \end{cases}.$$

If Condition 1 does not hold, quality offered by voucher schools is:

$$q_V : \begin{cases} \frac{c^V(q_V)}{c^{V'}(q_V)} = 2t\frac{n_V}{L} & \text{if } N = 1 \text{ and } N^P = 1 \\ q_V = c^{V^{-1}}\left(v - \frac{NF}{n_V}\right) & \text{if } N \geq 1 \text{ and } N^P \geq 2 \end{cases}.$$

This result highlights the role of competition in creating incentives for voucher schools to increase quality. In the case when $N = 1$ and $N^P = 1$, the single public school does not face potential competitors, chooses the minimum quality level (q_V^M) and earns rents in equilibrium. In contrast, when $N^P \geq 2$ and $N = 1$, the existence of potential entrants creates incentives for the incumbent voucher school to increase quality until profits are equal to 0. Similarly, when $N \geq 2$, the existence of potential competitors creates incentives for incumbents to offer a quality level such that profits are equal to 0 in equilibrium.

Results 1 through 5 allow me to characterize the equilibrium quality given different parameter values. This is presented in Proposition 1.

Proposition 1 (Equilibrium Public and Voucher School Quality) *If Condition 1 holds in equilibrium, public and voucher school quality are given by:*

$$q_P = \begin{cases} q_P^M & \text{if } N = 0 \\ 2t(\frac{\bar{n}}{L} - \frac{1}{2}) + q_V^M & \text{if } N = 1 \text{ and } N^P = 1 \\ 2t(\frac{\bar{n}}{L} - \frac{1}{2}) + c^{V^{-1}}\left(v - \frac{NF}{L-\bar{n}}\right) & \text{if } N \geq 1 \text{ and } N^P \geq 2 \end{cases},$$

$$q_V = \begin{cases} q_V^M & \text{if } N = 1 \text{ and } N^P = 1 \\ c^{V^{-1}}\left(v - \frac{NF}{L-\bar{n}}\right) & \text{if } N \geq 1 \text{ and } N^P \geq 2 \end{cases}.$$

If Condition 1 does not hold in equilibrium, public and voucher school quality are given by:

$$q_P = q_P^M \ \forall \ N,$$

$$q_V : \begin{cases} \frac{c(q_V)}{c'(q_V)} = 2tn_V & \text{if } N = 1 \text{ and } N^P = 1 \\ q_V = c^{-1}\left(v - \frac{NF}{n_V}\right) & \text{if } N \geq 1 \text{ and } N^P \geq 2 \end{cases}.$$

To focus on the most interesting cases for the purposes of this paper and to reduce the number of possible cases, I discuss mainly the case in which the minimum enrollment constraint binds in equilibrium (Condition 1). This seems the most plausible case for Chile.[6] When Condition 1 is violated, public school quality does not depend on the number of voucher schools. In turn, voucher school quality is an increasing function of the number of voucher schools in the market. When Condition 1 holds, the minimum enrollment level is binding; therefore, public school quality also depends on the number of voucher schools in the market, because public schools respond to voucher school quality in order to achieve the minimum enrollment level.

Proposition 1 allows me to study the effects of increases in N^P on public and voucher school quality. These comparative static exercises are closely related to my empirical analysis in this paper, which uses a potentially valid source of exogenous variation of N. In the remainder of the model, I only consider the case in which $N \leq 2$, which is the relevant interval for Chile, because the ratio of voucher-to-public schools is less than 2 in 95% of the educational markets.

Corollary 1 (Level Effects) *If Condition 1 holds in equilibrium and $N \leq 2$, an increase in N^P that increases N has a positive effect on equilibrium voucher and public school quality .*

[6] Condition 1 is supported by the data. The Chilean data suggests that: $-0.06 \approx (\frac{\bar{n}}{L} - \frac{1}{2}) > \frac{q_P^M - q_V}{2t} \approx \frac{-.16-.03}{1.61} \approx -0.12$. I estimate t from a regression of $\frac{n_P}{L}$ on $q_P - q_V$. I approximate q_P^M using the average test scores of public schools when $N = 0$, and q_V using the average test scores for voucher schools in markets with $N = 1$.

If Condition 1 holds in equilibrium and $N = 1$, an increase in N^P from 1 to 2 has a positive effect on equilibrium voucher and public school quality.

Intuitively, when N increases from 0 to 1, the public school increases the quality offered because the minimum enrollment constraint becomes binding. When N increases from 1 to 2, the incumbent voucher school has to increase its quality until rents are dissipated, because the entering voucher school offers a higher level of quality. In this case, the public school has to respond to the increase in voucher school quality in order to meet the minimum enrollment constraint. The second case stated in Corollary 1 highlights the effects of increasing potential competition when the market is such that only one voucher school operates. In this case, potential competition creates incentives for the incumbent voucher school to increase quality until profits are dissipated.

Corollary 2 presents another interesting theoretical implication of an increase in N that is caused by an increase in N^P. This corollary resembles an empirically relevant case for Chile because public schools in about 85% of the educational markets face competition from at most one voucher school and, as previously mentioned, the ratio of voucher to public schools is less than 2 in 95% of the educational markets. Thus, this corollary produces theoretical predictions related to the variation I observe in the data.

Corollary 2 (Public vs. Voucher School Response to Competition) *Let q_j^N denote equilibrium quality of school j when the number of voucher schools in a market is N. Define z_P and z_V:*

$$\begin{aligned} z_P &\equiv q_P^1 - q_P^0, \text{ and} \\ z_V &\equiv q_V^2 - q_V^1 \end{aligned}$$

If Condition 1 holds in equilibrium and N increases initially from 0 to 1 and next from 1 to 2 as a consequence of an increase in N^P:

1. *If $z_P > z_V$, public school quality responds more strongly than voucher school quality to an increase in voucher school competition.*

2. *If $z_P = z_V$, public school quality and voucher school quality respond the same to an increase in voucher school competition.*

3. *If $z_P < z_V$, public school quality respond less strongly than voucher school quality to an increase in voucher school competition.*

The comparative static exercise in Corollary 2 implies that voucher school competition could put stronger pressures to increase quality on public schools than on voucher schools. Theoretically, there is no restriction to the relative response of both voucher schools to the comparative static exercise presented in Corollary 2. For instance, public school quality may be more responsive when the difference between minimum voucher school quality (q_V^M) and minimum public school quality (q_P^M) is sufficiently large, which produces a tremendous increase in public school quality in order to meet the minimum enrollment level. On the contrary, if $q_V^M - q_P^M$ is small or the minimum enrollment level is sufficiently small, then voucher schools' response to competition may be greater. The empirical results in this paper suggest that both types of schools respond similarly to voucher school competition.

Finally, Proposition 1 implicitly states that the response of the public school to an increase in the number of voucher schools produced by an increase in N^P depends on how binding the minimum enrollment constraint is. The minimum enrollment constraint is more binding when the school age population is large or when non-voucher transfers are large. Corollary 3 states this result.

Corollary 3 (Interaction Effects) *If Condition 1 holds in equilibrium and N increases from 0 to 1 as a consequence of an increase in N^P, then the larger is the school-age population $\left(\bar{L}\right)$, and the more the non-voucher transfers there are, the lower is the response of the public school to the entry of a voucher school in the market.*

The predictions of Corollary 3 are quite intuitive. Public schools with more stringent incentives in the form of harder enrollment levels have to increase quality more when a voucher school enters the market. This corollary clearly illustrates the working of the model in terms of the mechanism that makes voucher schools increase quality when facing voucher school competition.

In summary, the most important empirical prediction of the theoretical framework presented in this section is that public and voucher school quality should increase as the number of voucher schools in a market increases exogenously. In addition, there should be interaction effects: the public school response to exogenous changes in voucher school competition depends on how binding the minimum enrollment is. This result illustrates the theoretical mechanism at work in the model, which is basically related to the implicit incentives that the minimum enrollment constraint gives to public school agents. In addition, the theory predicts that the response of public schools to an increase in the number of voucher schools in a market may be greater than the response of voucher

schools if the minimum public school quality is sufficiently low. Finally, the theory also suggests that the number of vouchers in a market is endogenous to public school quality. This suggests the use of instrumental variables in the empirical analyses of this paper.

