Effects of spatial competition on public educational efficiency: an analysis for the Chilean Metropolitan Region.

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Abstract: This study analyzes the effect of spatial competition on public schools' efficiency in Chile, an extreme case of market-oriented reforms in the educational sector. To address this issue, we use a measure of competition that captures three major characteristics of market competition in a spatial context: the number of competitors, based on distance buffers; the size of competitors, measured by the enrollment of voucher schools; and the geographical distance among public schools and their competitors. To control for the potential endogeneity of our measure of spatial competition on public schools' efficiency, we use an instrumental variable based on the discontinuities generated by admissions municipality boundaries. We do not find evidence that public schools' efficiency increases or decreases as the result of the increment of voucher schools located near to public schools, an increase in the enrollment of existing voucher schools, or both factors simultaneously. This result is robust to: (1) the limit of education market or other measures of spatial competition; (2) the methodology used to compute the efficiency measures; and (3) whether we explain efficiency or educational performance.

Keywords: Educational vouchers, public efficiency, spatial competition, Chile

JEL classification: C26, D47, I21

1. Introduction

In Chile, a large amount of research has focused on studying the effects of market-oriented education policies. Empirical evidence highlights that the competition encouraged by introducing the voucher system improves student academic performance (Gallego, 2002; Auguste and Valenzuela, 2004; Bravo et al., 2008). However, other studies find neither a statistically nor sizeable relationship (Hsieh and Urquiola, 2003; Cartagena Farias and McIntosh, 2019; Hofflinger et al., press). Instead, they suggest that policies oriented by competition principles inevitably lead to students' segregation by income and skills (Torche, 2005; Valenzuela et al., 2008; Mizala and Torche, 2012; Elacqua, 2012; Santos & Elacqua, 2016; González, 2017). [1]

The educational efficiency study is another strand that has received significant attention in the national literature (McEwan & Carnoy, 2000; Mizala, A., Romaguera, P., & Farren, D., 2002;

Tokman, 2002; Thieme, Prior & Tortosa-Ausina, 2013; Munoz & Queupil, 2016). This issue is crucial because despite the national government's attempts to transfer more resources to the public education system, evidence show that private schools continue to be more efficient. Some critical elements to consider are the few incentives and limited technical capacities that public education providers have (Bellei et al., 2018).

An interesting question to consider is whether the increased competition produced by the incorporation of voucher schools has had an impact on the public schools' efficiency. In economic terms, competition can affect the technical efficiency by altering schools' ability to produce better results at the cost of increasing the inputs and financial resources necessary to achieve acceptable levels.[2] According to the traditional economic theory, inefficiency arises from a lack of incentives in schools to behave efficiently and competition can be an incentive mechanism to promote a better use of resources (Grosskopf et al., 2001; Garcia-Diaz et al., 2016). In spite of the fact that the national literature has focused on the effect of the market-based policies on educational outcomes, competition is still a missing piece to understand how educational reforms implemented in the 1980s created the right incentives to promote and provide education efficiently.[3]

Therefore, the purpose of this article is to explain the effect of competition on the technical efficiency of public schools in the Metropolitan Region (RM) of Chile. To accomplish this objective, we address the following two relevant aspects. First, we use a gravitational index proposed by Misra and Chi (2011) to measure the spatial educational competition faced by public schools. This index has the advantage of including three significant market competition characteristics: the number of competitors, the size of competitors, and the geographical distance among competitors (Misra and Chi, 2011). These characteristics are in line with the implicit assumptions of spatial competition theories, which state that what really matters for the competition is the number of schools can be reached within a given travel cost, distance, or time (Gibbons et al., 2008; Chumacero et al., 2011). The above is crucial since previous studies have used measures of competition that ignore their effects beyond specific geographic areas.

Second, we extend the approach of Misra et al. (2012) by taking into account the potential endogeneity of the competition index on schools' technical efficiency. Since the voucher schools' decision to locate might also be a function of neighborhood characteristics and the performance of public schools, OLS estimated relationships might be biased (Hoxby, 1994; Hsieh and Urquiola, 2003; Gibbons et al., 2008). Thus, we employ an instrumental variable (IV) approach using as a source of exogenous variation the distance of public schools to the center of each municipality (Gibbons et al., 2008; Noailly et al., 2012). Finally, this study contributes to increasing the empirical evidence required to enrich the discussion about the need and relevance for better educational policies such as the recent New Public Education Law of 2017 (21.040).

The remainder of this paper is organized as follows: Section 2 introduces the education policy in Chile. Section 3 presents the literature review on educational efficiency, competition, and space. Section 4 and 5 describe the methodology and data, respectively. Section 6 presents the results. Section 7 concludes.

2. Educational policy in Chile

In 1981, the Chilean government transformed the education system with a range of policies that included: (1) the decentralization of schooling from central to local governments, (2) privatization of the educational market, and (3) introducing a voucher-type per-student subsidy (Sapelli and Vial, 2002; Sapelli, 2003; Gallego, 2002; Cartagena Farias and McIntosh, 2019). These reforms motivated the implementation of a country-wide voucher system, which began with establishing private-subsidized schools (or voucher schools) (Mizala & Romaguera, 2002; Contreras et al., 2005; Bellei, 2015). Since voucher schools have the incentive to attract students from public schools, more competition should result in mechanisms that force public schools to improve quality, make more efficient use of existing resources, adopt innovative learning approaches, or leave the market (Egalite, 2013; Gauri and Vawda, 2004; Belfield and Levin, 2002).