4 Data

I use several datasets in this paper. Table 1 presents the variables used, the level at which each variable is collected, and the descriptive statistics of each variable. I use data on students' educational outcomes, their backgrounds, parent preferences, school characteristics, and the characteristics of the area where they attend school from the dataset of the 2002 SIMCE (*Sistema de Medición de la Calidad de la Educación*) test, which was administered to 4th graders. This test has been given nationwide since 1988 to more than 90% of students in a different grade each year (4th, 8th, or 10th graders). I use the average of the Math and Spanish portions of the test (standardized to have an average of 0 and a standard deviation of 1) as my measure of academic outcomes. I use income per household member and mother's education to measure the socioeconomic background of students.[7]

Second, I use the CASEN (*Encuesta de Caracterización Socioeconómica*) 2000 survey, which collects information on socioeconomic variables for a representative cross-section of the population. I use a high school graduation dummy as a measure of educational attainment for members of different cohorts that attended school in different places. Third, I use the 2002 Social Protection Survey (called "Labor History and Social Security"), which collects life-time information for a sample of individuals. I use information on high school graduation rates at the market level for individuals attending school before the 1981 reform and the migration decisions of parents with school-age children in 2002.

I measure the degree of voucher school competition as the ratio of voucher schools to public schools in each educational market. I use 284 municipalities and the Metropolitan Area of Santiago as proxies for local educational markets. Municipalities are separate educational markets because, with the exception of municipalities in the Metropolitan Area of Santiago, most students attend schools in the town where they live (Hsieh and Urquiola, 2004; and Sapelli and Vial, 2002). Data on the availability of schools in each market come from the Ministry of Education files.

Data on religious variables at the diocese level related to my identification strategy

[7] I use five categories to measure mother's education (having attained at most primary education, secondary general education, secondary technical education, post-secondary technical education, and college or postgraduate education).

come from the yearly publication by the Vatican called *Annuario Pontificio* (the number of priests, the share of Catholics, and the ratio of order to total priests in each Chilean diocese).

I also use other sources of data in some empirical exercises. Data on Catholic schools come from the school directory of the Educational Foundation of the Chile Catholic Bishops Conference (http://www.feducech.cl/). Data on socioeconomic outcomes not included in the previous datasets at the market level come from the Chilean Municipal Dataset (available at http://www.sinim.cl/). Finally, when analyzing the interaction effects of inter-school competition, I use information on electoral outcomes at the municipality level from the Chilean Electoral Office.

5 Identification Strategy

One major challenge for an empirical analysis of the relationship between voucher school competition and educational outcomes is the potential endogeneity of the number of voucher schools. In this section, I argue that the interaction of the number of Catholic priests per person in 1950 and the school reform of 1981 allows me to identify the exogenous variation in the number of voucher schools in different educational markets.

The potential endogeneity between the number of voucher schools and public school quality can be illustrated using the model in Section 3. Increases in minimum quality (q_P^M) or minimum enrollment ($\overline{n}$) decrease the number of voucher schools operating in an area and have a positive effect on quality offered by public schools. Thus, entry into the market is endogenous to public school quality; therefore, simple correlations or OLS estimates will produce *downward* biased estimates of the causal effect of voucher-school competition on educational outcomes. Alternatively, OLS estimates could be biased upward if voucher school entry responds to some unobserved (to the econometrician) characteristic of the market that has a positive effect on school quality.

My identification strategy exploits the interaction of the (log of the) number of Catholic priests per person in 1950 and the 1981 reform to identify the exogenous variation in the number of voucher schools in an area, after controlling for the share of Catholic population.[8] The basic motivation for this identification strategy is that the involvement of priests in educational activities is understood as a key element of their religious mission (Garrone, 1977). However, although Catholic priests were involved

[8]By controlling for the share of the Catholic population, I take into account potential direct effects of this variable on educational results (as suggested by recent research on the effects of religious affiliation on income, education, and other social and economic variables, e.g., Barro and McCleary, 2003 and Gruber, 2005).

in the management and construction of Catholic schools after the reform when these schools started to receive vouchers, their involvement in schools for middle- and lower-class students before 1981 was negligible. The main reason for this shift is that only after the reform did Catholic schools start to receive vouchers, allowing priests to establish new schools or to expand enrollment among middle- and lower-class students. Before the reform, the Catholic schools existed but focused on high-income students because there was little public funding. Enrollment in free private schools before the reform was only about 5% of the school-age population (Aedo-Richmond, 2000), which defined an upper bound for enrollment in free Catholic schools. In contrast, after the reform, the enrollment in Catholic schools increased significantly to about two-thirds of total voucher school enrollment (based on data from 2002). Moreover, the voucher reform at the same time created incentives for public schools to react to voucher-school competition by linking public school revenues to enrollment.

Priests are important actors in Catholic schools. These schools can be owned directly by the Church, by religious orders, or by people supported by the Church, but they always have at least one priest acting as a chaplain. Currently, priests tend to focus on pastoral ministries (e.g., being chaplains and teaching religious education classes) and on the management of schools. In terms of time requirements of being a priest in a school, priests have to spend a significant amount of time working with students, teachers, and parents. Priests working in schools receive wages that are comparable to those of other teachers. Pasalacqua (2004) reports that about 5% of the teaching staff and 10% of the non-teaching staff in Catholic voucher schools are religious personnel (including not only priests, but also brothers and nuns).

The number of priests per person is historically determined and varies widely across Chilean dioceses, despite the majority of the population being Catholic.[9] While the average diocese has a ratio of about 0.15 priests per 1,000 people, the diocese with the highest ratio (0.23 priests per 1,000 people) has more priests per person than most Latin American countries; and, the diocese with the lowest ratio (0.06 priests per 1,000 people) is comparable to what is observed in a poor (and non-Catholic) country such as Kenya. The variation in the number of priests across Chilean dioceses has to do mainly with the fact that religious orders are more numerous in some areas than others.

Religious orders established themselves in a non-uniform way in different dioceses in the past. The allocation of orders to different dioceses was related mainly to the

[9]In the Catholic Church, a diocese is an administrative territorial unit, composed of many parishes and governed by a bishop. Technically, each diocese is independent of the others and the bishop only responds to the Pope. There were 19 Catholic dioceses in Chile in 1950.

desire to bring priests to some Chilean areas beginning in the mid nineteenth to the mid twentieth centuries (Aliaga, 1989; Araneda, 1986; Barrios, 1992). Some areas ended up with more order priests because the bishops of some dioceses either belonged to orders themselves or were more open to receiving order priests. While 71% of the order priests in Chile in 2002 belonged to orders that entered the country between 1810 (the year of independence) and the 1950s, only 5% of these priests belonged to orders that entered the country after the 1950s.[10] In general, there are more order priests than non-order priests. Therefore, dioceses where religious orders work tend to have more priests. The historical roots of the presence of orders in different areas creates a positive correlation between the number of priests today and in the past: the correlation between the number of priests per capita during the 1990s and the 1950s is 0.78.

Table 2 illustrates the importance of orders in explaining the cross-diocese variation in (the log of) priests per capita in 1950. I use the ratio of order priests to the total number of priests as a proxy for the presence of orders in different dioceses. Results in columns 3 and 4 support the claim that the variation of priests per capita is related to the presence of orders in different dioceses.

I use priests per capita in 1950 as the main instrument for voucher school entry in different areas during the voucher period, and the ratio of order-to-total priests as an alternative instrument. The next section empirically studies the validity of this identification strategy.

6 Reduced Form Estimates: Difference-in-Difference Analysis and Robustness Checks

To validate the identification strategy discussed in the previous section, I need to show that priests are not related to educational outcomes before the voucher reform and are related to educational outcomes after the reform. Table 3 presents the basic evidence supporting this identification strategy. In particular, I focus on three different cohorts. People older than 37 in 2000 (the year the CASEN survey was collected) attended school before the reform was implemented; people between 26 and 37 years attended school between 11 years and one year after the reform was implemented; and those less than 26 received their complete K-12 education after the reform was implemented. Because I do not have data on test scores before the reform, I use high school graduation as a proxy for school quality.

The results in Table 3 suggest that the number of priests has no relationship to

[10] These numbers were computed using information from the 2002 directory of the Catholic Church in Chile.

high school graduation rates for people attending school before 1981 (column 1). For the second group (i.e. those receiving only a share of their primary and secondary education after 1981), the effect of priests is positive but not significant. Finally, for those receiving their entire education after 1981, priests have a positive and significant effect on educational outcomes.

The results using the ratio of order-to-total priests point in the same direction, but they are not as precisely estimated as when using the number of priests (columns 4 to 6). Overall, this evidence supports the idea that priests are correlated with educational outcomes only for the cohorts that attended school after the 1981 reform.

Figure 1 presents a more detailed exercise to evaluate the differentiated effects of priests on educational outcomes for cohorts that have different degrees of exposure to the 1981 reform. The top panel of that figure plots the relation between high school graduation and priests in the decade closer to school attendance for individuals of different ages in 2000, after controlling for a complete set of age and municipality dummies. This exercise also allows me to study whether the effect of the reform varies for individuals of different ages. The results suggest that priests are only correlated with the level of education for cohorts that attended school after the reform was implemented. As importantly, the effect of priests on high school attainment is increasing in the number of years that people attended school after the reform. Panel B presents the results of the same exercise as shown in Panel A using the ratio of order-to-total priests as the proxy for the presence of priests in different areas. The results are qualitatively similar, but not as precisely estimated as when using the number of priests per person.

Overall, these results demonstrate the claim that priests only are correlated with educational outcomes after the 1981 reform, and they confirm the rationale presented in Section 5. Having established this central result, I present a number of additional exercises to validate my identification strategy. Table 4 presents estimates of the relationship between priests per capita and the ratio of order-to-total priests in 1950 and the ratio of voucher-to-public schools in each market in the voucher period. Priests and the ratio of order-to-total priests both have a positive and significant effect on the number of voucher schools per public school. The effect of Catholic affiliation is also positive and significant, as expected.[11]

One potential concern for my identification strategy is that priests may have affected education outcomes after the reform through other channels than voucher-school com-

[11]Results for other variables included in these regressions are similar to other papers (Gallego, 2002; Hsieh and Urquiola, 2004): mean (standard deviation of) education and income have positive (negative) effects on the availability of voucher schools, and more populated areas have more voucher schools.

petition. I study whether immigration decisions of families with school-age children are correlated with the presence of priests in different areas. If in-migration rates of families with children are higher in areas with more priests, then an alternative explanation may be sorting of families based on taste/motivation for education. I do not expect this channel to be important, given the available evidence showing that migration in Chile is low because of public housing policies (Soto and Torche, 2004; Tironi, 2003). The results in Table 5 confirm this presumption and show that both micro estimates of in-migration decisions of families with children and macro estimates of immigration rates at the region level do not support the view that in-migration rates are higher in areas with more priests.

Overall, I document that the number of priests per person is historically determined; prior to 1981, it has little effect on educational outcomes. I also show that Catholic priests affected educational outcomes after the voucher system was established. These results suggest that I have a potentially valid source of exogenous variation in the supply of voucher schools in different areas during the voucher period. Using these results, the next section estimates the level effects of voucher-school competition on student test scores in a cross-section of students in 2002.

7 Estimating Level Effects

In this section, I present the results of regressions using information on test scores from a cross-section of students in the voucher period. This approach has several advantages over the reduced form estimates I presented before. First, I have detailed information on the degree of voucher-school competition in the educational market where the student attends school. Second, I have a more direct measure of school outcomes (test scores) than in the previous exercises (high school graduation), which allows me to estimate more precisely the effect of voucher-school competition on test scores. Third, I am able to study whether the interaction effects predicted by the model are supported by the data. Since the results in Section 6 suggest that priests only affect educational outcomes after the reform, the number of priests per capita prior to 1981 is a valid instrument for voucher-school competition during the reform (as well as for the interaction of priests with the reform). Thus, I estimate the impact of voucher-school competition on student test scores by running a regression of the form:

$$q_{im} = \pi R_m + X_{im}^{'}\alpha + M_{m}^{'}\beta + Y_{m}^{'}\rho + \varepsilon_{im}. \tag{4}$$

Subscript i refers to students and m to educational markets. q is test scores, R is the ratio of voucher to public schools in market m, X is a vector including pre-school char-

acteristics of students (mother's education and log of income per household member), M is a vector including the mean and standard deviation of mother's education and income at the market level, Y is a vector including exogenous variables (Catholic population, total school age population, urbanization rate, and region dummies), and ε is a student-specific error term.[12]

Following the model presented in Section 3 , I use the ratio of voucher-to-public schools as my measure of voucher-school competition—R_m in equation (4)—at the market level. When I compute the number of voucher schools per public school at the market level, I obtain the average availability of voucher schools per public school in each neighborhood (assuming that one public school exists in each neighborhood, which is reasonable in the case of Chile).

I estimate equation (4) using the log of Catholic priests per person in 1950, or the ratio of order-to-total priests, as my instrument for R_m. In addition, as discussed in Section 5, the ratio of order-to-total priests corresponds to a more basic source of variation in the number of priests in different areas in Chile. Thus, I also present IV estimates using the ratio of order-to-total priests as an alternative instrument (in one specification I use both variables as instruments for voucher-school competition). I use variables measured in 1950, which corresponds to the end of the period of entry of Catholic orders into Chile.

7.1 Complete Sample Estimates

I first estimate equation (4) using the complete sample of students attending public and voucher schools in the 2002 SIMCE dataset. Table 6 presents OLS estimates (columns 1-3) and IV estimates of equation (4) using log of priests in 1950 (columns 4-6) and the ratio of order-to-total priests (columns 7-9) as my instruments for R_m. In each specification, I start from a parsimonious representation of the regression without including controls and only including my measure of voucher-school competition. Next, I include only student-level controls, and finally *both* market- and student-level controls. The IV estimates are larger than the OLS estimates as suggested by my model, because school entry may be endogenous to quality. While the OLS estimates are in the interval between -0.02 and 0.04, the IV estimates are in the interval between 0.13 and 0.20.[13] The IV point estimates

[12]Since I include multiple observations of variables in the same area, I use the White/Huber estimator of the variance-covariance matrix to compute corrected standard errors that are robust to arbitrary heteroskedasticity and clustered standard errors.

[13]Measurement error in voucher-school competition may also explain why my OLS estimates are smaller than my IV estimates.

are always positive and significant. These results imply that the effects of voucher-school competition on test scores are also economically relevant. An increase of one voucher school in a market is associated with an increase in test scores of between 0.13 and 0.20 standard deviations. This is equivalent to about half of the effect of increasing mother's attainment from primary to secondary general education.

Estimates for other variables included in the regression have the expected signs. All socioeconomic controls are significant and have the expected sign: students with more educated mothers tend to perform significantly better, and students from households with higher incomes have higher test scores. The only two market-level variables with a statistically significant effect are mean per capita income (a positive effect) and the school-age population of the market (negative effect). The effect of the share of Catholics is negative, but it is not precisely estimated.

Next, column (10) in Table 6 presents estimates using *both* priests and the ratio of order-to-total priests as instruments. As expected, the estimated effect falls between the estimates in columns (6) and (9). More importantly, an over-identification test of this specification does not reject the null hypothesis that the instruments are valid. Formally, the result of the over-identification test implies that IV estimates using each of the two instruments separately are not statistically different among them.

These estimates of the effect of voucher school competition on test scores are slightly smaller than the effects of inter-school competition reported in papers for the US. While Bayer and McMillan (2005) and Hoxby (2000) report that a one-standard deviation increase in their proxies for the degree of school competition increases test scores by about 0.15 standard deviations, my estimates imply that a one-standard deviation increase in voucher school competition increases test scores by about 0.10 standard deviations.

The estimates on the effect of voucher-school competition on test scores also are consistent with my reduced-form estimates of the effects of priests on high school graduation rates reported in Section 6. My reduced-form estimates in the previous section imply that a one-standard deviation increase in the (log of the) number of priests (roughly equivalent to 43 log points) increases high school graduation by about 11 percentage points for people attending school after the reform (computed using results from Figure 1). In turn, a similar increase in the number of priests increases the ratio of voucher-to-public schools by about 0.22 (Table 4), which increases test scores by between 0.031 and 0.037 standard deviations. To relate both results, I use the estimates of Hanushek and Kimko (2000), who find that a one-year increase in schooling is associated with an increase in about 0.042 standard deviations in test scores. In my sample, a person

who graduated from high school has about six years more of education than the rest of the population. Putting everything together, I expect the impact of the increase in high school graduation to be consistent with an increase in test scores of 0.03 standard deviations ($0.11 \times 0.042 \times 6 \approx 0.028$). Therefore, reduced-formed estimates of the impact of priests on high school graduation and cross-section estimates of the effects of voucher school competition on test scores are consistent.