In this institutional setting, one of the most critical aspects is the allocation of monetary resources to schools (Gonzales, 2003; Paredes & Pinto, 2009). The central government transfers funds to

public and private schools by each enrollment, conditional on student attendance during the school year. Thus, a student chooses a school, carries its voucher, and the school receives the monetary amount corresponding to the coupon. If the student decides to change the school, the voucher moves with him/her. For this reason, this financial plan is also known as "funds follow the students" (Mizala and Torche, 2012). Besides, voucher schools are allowed to charge tuition to families to supplement the payment received by the government (shared financing).

As a result, Chile became one of the countries with the most considerable participation of for-profit firms in the provision of schooling, causing a rapid expansion of voucher schools and a continuous reduction in the public-school enrollment shown in figure 1. The increased demand for private education has resulted in a weakening and constant public system abandonment. These schools exist only as a "plan b" to educate whom private schools cannot or do not want (Bellei et at., 2018).

(Insert figure 1, about here)

The observed students' migration between schools is closely related to families' preferences and socioeconomic conditions (Elacqua & Fabregas, 2004; Ayala, 2010). While some families choose schools according to technical criteria as the educational quality (Sapelli & Torche, 2002; Gallego & Hernando, 2010; Chumacero et al., 2011), other families decide on more practical aspects. For example, the lower-income families consider factors such as economic restrictions, educational experience of neighbors, a safe environment, or the physical distance between the school and home (Córdoba, 2014; Bellei et al. 2016; Román, M. and Corvalan, J., 2016; González, 2017). Meanwhile, middle-income families consider the social aspects of schools, mainly to differentiate from the poorest and avoid the social mixture (Canales, Bellei & Orellana, 2016). In this vein, Kosunen & Carrasco (2017) mention that the schools' reputation takes an essential position in Chile due to long-lasting benefits in students' social reproduction. In this way, the education system gives rise to a structure of self-segregation with significant consequences in academic performance (Mizala and Torche, 2012).

Sorting effects are even more significant due to the exclusion processes led by the schools. On this aspect, Carrasco, Gutiérrez & Flores (2017) argue that school selectivity arises as a schools' mechanism that allows responding to the educational system's requirements. Therefore, and even in the absence of demand pressure, schools decide to educate certain students according to strict selection criteria (Contreras, Sepúlveda & Bustos, 2010; Mizala and Torche, 2012; Valenzuela et al., 2008). By contrast, public schools must accept all students, some of whom have more teaching difficulties, requiring more monetary and non-monetary resources. The Inter-American Development Bank (BID for its acronym in Spanish) (2018) highlights the critical management and financing problems that the public system face, where 63% of Chilean public schools had structural deficits in 2015, representing a relevant restriction for the competitiveness of these schools.

Recently, the Chilean government modified the educational policy to strengthen public schools.[4] One of the most meaningful actions was the School Inclusion Act implemented in 2015.[5] This educational reform improves public schools' support and prohibits the profit for private schools receiving state contributions into the shared financing system. This initiative also seeks to eliminate all forms of arbitrary discrimination or segregation by regulating the school admission system. Despite this vital step, the Chilean education system remained a system guided by market-oriented dynamics (Bellei et al., 2018).

Later in 2017, the government enacted Law 21,040 (called New Public Education) to improve the General Education Law of 2009.[6] This institutional change created a new figure in the school system: The Local Education Services (SLE for its acronym in Spanish).[7] The SLEs are an intermediary level between the National Education Board and public schools. Some examples of this arrangement are Local Education Authorities (LEAs) in England or School Districts in the United States. In this way, the schools' financial, administrative, and operational affairs are transferred from municipalities to SLEs. It is a relevant change in comparison with the first market reforms implemented during the 1980s.

3. Literature review

Considering the vast amount of research about school choice, our literature review focuses on: (1) the national and international empirical evidence on the relationship between competition and schools' efficiency, (2) the empirical measures of spatial competition used in the education literature, and (3) the instruments used to identify the effect of competition on efficiency.

National and international empirical evidence on the relationship between competition and efficiency.

To our knowledge, there is no empirical evidence about the effect of competition on schools' efficiency in the Chilean context. Instead, studies have focused on determining the competition's effect on educational outcomes, determining the degree of efficiency, or comparing the amount of competition faced by different types of schools. Regarding the last point, the national evidence shows that private schools are more efficient than their public counterparts (Mizala, A., Romaguera, P., & Farren, D., 2002; Thieme, Prior & Tortosa-Ausina, 2013; Munoz & Queupil, 2016). However, other studies point out that public schools have not always the worst performance (McEwan and Carnoy, 2000; Tokman, 2002). Although these articles use robust empirical strategies, the evidence is limited to studying the effects of internal inputs on schools' efficiency, leaving out those external factors, such as the degree of competition that public schools face.