Table 7 presents additional specifications. I study one potential concern with the results in Table 6: some variables, such as income and mother's education, may be affected by my instruments if parents attended school after the reform. If mother's education and income do not involve measurement error, then my earlier estimates can be interpreted as the direct effects of voucher-competition on student outcomes. However, if mother's education and income are subject to measurement error, then the estimates of voucher-school competition may be biased upward.[14] To deal with this potential problem, Columns (1) and (2) present the results excluding students with parents who attended school after the reform (i.e. parents older than 39 years). The results are very similar to those shown in the other columns, suggesting that my previous estimates do capture the direct effect of voucher-school competition on test scores, controlling for mother's education and income.

Next, Columns (3) and (4) in Table 7 present the results of an additional exercise: I include controls for systematic differences in pre-reform educational outcomes in equation (4). Even though my results in Section 6 suggest that my instruments are not correlated with pre-reform differences in academic outcomes, these results provide an additional check. I include the high school graduation rate for people attending school in the market before the reform as my measure of pre-reform educational outcomes in different markets. The results show that my main estimates of the effect of the ratio of voucher-to-public schools are not affected. The point estimates increase slightly, to 0.17 and 0.15, when using the number of priests and the ratio of order-to-total priests, respectively. Finally, columns (5) and (6) present regressions using average test scores at the market level as my left-hand-side variable. I find positive and significant effects of voucher-school competition on test scores when I use the number of priests as my instrument. When I use the order dummy, the point estimates are smaller and significant at 10%. Interestingly, one test suggests that student-level and market-level regressions are not statistically different.

Overall, the results from the complete sample of students taking the 2002 SIMCE

[14] More precisely, mother's education and income may not capture all the effects of mother's human capital on children's educational outcomes.

test represent the first piece of evidence showing that voucher-school competition has a positive effect on student outcomes. The results are obtained by estimating the effect of voucher-school competition on students in a particular market irrespective of whether the student is attending a specific school, using individual data and after controlling for students' socioeconomic background and market characteristics. In the next section, I study whether the effects of voucher school competition are different for students attending different schools.

7.2 Students attending Public and Non-Catholic Voucher Schools

In this section, I study the effects of voucher-school competition on test scores for students attending public schools and non-Catholic voucher schools. These sub-samples allow me to analyze whether the estimated effect of voucher-school competition on student outcomes in public schools is different than for voucher schools. Therefore, I study empirically the predictions of Corollary 2.

Since I estimate (4) for sub-samples of students, I implement a Heckman selection model with endogenous variables (Wooldridge, 2002). This procedure allows me to control for potential selection bias if the students included in these regressions are not randomly selected from the population. To implement this procedure, I need to find a variable that affects the selection of students in different schools and has no direct effect on test scores. My instrument in the selection equation is a dummy that takes a value of one if the teaching of values was among the top three criteria used by parents for choosing schools. Since the mention of "teaching of values" (i.e., *la enseñanza de valores* in Spanish) has a religious connotation in Chile, this variable may capture relative preferences for voucher vis-a-vis public schools, or Catholic vis-a-vis non-Catholic voucher schools.[15] In terms of my model, the values variable is a proxy for the location of parents in the linear city.

In the initial stage of the estimation, I run a selection equation of the following form, using probit:

$$p_{im} = \mathbf{1}\left(\varphi S_{im} + \zeta Z_m + X_{im}^{'}\xi + M_m^{'}\varkappa + Y_m^{'}\tau + \mu_{im} > 0\right), \tag{5}$$

where p_{im} takes a value of 1 if an observation is included in the regression of interest, S_{im} is some variable that affects p_{im} and is not included in equation (4), Z_m is an instrument for R_m (i.e., priests in 1950 or the ratio of order to total priests), and $\mu_{im} \sim N(0,1)$.

[15] Other papers have found that parents' preferences for the teaching of values affect the choice of private versus public schools in the US (Sander, 2001). In a related result, Howell (2004) finds that religious identity affect the participation in a voucher program in New York.

Notice that in this equation I include all the right-hand side variables included in the first stage of (4). Next, for the selected subsample (i.e., for observations with $p_{im} = 1$), I estimate the equation:

$$q_{im} = \pi R_m + X_{im}^{'}\alpha + M_m^{'}\beta + Y_m^{'}\rho + \psi\hat{\lambda}_{im} + \varepsilon_{im}$$

by 2SLS, excluding S_{im} from the second stage regression. $\hat{\lambda}_{im}$ is the estimated inverse Mill's ratio for each observation.

Table 8 presents probit estimates of the marginal effects of the variables included in equation (5) on the choice between attending a public versus a voucher school and the choice between a non-Catholic versus a Catholic voucher school. The results indicate that the values variable is significantly correlated with the decision to send the student to a non-Catholic school. Marginal effects imply that if parents care about the teaching of values, they are 36% less likely to send their children to a public school versus a voucher school, and are 28% less likely to send their children to a non-Catholic voucher school vis-a-vis a Catholic voucher school.

Estimates for other variables included in equation (5) confirm previous results in the literature on the socioeconomic determinants of attending a public school (e.g. Sapelli and Vial, 2002 and 2003 for Chile; Checchi and Jappelli, 2004 for Italy): mother's education and family income have a negative and significant impact on the probability of attending a public school. Other estimates in columns (1) and (2) suggest that market characteristics are also important: the probability of attending a public school drops in urban and more populated areas, in poorer areas, and in areas where Catholic affiliation increases. Results for the probability of attending a non-Catholic versus a Catholic voucher school indicate that education and income play a similar role to the choice between a public and a voucher school, although the estimated effects are smaller and less significant. Similarly, the probability of attending a non-Catholic voucher school decreases in areas with a larger Catholic population and increases in more populated markets.

Using these probit models, I include the inverse of the Mills ratio in the second stage regression (Table 9). From these regressions, I obtain estimates that allow me to evaluate whether the effect of an additional voucher school is greater on public schools or existing voucher schools. The results show that the effect of an additional voucher school is quantitatively similar for public and voucher schools.

The results in Table 9 confirm the prediction of Corollary 2 in my model: public schools may react similarly to the entry of an additional voucher school if most public schools face competition from at most one voucher school as the data for Chile con-

firm and the difference between the minimum quality offered by public schools and the minimum quality offered by voucher schools is sufficiently high.

Overall, the evidence presented in this section presents a consistent pattern of positive effects of voucher-school competition on test scores for students attending public and voucher schools, as predicted by the model.[16] In the next section, I apply a more demanding test of the predictions of my model.

8 Estimating Interaction Effects

In this section, I expand the previous analysis by studying the implication of my model that there should be interaction effects: public school response to exogenous changes in voucher school competition depends on how binding the minimum enrollment is. Corollary 3 predicts that the effect of voucher school entry on test scores is smaller for schools that receive big non-voucher transfers and are located in areas with large populations of students. In both cases, public schools can meet the minimum enrollment constraint more easily. This result illustrates the theoretical mechanism at work in the model, which is related to the implicit incentives that the minimum enrollment constraint presents for public school agents. In this section, I test these two predictions against the data.

First, I study whether differences in non-voucher transfers affect the response of public schools to voucher-school competition. To do so, I split the sample of public schools into those located in municipalities that receive non-voucher transfers above and below the median. I expect the effect of voucher-school competition to be larger in the second sample.

I use a short-lived change in the Chilean electoral law that allows me to identify the short-run variation in non-voucher transfers and, therefore, to control for potential selection bias in my estimates. The electoral law operating between 1999 and 2003 establishes that a mayor (who manages the public schools) is the elected member of the municipal council who receives the most votes (conditional on getting at least 20% of the votes). This source of variation is useful for my identification strategy because, as previously discussed, municipalities receive discretionary transfers from the central government and pro-government mayors are able to raise more of these funds.