Although international literature has directly studied the effect of competition on efficiency, the results are not conclusive. For instance, studies applied widely in the US have found that higher competition increases schools' efficiency (Bradley et al., 2001; Millimet and Collier, 2008; Misra et al., 2012; Agasisti, 2013). However, other empirical cases highlight that competition is a source of inefficiency for schools, especially for the public ones (Kang and Greene, 2002; Andersen and Serritzlew, 2006; Ni, 2009; Garcia- Diaz et al., 2016). As regards the latter, McMillan (2000, 2004) concludes that public schools have incentives to reduce their productivity into a competition context. This situation occurs because it is less expensive to give up a part of the market than seeking to capture a high-income demand with special educative requirements. Other authors, as Grosskopf et al. (2001), conclude that competition has no relation to the schools' technical efficiency.

Spatial competition

When considering the effect of competition on educational outcomes/efficiency, it is crucial to explicitly incorporate geographical space into the discussion (Bradford, 1990; Bell, 2009; Taylor, 2001a; André-Bechely, 2007). Space is a significant element because it defines educational markets or influence areas where schools interact (Glatter et al., 1997; Taylor, 2001b). Furthermore, space reveals and shapes the geographical inequalities of educational opportunities. For example, education provision is closely related to parents' socioeconomic characteristics, which vary across space (Oberti, 2007; Bell, 2007). Moreover, the traditional spatial theories state that what matters for the competition is the number of schools reached within a given travel cost, distance, or time (Gibbons et al., 2008; Chumacero et al., 2011). Thus, a correct measure of competition should include three significant market competition characteristics: the number of competitors, the size of competitors, and the geographical distance among competitors.

However, most of the empirical approaches employ conventional competition measures, such as the share of students in private schools (Jepsen, 2002; McMillan, 2000), the total number of private schools (Arum, 1996), or the Herfindahl concentration index (Borland and Howsen, 1993). The main disadvantage of these measures is that competition is delimited to some administrative area resulting in an aggregation bias by imposing homogeneity in a space conformed for different units (Misra and Chi, 2011). In the national context, Cartagena Farias and McIntosh (2019) use the number of voucher schools in a fixed geographic radius around schools instead of geographical boundaries to represent educational markets. However, this measure assumes that competition's levels are the same within the radius, limiting a better representation of the spatial competition. Despite this problem, the authors find that the number of voucher schools negatively affects public schools' educational quality.

To solve these problems, Misra and Chi (2011) provide a refreshing approach considering the number and the size of competitors, as well as their distance. This index was used later by Misra

et al. (2012) for the Mississippi case, finding positive results from the competition on the educational efficiency. Although these authors do not consider the endogeneity problem, this index demonstrates a better representation of the competition.

Endogeneity of competition and instruments

Since the schools' decision to locate might also be a function of neighborhood characteristics and the performance/efficiency of surrounding schools, any traditional estimator as the OLS might be biased (Hoxby, 1994; Hsieh and Urquiola, 2003; Gibbons et al., 2008). To deal with this issue, most of the national and international studies use an instrumental variable approach to identify the true effect of competition.

The most employed instrument in the US is the religious affiliation of families or schools to minimize selection's effects (Hoxby, 1994; Dee, 1998; Sander, 1999; Jepsen, 2002; Geller et al., 2006). In this context, Bettinger (2005) uses two different instruments: the distance from public schools to state universities and the Herfindahl index based on racial shares. The author notes that racial diversity is a useful instrument because it must not be related to student performance, although it does not always hold in the United States. In Sweden, Böhlmark and Lindahl (2015) use the size of independent schools (i.e., a voucher school in Chile) in each market area. Sandström and Bergström (2005) suggest exploiting municipalities' attitude towards independent schools as a source of exogenous variation in the same context. These authors argue that a hostile attitude towards these schools leads to reducing competition levels in school markets and vice-versa.

In the Chilean context, Gajardo and Grau (2019) use three different instruments proposed by the literature: the total district enrollment (Gallego, 2002), the district population (Hsieh and Urquiola, 2003), and the district urbanization rate (Auguste and Valenzuela, 2004; Gallego, 2002; Hsieh and Urquiola, 2003). In this vein, Gallego (2002) argues that geographical characteristics are related to the new schools' penetration in certain areas. This author assumes that voucher schools are mainly an urban phenomenon so that a positive relationship could be expected between the urbanization rate of the municipalities and the levels of schooling competition.

Finally, Gibbons et al. (2008) propose the distances between schools and municipalities' centers as a novel instrument for spatial competition. Based on the argument of transport costs, these authors argue that schools located in the periphery perceive less competition than those located near the center. These authors conclude that pupil achievement in Primary schools in England increased because of the schooling competition. This result is supported later by Noailly et al. (2012), who use the same identification strategy for the Netherlands case.

4. Methodology

4.1. Estimating schools' efficiency

Similar to Millimet and Collier (2008) and Misra et al. (2012), we use a production frontier model to estimate each public school performance compared with the so-called efficient frontier. We assume that each public school has the following Cobb-Douglas production function (Schmidt and Sickles, 1984):

$$\ln(y_{it}) = f(\ln(x_{it})\,;\beta) + v_{it} - u_i \qquad (1)$$

Where y_{it} is the observed national standardized test scores in either reading or mathematics for public school i in year t = 2016, 2017, 2018; $f(\ln(x_{it})\,;\beta)$ is a linear function that relates the K x 1 vector of inputs $\ln(x_{it})$ with the outcomes, whereas β is the vector measuring the marginal productivity of each input; v_{it} is the traditional random error which is assumed to be uncorrelated with the choice of inputs; and $u_i > 0$ is the time-invariant technical inefficiency of school i. As the technical efficiency of schools increases, the value of u_i becomes close to zero, indicating that the school i has efficiency near the optimum. The function to estimate is then given as:

$$\begin{aligned} ln y_{it} &= \beta_0 + ln\boldsymbol{x}'_{\boldsymbol{it}}\beta + v_{it} - u_i \\ &= \alpha_i + ln\boldsymbol{x}'_{\boldsymbol{it}}\beta + v_{it}\,, \end{aligned} \qquad (2)$$

where $\alpha_i = \beta_0 + u_i$. Under this model, both u_i and α_i are assumed to be fixed parameters that are to be estimated along with the parameter vector β. In this article, model (2) is estimated using the standard Fixed-Effect (FE) panel data model for two reasons. First, in the FE model u_i is allowed to be correlated with input variables x_{it}, which is a more plausible assumption in the current context. Second, unlike a RE model, it is not necessary to assume a certain distribution for the fixed effects, which frees us from a potential misspecification problem. Therefore, as the estimates will be used in a second stage, it is more desirable and conservative to obtain consistent rather than efficient but potentially biased estimates of the fixed effects.

Once the model is estimated, the relative distance of each school to the efficiency frontier is computed as:

$$\widehat{u_\iota} = \max\{\widehat{\alpha_\iota}\} - \widehat{\alpha_\iota},$$

so that the school with the highest $\hat{\alpha}$ is assumed to be frontier (Schmidt and Sickles, 1984; Millimet and Collier, 2008). Thus $\hat{u}_i$ x 100% is the percentage by which actual national standardized test scores can be increased by public school *i* using the same inputs if production is fully efficient. In the other words, $\hat{u}_i$ x 100% is the estimated percentage of the standardized test score that is lost by school *i* due to technical inefficiency.

The school-specific efficiency, which is used in the second step, is obtained from:

$$\widehat{TE_\iota} = \exp(-\widehat{u_\iota}), \quad i = 1, \dots, N. \qquad (3)$$

The technical efficiency of school *i* is interpreted as follow: if $\widehat{TE_\iota}$ x 100% = 65%, the public school is producing only 65% of the maximum possible (frontier) of good scores in the standardized test.

4.2. An index for spatial competition

To assess the effect of spatial competition on schools' efficiency, we use the gravitational competition index proposed by Misra and Chi (2011). Formally, the index is computed as follows:

$$A_i = \frac{1}{E_i} \sum_{j \neq i}^{s} E_j \, d_{ij}^{-2}, \qquad (4)$$

where A_i represents the level of competition faced by public school i; E_j is the students' enrollment in voucher school j and S is the total number of competitors, whereas E_i is the total enrollment in public school i; and d_{ij} is the Euclidean distance between the public school i and its neighboring voucher school j. Note that we consider vouchers schools as competitors for public schools because vouchers and public schools receive public funding based on enrollment.

The measure in Equation (4) has the advantage of including three major characteristics of market competition in a spatial context: the number of competitors, based on distance buffers; the size of competitors, measured by the enrollment of voucher schools; and the geographical distance among competitors, measured by d_{ij}. Since the distance is squared, it is assumed that spatial competition is nonlinear and decline faster than proportionally to the distance. Thus, closer voucher schools are considered as stronger competitors for public school i.

Another important advantage of this spatial competition measure is that is not constrained to a specific geographical area based on administrative boundaries. Previous studies define the educational market area based on the number of voucher schools in a given municipality (Gallego, 2002; Auguste and Valenzuela, 2004), however it is misleading to assume that a voucher school located in the boundary of the municipality i cannot be a competitor of a public school in municipality j. By assuming different distance buffers for computing the number of competitors, S, of public school i, we circumvent this problem.

4.3. Instrumental variable approach

Similar to Misra et al. (2012), we propose the following regression model to evaluate the relationship between public schools' efficiency and spatial competition:

$$ln\,\widehat{TE}_{ic} = \beta ln A_i + ln\boldsymbol{x}'_i\boldsymbol{\delta} + \xi_c + \epsilon_{ic}\,, \qquad i = 1, \ldots, N, \qquad (5)$$

where $\widehat{TE}_{ic}$ is the public school *i'* efficiency located in municipality c, which is estimated using Equation (3); A_i is the spatial competition index given by Equation (4); $\boldsymbol{x}_i$ is a set of exogenous covariates that affect school i's efficiency; ξ_c is a fixed effect at the municipality (market) level and ϵ_{ic} is the error term. It is important to note that schools' technical efficiency given by Equation (3) is time-invariant, thus Equation (5) is estimated by OLS for different time periods. Due to the short panel (T = 3), the time-invariant assumption seems more appropriate in this context (see also Millimet and Collier, 2008, for a similar argument).

The purpose of this paper is to determine whether more competition can be an incentive mechanism for public schools to promote better use of resources and hence increase their efficiency, $\beta > 0$. However, OLS estimates of Equation (5) can be biased. For example, if public schools tend to increase their efficiency, then voucher schools may have less incentive to be located near the area of operation of these public schools. Hence, entry into the market is endogenous to public school efficiency (Gajardo and Grau, 2019). If such is the case, the OLS estimate of β is downward biased. Also, unobserved variables might affect efficiency of public schools and potentially be correlated with the degree of competition. For instance, voucher schools may be more common in high-income areas. If high income is also associated with schools' efficiency (because they receive better students), the relationship between competition and efficiency is biased (Andersen and Serritzlew, 2006; Noailly et al., 2012). Finally, competition might be measured with error resulting in attenuation bias.