I implement a difference-in-difference regression to study the effects of the 1999 elec-

[16] I have estimated other regressions that to save space I do not present in the main text. First, quantile regressions suggest that the effect of voucher-school competition does not vary across different groups of students. Second, regressions for private and public expenditures on education show no effect of voucher school competition on these variables. Results available upon request.

toral law on non-voucher transfers in the context of a selection model of the form:

$$P_m = \mathbf{1}\left(\varphi V_m K_m + \varpi V_m + \phi K_m + \zeta Z_m + M_m^{'}\varkappa + Y_m^{/}\tau + \mu_m > 0\right), \tag{6}$$

where P_m is an indicator function that takes a value of one if the municipality receives non-voucher transfers above the median; V_m is the share of votes that goes to the pro-government coalition; and K_m is a dummy that takes a value of one if the mayor belongs to the pro-government coalition. I exclude the interaction of V_m and K_m from (4) and include each variable separately, as well as the estimated inverse of the Mills-ratio in (4). Table 10 presents my marginal probit estimates of equation (6). The results indicate that the interaction variable has a positive and significant effect: the probability that a municipality receives above-the-median transfers increases by more than 80% if the mayor belongs to the pro-government coalition, given the vote obtained by the pro-government coalition.

The results for the subsample of students attending public schools receiving high non-voucher transfers suggest that the effect of R on test scores is smaller in magnitude than the estimates for the complete sample (Table 11, columns 1 and 2). Moreover, a Wald test implies that estimates for these students are significantly different from estimates for students in areas with low non-voucher transfers, when I use priests as my instrument for voucher-school competition. If I use the ratio of order-to-total priests as my instrument, then the estimated effects are similar, but the Wald test does not reject the null hypothesis of no structural change (because the standard errors increase).

Overall, these results show that non-voucher transfers affect the degree of response of public schools to voucher-school competition, as predicted by my model.

Finally, I study whether the effects of voucher school competition on test scores decrease for the sample of public students that attend school in areas with above the median population density. The estimated effect of voucher-school competition for these students is significantly smaller than for students attending public schools outside these areas (Table 11, columns 3 and 4). As in the previous case, this result supports the idea that public schools located in areas with a bigger potential market tend to face less binding budget constraints and, therefore, tend to react less to the entry of an additional voucher school.

Overall, the data support the existence of heterogeneous effects of voucher school competition on public schools. As predicted by my model, public schools located in areas with larger school-age populations, or that receive above-the-median transfers from the government, do not react strongly to voucher-school competition. These results are

hard to reconcile with alternative explanations for the positive effects of voucher school competition.

9 Concluding Comments

The potential effects of school vouchers and inter-school competition on student outcomes has been a much debated topic in the US and elsewhere. My study of the Chilean voucher system, which has operated for more than 20 years in the complete K-12 system, can help us to understand the effects of vouchers on educational outcomes. Previous research has been stymied by endogeneity problems. I argue that the interaction of the variation in the number of priests per person across Chilean areas in 1950, and the institution of the voucher system in 1981, allows me to identify the effects of voucher-school competition on test scores. I document that the number of Catholic priests *is not* correlated with educational outcomes in the pre-voucher period and *is* correlated with educational outcomes in the post-1981 period. I also present evidence that the number of Catholic priests in 1950 is not related to other socioeconomic outcomes during the voucher period. This result allows me to use the number of priests per person in 1950 as an instrument for voucher-school entry during the voucher period.

I find that once I instrument for the ratio of voucher-to-public schools in an area, one additional voucher school increases test scores by about 0.14 standard deviations. The magnitude of this effect on test scores is equivalent to about half of the effect of increasing a mother's attainment from primary to secondary education. These results are roughly similar for students attending public schools and students attending non-Catholic voucher schools.

My estimates of the effects of school competition on test scores are smaller for students attending public schools that receive larger non-voucher transfers and that operate in areas with larger school-age populations. While agents operating voucher schools receive higher payoffs if they increase enrollment, agents operating public schools receive fixed wages and only have to meet a minimum enrollment constraint. Therefore, agents operating in areas where the minimum enrollment constraint is less binding—because either schools receive larger non-voucher transfers or because markets are bigger—react less to voucher-school competition, as predicted by the theoretical model presented in the paper. Overall, the evidence is consistent with a theoretical rationale that emphasizes the role of incentives provided by voucher-school competition.

My results do not imply that selection or segregation are not relevant issues in the Chilean case. Rather, controlling for characteristics of students and markets, there are

sizeable direct effects of competition on test scores. More than 20% of educational markets in Chile have no voucher school in operation. Similarly, there are heterogeneous effects of voucher school competition for public school students, depending on how binding minimum enrollment constraints are. Thus, the introduction of the voucher system does increase educational inequality in Chile. The paradox, though, is that the Chilean system does not become more unequal because of the existence of voucher schools, but rather because of the absence of voucher schools in some areas, and the absence of strong incentives for some public school agents. The government could correct this inequality while preserving school choice by using the right incentives, such as letting per-student subsidies depend upon student characteristics, as proposed by Gonzalez et al. (2002) Hoxby (2001), and Sapelli (2003), or by creating explicit incentives that relate the welfare of public school agents to student outcomes.

A Appendix: Proofs

A.1 Result 1

First, notice that if $N = 0$, $n_P = \overline{L}$.

Second, I analyze the case when $N = 0$. Define $\bar{x}$ as the location of parents that are indifferent toward both types of schools. These parents determine the share of the market going to each school. $\bar{x}$ is given by:

$$\bar{x} = \frac{q_P - q_V + t}{2t} = \frac{q_P - q_V}{2t} + \frac{1}{2}.$$

This expression implies that the number of students attending public and voucher schools are $\overline{x}\overline{L}$ and $(1 - \overline{x})\,\overline{L}$, respectively. Therefore,

$$n_P = \overline{L}\frac{q_P - q_V}{2t} + \frac{\overline{L}}{2}, \text{ and}$$

$$n_V = \overline{L}\frac{q_V - q_P}{2t} + \frac{\overline{L}}{2}.$$

Regarding the distribution of students among voucher schools. If $N = 1$ obviously the enrollment of the only market school in the market is n_V. If $N \geq 1$, since parents randomize among all schools that offer the same quality, the probability that each of them is selected is $\frac{1}{N}$, which implies that:

$$n_{Vi} = \frac{n_V}{N} \qquad \text{if } \; N \geq 1.$$

A.2 Result 2

Since quality is costly and that the only incentive to increase quality above the minimum level is to meet the minimum enrollment constraint, always one of the two constraints will bind in equilibrium. The simplest case is when $N = 0$, then optimal public school quality is q_P^M.

If $N > 0$ and the minimum quality constraint binds (i.e. Condition 1 does not hold), $q_P = q_P^M$. This will be the case if:

$$(\frac{\bar{n}}{\overline{L}} - \frac{1}{2}) < \frac{q_P^M - q_V}{2t}. \tag{7}$$

In this case, the number of students attending public schools is:

$$n_P = \overline{L}\frac{q_P^M - q_V}{2t} + \frac{\overline{L}}{2}.$$

If Condition 1 holds, then the minimum enrollment constraint binds and, therefore, $n_P = \bar{n}$. Given Result 1, optimal public school quality is:

$$q_P = 2t\left(\frac{\bar{n}}{\overline{L}} - \frac{1}{2}\right) + q_V.$$

A.3 Result 3

Voucher schools enter the market if:

$$\left[(v - c^V(q_V))\frac{n_V}{N} - F\right] \geq 0.$$

$N^* = 0$ if

$$(v - c^V\left(q_V^M\right))n_V < F.$$

because in this case, even producing the lowest possible level produces negative profits.