To deal with endogeneity, we propose an IV approach to reduce the potential biases of $\widehat{\beta}$. The first step is estimated by the following reduced equation:

$$ln\,A_{ic} = \lambda dist_{ic} + ln\boldsymbol{x}'_i\boldsymbol{\gamma} + \tau_c + \upsilon_{ic}\,, \qquad (6)$$

where $\boldsymbol{x}_i$ is the set of assumed pre-determined variables in Equation (5) at the school level; τ_c is a municipality FE, and $dist_{ic}$ is the additional instrument. Following Gibbons et al. (2008) and more closely Noailly et al. (2012), $dist_{ic}$ measures the linear distance between school *i* and the center of the municipality, c.[1] The argument provided by Gibbons et al. (2008) is that those families living near the boundaries of any administrative area will prefer to enroll their children in schools located in these limits rather than farther schools avoiding high costs travel. This means that schools located on the periphery will face less competition than schools located in or near the center. Thus, we should find that $\hat{\lambda} < 0$ in Equation (6): the higher the distance of public school *i* to the center of the municipality, the lower the degree of spatial competition that it faces.

An important assumption is that the distance from public schools to the center is not correlated with other unobserved characteristics at the student, schools, and/or neighborhood level that might affect schools' efficiency. Thus, we try to minimize the potential correlation of the instrument with the error term ϵ_{ic} by controlling for a large set of public schools' characteristics and municipality fixed effects to consider the unobserved differences of efficiency at the market level.

5. Data

To carry out this analysis, we use information from different databases of the Educational Quality Measurement System (i.e., SIMCE) and the Chilean Ministry of Education (MINEDUC). Our sample consists of 1,843 public schools' observations in the Metropolitan Region for three years (2016 - 2018). Although two major educational reforms took place in this period, these were implemented gradually without affecting our study case. For example, the School Admission System (SAE) enabled by the School Inclusion Act began operating in 2016, but only until 2019 was implemented in the Metropolitan Region. Likewise, the transition to Local Education Services (SLE) as public educational authorities was progressive. It began in 2018 with the implementation of 4 local services, impacting four regions of the country. One of the first SLEs created in the Metropolitan Region is responsible for 77 public educational institutions and 23 thousand students.

Therefore, to maintain data consistency, we excluded those schools transferred to local services according to Law 21.040.

To estimate the efficiency equation, we use the average SIMCE score across all grades in reading and mathematics for public schools as academic output.[8] Although this indicator is supposed to represent schools' effectiveness, it is not the only nor the most complete measure (Ortiz-Cáceres, 2012). However, studies in the Chilean literature have used it to allow objective comparisons. As inputs for the efficiency equation we use government subsidies to public schools,[9] the total number of scholar elements provided by the National Scholarship and School Aid Board JUNAEB (Junta Nacional de Auxilio Escolar y Becas), and the number of teachers as a measure of human capital.

Socioeconomic information is also available. Using cluster analysis, the SIMCE methodology allows the classification of students into five categories (low, medium-low, medium, medium-high, and high) based on criteria as parents' schooling, monthly household income, and level of school vulnerability. This information reveals the social composition of each school in our database. For example, as shown in Table 1, public schools in the Metropolitan Region have, on average, 23% of students with low socioeconomic status, and 52% of students with a medium-low socioeconomic status. As might be expected, the percentage of students with better socioeconomic conditions is small. Therefore, we can say that a critical aspect of data is the schools' significant vulnerability level (Elacqua, 2012). We include these characteristics in Eq. (5) because the socio-economic background is relevant in the academic performance of students.

(Insert table 1, about here)

Finally, using the geo-referenced information available in the official of MINEDUC, we built the spatial competition index for each public school in our sample. Initially, we consider a 3 km radius to represent each educational market as Cartagena Farias and McIntosh (2019). However, in the robustness section, we extend the analysis to take into account other distances.

6. Results

6.1. Results for public schools' technical efficiency

Table 2 shows the results of Equation (2) for the FE estimator using the period span with the most available public information on school inputs (2016-2018). The columns in this table correspond to reading (column 1), mathematics (column 2) and the average of both SIMCE scores (column 3).

(Insert table 2, about here)

The results show that the correlation between the inputs and education outcome differs between reading and mathematics. The grants per student reduce the education outcome, whereas the teacher-student ratio is positive correlated with both tests. In particular, a 1% increase in the teacher-student ratio is correlated with an increase of 0.027% and 0.025% in reading and mathematics performance, respectively. The school elements per student seems to matter for the reading test and the average of both. The result that some of the observable inputs tend to have little impact on the student test scores and the relative low explanatory power (within-R2 between 3% and 5%) is also found by Millimet and Collier (2008) and Misra et al. (2012).

The bottom of Table 2 shows the summary statistics of the schools' efficiency estimated using Equation (3). On average, public schools have higher efficiency in reading compared to mathematics: on average, public schools achieve 72% and 63% of the maximum potential output for reading and mathematics scores, respectively. The average efficiency is somewhat larger than those found by Millimet and Collier (2008), but closer to those reported by Misra et al. (2012) for public schools in Mississippi, and lower to those reported by Garcia-Diaz et al. (2016) for Mexico. The least efficient school achieves only 57% and 45% of its maximum achievable SIMCE score in reading and mathematics, respectively. In terms of variability, Figure 3 shows that there exists more variability in the test scores for mathematics than for reading, which is a consistent result in the literature (see for example Millimet and Collier, 2008; Garcia-Diaz et al., 2016).

(Insert figure 2, about here)

6.2. Is spatial competition correlated with public schools' efficiency?

In this section, we explore whether there exists a relationship between public schools' efficiency and geographic proximity to voucher schools. Table 3 shows the OLS estimates of Equation (5) using as dependent variable the public schools' efficiency to produce good results in reading (columns 1-3) and mathematics (columns 4-6) for the three years under consideration. To consider the potential correlation of residuals when the same municipality manages a group of schools, cluster standard errors at the municipality level are used in all specifications.

(Insert table 3, about here)

For both tests and all available years, we can observe that there exists a statistically significant negative correlation between the competition index and efficiency, but the elasticities are very modest. Considering public schools' efficiency in reading scores, a one percent increase in the competition index is correlated on average with a decrease of 0.008% in terms of efficiency, which is slightly higher than the decrease in mathematics efficiency (approximately 0.006% considering the three years), holding schools' and municipalities' characteristics fixed. Therefore, although the relationship is highly statistically significant, in economic terms the relationship between efficiency and spatial competition is quite inelastic.

In terms of the expected relationship, these preliminary results agree with the presumption that competition encourages public schools to reduce their efficiency in producing educational outcomes (e.g, Kang and Greene, 2002; McMillan, 2004; Gronberg et al., 2015), but disagrees with the more traditional evidence that competition increases educational efficiency (e.g, Bradley and Taylor, 2001; Millimet and Collier, 2008; Misra et al., 2012) and public schools outcomes (e.g, Dee, 1998; Hoxby, 2003; Chakrabarti, 2008).

The rest of the variables show a robust and consistent pattern across the models. For example, the number of priority students, the number of principals, and a higher proportion of students from higher socioeconomic status increase public schools' efficiency. However, the degree of human capital (experience and squared experience) has no effect on technical efficiency after controlling for other factors in the model, which is also found by Mizala, Romaguera & Farren (2002). The

gender of teachers is also an important factor as it is highly significant across all the models: a higher proportion of male teacher is associated with more public schools' inefficiency. Longer average working hours of teachers is also negatively related to efficiency. Considering the results for reading, a one percent increase in the working hours is associated, on average, with a decrease of about 0.046%-0.057% on schools' efficiency. Finally, the F -statistic for the null hypothesis that all the municipality FE are jointly zero is rejected at any conventional level, which demonstrates that controlling for idiosyncratic characteristics of the markets where public schools are located is important when explaining their level of efficiency.

In summary, our preliminary results indicate that public schools' efficiency to produce better SIMCE scores with a lower level of inputs is negatively correlated with the degree of spatial competition from voucher schools. However, the location of voucher schools can be endogenous to the levels of efficiency, which might invalidate this initial result. In the next section, we address this problem by using an IV approach and the instrument proposed by Gibbons et al. (2008).

6.3.Results controlling for the endogeneity of spatial competition

6.3.1. Quality of instrument

Before presenting the IV results, we first test the validity of the distance of each public school to the municipality geographical center (our instrument) to predict the degree of school competition. Table 4 shows OLS specification of Equation (6) using as dependent variable the logarithm of competition index using a 3 km radius and the same controls as in Table 3. Columns 1-3 shows the first stage regressions for each year, controlling for municipality fixed effects.

(Insert table 4, about here)

As we expected, the distance of each school to the center of the municipality is negatively correlated with the degree of competition in all the specifications and highly significant at the 1% level. That is, the further away the public school is from the center of the municipality, the less competition it faces. This result is also found by Noailly et al. (2012) and Gibbons et al. (2008)

who use the same instrument for school competition. In particular, if a public school increases its distance to the municipality center by an additional kilometer, then the level of competition it faces is reduced by approximately 18%, holding constant its characteristics and the characteristics of the municipality in which it is located. Additionally, we present the first stage F -statistics to analyze the power of the instrument. All F -statistics are above the cut-off of 10 (Stock and Yogo, 2005), except for 2018 where the F -statistic is slightly below (F = 9.4). Thus, our instrument has sufficient power for almost all the specifications considered.

For the school proximity to the center of the municipality to serve as a legitimate instrument for schooling competition, it must affect the location decision of voucher schools, but have no direct effect on public schools' efficiency. However, there are reasons why schools located farther away from the center may be less efficient, controlling for schools' characteristics. In other words, there might be reasons why school proximity to the center of the municipality might be correlated with other unobserved characteristics of students, schools, and neighborhoods that might affect public schools' efficiency (Gibbons and Silva, 2006; Gibbons et al., 2008; Noailly et al., 2012).