Using a similar argument, $N^* = 1$ when:

$$\begin{aligned}(v - c^V\left(q_V^M\right))n_V &\geq F, \text{ and} \\ (v - c^V\left(q_V^M\right))\frac{n_V}{2} &< F.\end{aligned}$$

Analogously, $N^* = 2$ when:

$$\begin{aligned}(v - c\left(q_V^M\right))\frac{n_V}{2} &\geq F, \text{ and} \\ (v - c\left(q_V^M\right))\frac{n_V}{3} &< F.\end{aligned}$$

Generalizing this argument, N^* has to satisfy:

$$\begin{aligned}(v - c^V\left(q_V^M\right))\frac{n_V}{N} &\geq F, \text{ and} \\ (v - c^V\left(q_V^M\right))\frac{n_V}{N+1} &< F.\end{aligned}$$

Rearranging terms:

$$(v - c^V\left(q_V^M\right))\frac{n_V}{N+1} < F \leq (v - c^V\left(q_V^M\right))\frac{n_V}{N}.$$

A.4 Result 5

If Condition 1 holds, $N = 1$, and $N^P = 1$, voucher schools face no competition from other voucher schools and public schools will respond to their choices in order to meet the minimum enrollment constraint. Therefore, voucher schools face a constant demand $n_V = (\bar{L} - \bar{n})$, for any level of quality they offer. Then, profit maximization implies that voucher schools offer:

$$q_V = q_V^M.$$

If $N = 1$, but $N^P = 2$, and Condition 1 holds, the incumbent voucher has to offer a quality level such that the potential entrant is indifferent, i.e., profits have to be 0. Thus,

$$q_V = c^{V^{-1}}\left(v - \frac{NF}{\bar{L} - \bar{n}}\right).$$

If Condition 1 does not hold, and $N = 1$, $N^P = 1$, the only difference with the previous case is that enrollment in the voucher school is not constant. Moreover, Result 1 implies that voucher school enrollment is increasing in voucher school quality (notice that the public school produces q_P^M. Therefore, the optimization of the voucher school is:

$$Max_{q_V}\left[(v - c^V\left(q_V\right))\overline{L}\left(\frac{q_V - q_P^M}{2t} + \frac{1}{2}\right) - F\right],$$

the first order condition of this problem is (assuming an interior solution):

$$c^{V'}\left(q_V\right)n_V - \frac{c^V\left(q_V\right)\overline{L}}{2t} = 0 \Leftrightarrow \frac{c^V\left(q_V\right)}{c^{V'}\left(q_V\right)} = 2t\frac{n_V}{\overline{L}}.$$

Finally, If Condition 1 does not hold, and $N \geq 1$, and $N^P \geq 2$, competition between voucher schools imply that profits of incumbents go to 0, and, therefore:

$$q_V = c^{V^{-1}}\left(v - \frac{NF}{n_V}\right).$$

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Table 1: Descriptive Statistics

Variable	Obs.	Mean	Median	Standard Deviation	5th percentile	95th percentile	Source
Student-level variables							
Test scores (standardized)	172309	-0.07	-0.03	0.98	-1.76	1.49	SIMCE
Mother's education							
Primary	172309	0.37	0.00	0.48	0.00	1.00	SIMCE
Secondary-General	172309	0.32	0.00	0.47	0.00	1.00	SIMCE
Secondary-Technical	172309	0.16	0.00	0.36	0.00	1.00	SIMCE
Higher-General	172309	0.23	0.00	0.42	0.00	1.00	SIMCE
Higher-Technical	172309	0.09	0.00	0.28	0.00	1.00	SIMCE
Average Years of Schooling	172309	9.67	10.00	3.63	4.00	16.00	SIMCE
Log(Per-Capita Income)	172309	10.23	10.31	0.91	8.87	11.78	SIMCE
Values among the three most important reasons for choosing a school	172309	0.27	0.00	0.44	0.00	1.00	SIMCE
Voucher school	172309	0.40	0.00	0.49	0.00	1.00	SIMCE
Non-Catholic voucher school	172309	0.27	0.00	0.44	0.00	1.00	http://www.feducech.cl/
Individual-level variables							
High school graduation dummy	75805	0.3989	0	0.4897	0	1	CASEN
Immigration dummy	8857	0.1670	0	0.3730	0	1	Social Protection Survey
Market-level variables							
Ratio of Voucher to Public Schools	285	0.50	0.25	0.70	0.00	1.8	Ministry of Education
Mean years of schooling	285	8.84	8.67	1.30	7.21	10.95	CASEN
Standard Deviation of Years of schooling	285	3.45	3.48	0.46	2.71	4.09	CASEN
Mean Log Income	285	9.99	9.94	0.34	9.57	10.54	CASEN
Standard Deviation of Log Income	285	0.86	0.84	0.14	0.66	1.09	CASEN
Log School-Age Population	285	8.37	8.36	1.29	6.22	10.7	http://www.sinim.cl/
Urbanization Rate	285	0.64	0.67	0.28	0.00	1	Ministry of Education
Infant Mortality (per 1000 births)	285	8.77	7.06	5.52	3.00	20.41	http://www.sinim.cl/
Index of Health Status (Max=100)	285	83.70	85.20	8.77	66.60	94.6	http://www.sinim.cl/
Crime Rate	285	9.25	7.47	6.58	2.15	22.69	http://www.sinim.cl/
High-School Graduation Rate							
37<age	285	0.28	0.26	0.15	0.08	0.55	CASEN
25<age<38	285	0.46	0.46	0.18	0.20	0.78	CASEN
age<26	285	0.49	0.50	0.17	0.24	0.76	CASEN
High-School Graduation Rate before the Voucher Reform	285	0.38	0.39	0.18	0.11	0.66	Social Protection Survey
Pro-Government Mayor	285	0.50	0.00	0.50	0.00	1.00	Electoral Office
Pro-Government Vote	285	0.52	0.52	0.24	0.16	0.77	Electoral Office
Diocese-level variables							
Priests per 1000 people in 1950	19	0.32	0.31	0.13	0.15	0.54	Annuario Pontificio
Priests per 1000 people in 2000	26	0.15	0.14	0.04	0.08	0.21	Annuario Pontificio
Catholic Affiliation	26	0.78	0.79	0.08	0.68	0.90	Annuario Pontificio
Ratio of Religious to Total Priests in 1950	19	0.44	0.47	0.16	0.17	0.66	Annuario Pontificio

Notes: Detailed definitions of each variable appear in the main text

Table 2

Determinants of Priests per Capita in 1950: Religious Order Effects

Dependent Variable:	Log of Priests per 1,000 people in 1950			
	(1)	(2)	(3)	(4)
Log(income)	0.28		0.10	
	(0.27)		(0.26)	
Average Schooling		0.13		0.06
		(0.09)		(0.09)
Ratio of order to total priests in 1950			1.25	1.19
			(0.52)	(0.53)
R^2	0.0462	0.0783	0.2415	0.2494
Number of dioceses	19	19	19	19

Cross section regressions, each observation represents the value for a diocese. Robust standard errors in parentheses. Constants are not reported

Table 3

Municipal level regressions for educational outcomes *before* and *after* the reform

Dependent Variable:	High-School Graduation Rate					
Sample:	Not exposed to 1981 reform	Partially exposed to 1981 reform	Exposed to 1981 reform	Not exposed to 1981 reform	Partially exposed to 1981 reform	Exposed to 1981 reform
Age range:	Age >37	37>=Age>=26	Age<26	Age >37	37>=Age>=26	Age<26
	(1)	(2)	(3)	(4)	(5)	(6)
Log(Priests per 1000 people in 1950)	-0.03	0.04	0.17			
	(0.10)	(0.09)	(0.08)			
Ratio of order to total priests in 1950				0.07	0.13	0.26
				(0.06)	(0.11)	(0.14)
Catholic affiliation	0.02	0.10	0.01	-0.06	-0.21	0.16
	(0.14)	(0.24)	(0.22)	(0.20)	(0.45)	(0.35)
Urbanization Rate	0.29	0.33	0.26	0.32	0.37	0.30
	(0.03)	(0.03)	(0.03)	(0.05)	(0.05)	(0.04)
Log(population)	-0.02	0.01	0.04	-0.01	0.01	0.06
	0.03	(0.03)	(0.26)	(0.04)	(0.04)	(0.02)
R^2	0.49	0.55	0.46	0.37	0.38	0.31
Number of markets	285	285	285	285	285	285

Cross section regressions, each observation represents a value a for a market. Standard errors clustered at the diocese level in parenthesis. Region dummies and constants are not reported.