To reduce the concern about possible omitted variables, we obtained aggregate information such as total income, percentage of poor population, and the average housing fiscal value for each municipality to examine its correlation with our instrument. Table 5 reports the coefficients after regressing each attribute with the distance from each public school to the center of the municipality. Columns 1-3 show the results without controls, while columns 4-6 reports the results including the same variables as in Table 4 as controls. Similar to the Noailly et al. (2012)'s robustness exercise, we do not find evidence that socioeconomic characteristics of neighborhoods are related to our instrument.

(Insert table 5, about here)

6.3.2. IV estimates

The IV coefficient estimates are presented in Table 6 and Table 7 for efficiency using reading and mathematics results, respectively.

(Insert table 6, about here)

The results for reading show a negative impact of spatial competition on schools' efficiency (columns 1-3). Considering the results for 2018, a one percentage increase in competition index is associated with a 0.032 percent decrease in efficiency of public schools. However, when we control for municipality FE to further control for market differences (columns 4-6), the point estimates tell a different story: the IV estimates are still negative but no longer significant. In fact, the IV estimates are considerably lower than the OLS estimates reported in Table 3. This result provides support that not controlling for municipality-specific sources of unobserved heterogeneity might bias the estimates. A similar result is found by Noailly et al. (2012). They show that when controlling for city fixed effect, the effect of competition (measured by the inverted Herfindahl index) on school performance is lower. However, the Hausman tests presented at the bottom of Table 6 cannot reject the hypothesis that OLS and IV estimates are statistically equivalent when unobserved factors at the municipality level are included. The results for mathematics show very similar results (Table 7): once we control for market characteristics, there is no apparent link between spatial competition and efficiency.[10]

(Insert table 7, about here)

As an additional test for the instrument's validity, we estimate Equation (5), including our instrument as an additional variable. The results show that we can only reject the hypothesis that the instrument has a direct association with public schools' efficiency when municipality-specific sources of unobserved heterogeneity are controlled for. This result again posits that the degree of competition experienced by public schools is correlated with unobservable factors at the municipal level, which might be also correlated with efficiency.

Our IV estimates are different from other studies that also take into account the potential endogeneity in the relationship between the level of competition and public school performance and find a positive relationship (e.g, Dee, 1998; Hoxby, 2003; Gibbons et al., 2008; Card et al., 2010; Thapa, 2013), but are in line with the more general view that positive gains from competition are modest in scope and magnitude (see for example Cardon, 2003; Bettinger, 2005; Geller et al., 2006).

6.4. Robustness checks

6.4.1. Sensitivity to other measures of spatial competition

So far, all the estimates of the effect of competition on efficiency are based on 3 kilometers buffer distance. However, a potential concern is whether the results are sensitive to different buffer distances. To evaluate the consistency of the previous results, we use alternative distances to delimit the market areas when creating the spatial competition index in Equation (4). Figure 4 plots the IV estimates of the spatial competition index on efficiency considering buffer rings from 1km to 10km for 2017.[5] These estimates consider the same set of controls used in Table 3 and the standard errors are clustered at the municipality level. The results show that there is not enough evidence that competition affects the efficiency of public schools in the Metropolitan Region, regardless of how the competition is defined in geographical terms.

(Insert figure 3, about here)

As an additional sensitivity analysis, we use the same measure of competition as Cartagena Farias and McIntosh (2019). They compute the level of competition faced by each school as the number of other schools in a fixed geographic radius around each school. Thus, this measure can be considered as a density index of competition assigning the same weight to all schools inside the chosen buffer distance. Table 8 shows the results for the IV estimates for both tests using as competition measure the number of voucher schools in a radius of 3 km. Again, there is no evidence that the competition coming from voucher schools has an effect on the efficiency of public schools.

6.4.2. Using time-variant efficiency across schools

An important shortcoming of previous results is that public schools' efficiency is time- invariant, which restrict us from exploiting the panel structure of our dataset. To overcome this problem, we estimate the TE using the time-varying model proposed by Battese and Coelli (1992). This specification approach assumes that the technical inefficiency in Equation (2) varies across times according to $u_{it} = u_i \exp(-\eta(t-T))$, where T is the terminal period of the sample; u_i is a non-negative random variable distributed as truncated at zero normal distribution with N (μ, σ2) and 0 < η < 1 is a parameter to be estimated; whereas $v_{it}$is distributed as N (0, σ2), and is independent of u_{it}. The Maximum Likelihood estimates are reported in Table 9. The mean TE are very similar as those using the FE estimator in Table 2.

(Insert table 9, about here)

Since the TE estimates vary across time and our instrument is time- invariant, we estimate the effect of spatial competition on public schools' efficiency using a Random-Effect (RE) IV approach. A key advantage of the panel data approach is that it enables us to take into account unobserved time-invariant schools' effects that might bias the results from Table 2. Table 10 confirms previous results: spatial competition from voucher schools is correlated negatively with public schools' efficiency only when assuming exogeneity, however this potential negative effect disappears when we instrumentalize competition with the distance of each school to the municipalities' center.

(Insert table 10, about here)

6.4.3. Competition's effect on performance

The results so far are quite robust concerning to the null relationship between competition and efficiency of public schools once the potential endogeneity is considered. However, this somewhat contradicts the results obtained for the Chilean case, which shows a positive relationship between competition and performance of public schools. To test this relationship, we estimate the effect of spatial competition but considering as dependent variable SIMCE scores in reading and

mathematics as a proxy of educational quality. Table 11 shows these IV estimates. Once again, the results show no significant relationship between competition and school performance.