Table 4
Availability of Voucher Schools

Dependent Variable:	Ratio of voucher to public schools, 2002	
	(1)	(2)
Average schooling	0.22	0.21
	(0.08)	(0.09)
	-0.16	-0.07
Standard Deviation of schooling	(0.23)	(0.33)
Mean of Log Income	0.16	0.20
	(0.13)	(0.11)
Standard Deviation of Log Income	-1.20	-1.28
	(0.236)	(0.551)
Log(Population)	0.22	0.21
	(0.08)	(0.09)
Urbanization Rate	0.38	0.30
	(0.23)	(0.23)
	0.50	
Log(Priests per 1,000 people in 1950)	(0.10)	
		1.69
Ratio of order to total priests in 1950		(0.69)
	1.69	2.99
Share of Catholics in total population	(0.69)	(0.75)
R^2	0.72	0.76
Number of markets	285	285

Cross section regressions, each observation represents the value for a market. Clustered standard errors at the diocese level in parenthesis. Region dummies and constants are not reported

Table 5
Priests and In-Migration Decisions

Dependent Variable:	In-migration Dummy		In-migration Rates	
	(1)	(2)	(3)	(4)
Log(Priests per 1000 people, destination/origin)	0.04		0.03	
	(0.10)		(0.13)	
Ratio order to total priests, destination-origin		0.20		0.09
		(0.24)		(0.31)
Econometric Technique	Marginal Probit Estimates		OLS Estimates	
Number of observations	8857		13	

Standard errors clustered at the region level in parenthesis. Constants are not reported.

Table 6

Test Scores: OLS and IV Results

Dependent Variable:	Test scores									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Estimation Technique	OLS	OLS	OLS	IV	IV	IV	IV	IV	IV	IV
Voucher school competition	0.04	0.00	-0.02	0.17	0.20	0.15	0.16	0.16	0.13	0.14
	(0.01)	(0.02)	(0.02)	(0.06)	(0.05)	(0.05)	(0.04)	(0.04)	(0.04)	(0.03)
Mother Education:										
Secondary-General		0.28	0.27		0.26	0.28		0.26	0.28	0.28
		(0.01)	(0.01)		(0.01)	(0.01)		(0.01)	(0.01)	(0.01)
Secondary-Technical		0.41	0.40		0.38	0.40		0.38	0.40	0.40
		(0.02)	(0.02)		(0.02)	(0.02)		(0.02)	(0.02)	(0.02)
Higher-General		0.66	0.64		0.63	0.64		0.63	0.64	0.64
		(0.01)	(0.02)		(0.01)	(0.02)		(0.01)	(0.02)	(0.02)
Higher-Technical		0.51	0.49		0.48	0.50		0.48	0.50	0.50
		(0.02)	(0.02)		(0.01)	(0.02)		(0.01)	(0.02)	(0.02)
Log(Per-Capita Income)		0.24	0.23		0.23	0.23		0.23	0.23	0.23
		(0.01)	(0.00)		(0.01)	(0.00)		(0.01)	(0.00)	(0.00)
Market Level Variables:										
Mean Education			0.02			-0.01			-0.01	-0.01
			(0.02)			(0.02)			(0.03)	(0.02)
Standard Deviation of Education			0.03			0.05			0.05	0.05
			(0.04)			(0.07)			(0.07)	(0.07)
Mean Log(Per-Capita Income)			0.18			0.12			0.13	0.13
			(0.03)			(0.07)			(0.05)	(0.06)
Standard Deviation of Log(Per-Capita Income)			-0.27			-0.02			-0.05	-0.04
			(0.05)			(0.11)			(0.08)	(0.08)
Log(Population)			-0.03			-0.06			-0.06	-0.06
			(0.02)			(0.02)			(0.02)	(0.02)
Urbanization Rate			0.00			-0.08			-0.07	-0.07
			(0.09)			(0.14)			(0.12)	(0.13)
Share of Catholic Population			-0.20			-0.48			-0.44	-0.46
			(0.17)			(0.26)			(0.21)	(0.22)
Instrumental Variable:	-	-	-	Priests	Priests	Priests	Order	Order	Order	Priests, Order
Over-identification test (p-value)	-	-	-	-	-	-	-	-	-	0.83
Number of students	172309	172309	172309	172309	172309	172309	172309	172309	172309	172309
Number of schools	5433	5433	5433	5433	5433	5433	5433	5433	5433	5433
Number of markets	285	285	285	285	285	285	285	285	285	285

Cross section regressions. Standard errors clustered at the diocese level in parenthesis. Region dummies and constants are not reported.

Table 7

Test Scores: Additional IV Results

Dependent Variable:	Test scores					
	(1)	(2)	(3)	(4)	(5)	(6)
Voucher school competition	0.17	0.12	0.17	0.13	0.13	0.07
	(0.05)	(0.04)	(0.06)	(0.04)	(0.06)	(0.04)
Mother Education:						
Secondary-General	0.27	0.27	0.26	0.28		
	(0.02)	(0.02)	(0.01)	(0.01)		
Secondary-Technical	0.40	0.40	0.39	0.40		
	(0.02)	(0.02)	(0.02)	(0.02)		
Higher-General	0.62	0.62	0.63	0.64		
	(0.02)	(0.02)	(0.02)	(0.02)		
Higher-Technical	0.48	0.48	0.48	0.50		
	(0.02)	(0.03)	(0.02)	(0.02)		
Log(Per-Capita Income)	0.24	0.24	0.23	0.23		
	(0.00)	(0.00)	(0.00)	(0.00)		
Market Level Variables:						
Mean Education	0.07	0.07	-0.03	-0.01	0.10	0.09
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)
Standard Deviation of Education	-0.01	-0.01	0.03	0.05	0.07	0.05
	(0.02)	(0.02)	(0.06)	(0.07)	(0.06)	(0.06)
Mean Log(Per-Capita Income)	-0.13	-0.11	0.13	0.13	0.10	0.11
	(0.10)	(0.09)	(0.06)	(0.05)	(0.16)	(0.13)
Standard Deviation of Log(Per-Capita Income)	0.12	0.06	0.03	-0.05	-0.02	-0.02
	(0.12)	(0.09)	(0.11)	(0.08)	(0.06)	(0.05)
Log(Population)	-0.07	-0.06	-0.05	-0.06	0.03	0.02
	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)
Urbanization Rate	-0.15	-0.12	-0.18	-0.07	0.24	0.17
	(0.13)	(0.10)	(0.14)	(0.12)	(0.12)	(0.11)
Share of Catholic Population	-0.49	-0.42	-0.54	-0.44	0.88	0.53
	(0.29)	(0.23)	(0.27)	(0.21)	(0.45)	(0.40)
High-School Graduation Rate *before* the Reform			0.39	0.38		
			(0.06)	(0.06)		
Instrumental Variable:	Priests	Order	Priests	Order	Priests	Order
Sample	Exclude if parents attended school after reform		All students		All markets	
Number of students	85819	85819	172309	172309	-	-
Number of schools	5267	5267	5433	5433	-	-
Number of markets	285	285	285	285	285	285

Cross section regressions. Standard errors clustered at the diocese level in parenthesis. Region dummies and constants are not reported.

Table 8
Choice of Schools: Marginal Probit Estimates

Dependent Variable: Dummy takes a value of 1 if:	Student attends a public school versus a voucher school	Student attends a public school versus a voucher school	Student attends a non-Catholic versus a Catholic voucher school	Student attends a non-Catholic versus a Catholic voucher school
	(1)	(2)	(3)	(4)
Values among top priorities when choosing among schools	-0.36	-0.36	-0.28	-0.28
	(0.01)	(0.01)	(0.01)	(0.01)
Mother Education:				
Secondary-General	-0.07	-0.07	-0.03	-0.03
	(0.01)	(0.01)	(0.01)	(0.01)
Secondary-Technical	-0.10	-0.10	-0.05	-0.05
	(0.01)	(0.02)	(0.02)	(0.02)
Higher-General	-0.21	-0.21	-0.07	-0.07
	(0.02)	(0.02)	(0.02)	(0.02)
Higher-Technical	-0.19	-0.20	-0.06	-0.06
	(0.02)	(0.02)	(0.02)	(0.02)
Log(Per-Capita Income)	-0.11	-0.11	-0.03	-0.03
	(0.01)	(0.01)	(0.01)	(0.01)
Market Level Variables:				
Average Education	-0.02	-0.03	-0.01	-0.01
	(0.02)	(0.02)	(0.07)	(0.07)
Standard Deviation of Education	-0.09	-0.05	0.15	0.16
	(0.06)	(0.05)	(0.07)	(0.07)
Mean of Log(Per-Capita Income)	-0.11	-0.17	-0.14	-0.14
	(0.01)	(0.03)	(0.07)	(0.07)
Standard Deviation of Log(Per-Capita Income)	0.00	0.01	-0.17	-0.18
	(0.10)	(0.09)	(0.25)	(0.25)
Log(Population)	-0.06	-0.06	0.09	0.09
	(0.01)	(0.01)	(0.03)	(0.03)
Urbanization Rate	-0.14	-0.20	0.08	0.07
	(0.10)	(0.07)	(0.15)	(0.15)
Log of (Priests per 1,000 people)	-0.07		0.04	
	(0.02)		(0.03)	
Ratio of order to total priests		-0.19		0.11
		(0.05)		(0.07)
Share of Catholic Population	-1.07	-1.25	-0.63	-0.53
	(0.15)	(0.15)	(0.22)	(0.26)
Pseudo R^2	0.22	0.22	0.15	0.15
Number of students	172309	172309	69937	69937
Number of schools	5433	5433	1701	1701
Number of markets	285	285	225	225

Cross section regressions, each observation represents a value for a student. Standard errors clustered at the diocese level in parenthesis. Region dummies and constants are not reported.

Table 9

Test Scores: IV Results for Municipal and Non-Catholic Schools

Sample	Municipal schools	Municipal schools	Non-Catholic Voucher schools	Non-Catholic Voucher schools
	(1)	(2)	(3)	(4)
	Second stage estimates			
Ratio of voucher to public schools	0.15	0.13	0.13	0.12
	(0.04)	(0.06)	(0.05)	(0.04)
Instrumental Variable	Priests	Ratio	Priests	Ratio
Number of students	106094	106094	39729	39729
Number of schools	3355	3355	1247	1247
Number of markets	285	285	204	204

Cross section regressions, each observation represents a value for a student. Standard errors clustered at the diocese level in parenthesis. Coefficients of control variables included in the second stage equations are not reported.

Table 10

Non-Voucher Transfers: Marginal Probit Estimates

Dependent Variable: Dummy takes a value of 1 if:	Municipality receive non-voucher transfers above the median	
	(1)	(2)
Pro-Government Mayor*Pro-Government Vote	0.82	0.84
	(0.27)	(0.23)
Pro-Government Mayor	-0.46	-0.45
	(0.11)	(0.09)
Pro-Government Vote	-0.21	-0.23
	(0.22)	(0.28)
Mean Education	0.05	0.03
	(0.02)	(0.02)
Standard Deviation of Education	0.07	0.08
	(0.07)	(0.07)
Mean of Log(Per-Capita Income)	-0.48	-0.44
	(0.16)	(0.17)
Standard Deviation of Log(Per-Capita Income)	0.51	0.54
	(0.34)	(0.38)
Log(Population)	-0.11	-0.12
	(0.04)	(0.04)
Urbanization Rate	-0.10	-0.07
	(0.11)	(0.11)
Log of (Priests per 1,000 people)	0.22	
	(0.13)	
Ratio of Order to Total Priests		0.00
		(0.25)
Share of Catholic Population	-1.08	-1.00
	(0.25)	(0.33)
Pseudo R^2	0.49	0.48
Number of municipalities	217	217

Cross section regressions, each observation represents a value for a municipality. Standard errors clustered at the diocese level in parenthesis.

Table 11

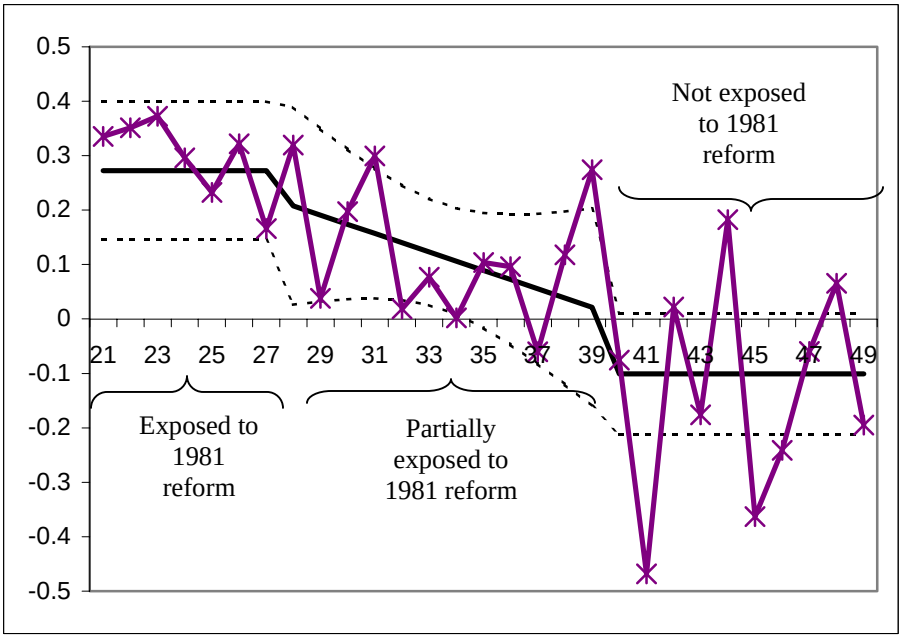
Test Scores: IV Estimates, Interaction Effects

	(1)	(2)	(3)	(4)
	Second stage estimates using priests			
Ratio of voucher to public schools	0.07	0.22	0.04	0.26
	(0.06)	(0.03)	(0.04)	(0.04)
Structural change Chow-test (p-value)	0.02		0.00	
	Second stage estimates using ratio			
Ratio of voucher to public schools	0.07	0.20	-0.01	0.27
	(0.11)	(0.08)	(0.01)	(0.11)
Structural change Chow-test (p-value)	0.34		0.00	
Sample: Municipalities with	Big non-voucher transfers	Small non-voucher transfers	High student density	Low student density
Number of students	42578	37458	48833	57261
Number of schools	1696	835	1078	2277
Number of municipalities	108	107	142	143

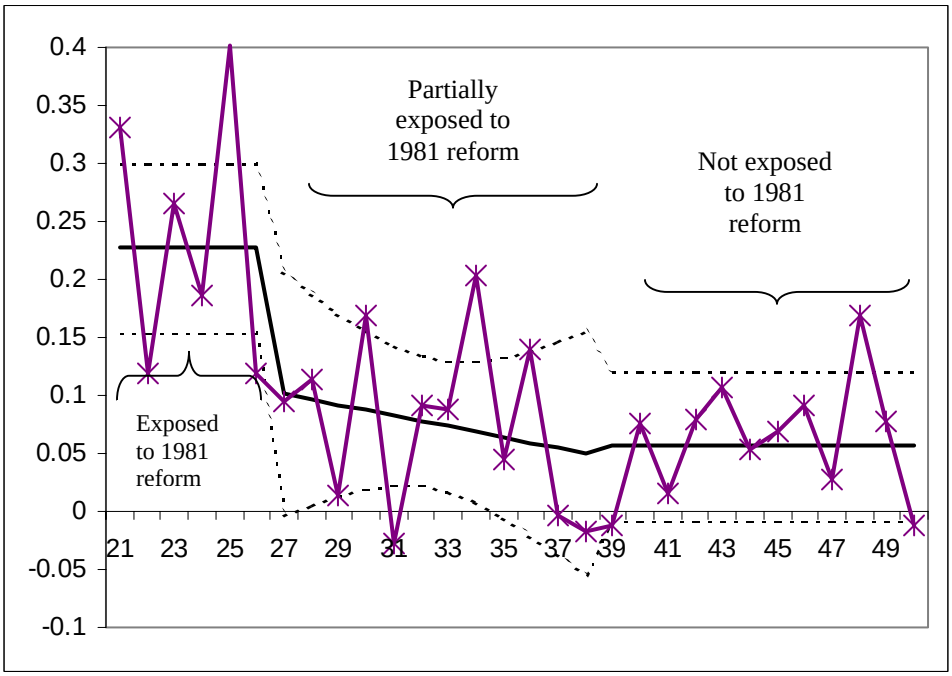
Cross section regressions, each observation represents a value a for a student. Standard errors clustered at the diocese level in parenthesis. Coefficients of all other control variables included in the second and first stage equations are not reported.

Figure 1

(A) Estimated relationship of priests with high-school graduation rate, by age.



(B) Estimated relationship of ratio of order-to-total priests with high-school graduation rate, by age.



Notes: Solid lines with stars represent unrestricted point estimates, solid lines represent restricted point estimates (assuming a linear trend on the number of years attending school after the reform), and dashed lines represent 95% confidence intervals around the restricted estimates.