(Insert table 11, about here)

7. Conclusion

In this study, we explain the effect of competition on public schools' technical efficiency in the Metropolitan Region (RM) of Chile after implementing the School Inclusion Act, but before the New Education Public Law took place. In doing so, we use a gravitational competition index that captures three crucial characteristics of educational markets. To control the spatial competition index's potential endogeneity on public schools' efficiency, we use the geographical distance between schools and municipality centers as an instrument (Gibbons and Silva, 2006). Our results provide evidence of the potential misleading conclusions that might be derived when we do not consider the endogeneity of the spatial competition index. The OLS estimates show that spatial competition is negatively and significantly correlated with public schools' educational efficiency after controlling by several characteristics at the school level and unobserved heterogeneity at the municipality level. However, this result completely disappears using an IV strategy. Thus, we do not find evidence that public schools' efficiency increases or decreases as the result of increasing private competition (Contreras et al., 2010; Hsieh and Urquiola, 2003; Cartagena Farias and McIntosh, 2019).

Another important result is that spatial competition has a negative effect on efficiency only when municipality fixed effects are not included in the model. This result shows that unobservable factors at the municipality level may affect the efficiency beyond the competition, such as the incentives and capacities. In this vein, Bellei et al. (2018) highlight three elements potentially related to management problems and structural limitations that local governments face. First, since municipal administration does not revolve around a single objective but around others considered priorities by the community, there are no strong incentives to provide effective public education

management. Second, the lack of integration between national and local directorates generates little alignment of double governance responsibilities and problems. Third, teachers' low professionalization and the few technical-pedagogical supports to schools accentuate these problems. In this sense, market-based reforms have likely not generated the right incentives for public schools but have emphasized the limitations of municipalities for providing education.

Finally, in this paper, we want to highlight the importance of incorporating the space into the discussion of public education policies. It goes so far beyond what happens within schools (e.g., student selection). It also has to do with where schools are located, considering the high residential segregation levels that MR exhibits (Rodríguez & Arriagada, 2004), affecting the prestige and identity of the schools (Falabella, 2014). Recently, Mendez and Gayo (2019) introduce an exciting discussion about how residential and school choices are linked. It highlights that both decisions are unequally distributed among the population, where upper and middle classes choose places trying to improve or preserve the social status. The above have significant consequences on the distribution of educational opportunities inside neighborhoods, exacerbating differences between rich and poor in increasingly polarized cities. Thus, the territory notions provide insights to introduce a necessary discussion about educational opportunities' geography, making much sense in enhancing the recent efforts, as Law 21,040 of 2017, to improve education equity among the Chilean population.

Notes

1. The degree of competition promoted by market-oriented policies incentives school stratification, where the middle-income class by using social, economic, and cultural capital, might have a strategic school choice behavior, reshaping the schooling landscape to ensure social reproduction (Botterman, 2019; Bechely, 2007).
2. This approach refers to input-oriented technical efficiency. Under this framework, the inefficiency is the difference between the production plans of each unit (schools), and the optimal production frontier drawn with a specific technology function (Lovell, 1993; Kumbhakar, Wang, & Horncastle, 2015).
3. A possible explanation is the simultaneity between efficiency and competition, which implies the use of more rigorous empirical strategies.
4. For further background see Marcel, M. & Raczynski D. (2009), Raczynski, D. & Salinas, D. (2008; 2009).
5. For more information see http://bcn.cl/1uv1u

6. For more information see http://bcn.cl/1uvx5

7. This law seeks to transfer public education responsibility from 345 municipalities to 70 SLEs throughout the national territory by 2025.

8. SIMCE is a standardized test applied to students in primary and secondary education in Chile. This test has the objective of measuring the learning assessment in some curriculum areas, such as Reading (Spanish), Mathematics, Natural Science and History.

9. According to Raczynski, D. & Salinas, D. (2008), scholar subsidies are the primary source of schools' financing. Using the National System of Municipal Information (SINIM; Sistema Nacional de Información Municipal) we find that the state's average subsidy to public schools in the metropolitan region was over 42% for 2016, 2017 and 2018, respectively.

10. We also make IV estimates by grade. Results are in line with our main hypothesis for mathematics in the sense that spatial competition does not have an important effect on efficiency of public schools regardless of the grades considered. For reading, it seems to exist a negative impact on lower grades, but a non-significant effect for higher grades.

Disclosure statement

No potential conflict of interest was reported by the authors.

References

Agasisti, T. (2013). The efficiency of Italian secondary schools and the potential role of competition: a data envelopment analysis using oecd-pisa2006 data. Education Economics, 21(5):520–544.

Andersen, S. C. and Serritzlew, S. (2006). The unintended effects of private school competition. Journal of Public Administration Research and Theory, 17(2):335–356.

André-Bechely, L. (2007). Finding space and managing distance: Public school choice in an urban California district. Urban Studies, 44(7):1355–1376.

Auguste, S. and Valenzuela, J. P. (2004). Do students benefit from school competition? The Chilean experience. PhD thesis, PhD dissertation, University of Michigan: Ann Arbor, MI.

Arum, R. (1996). Do private schools force public schools to compete? American Sociological Review, 61, 29–46.

Ayala Carrère, J. M. (2010). Estudio de las variables determinantes de los padres en la elección de colegios para enseñanza básica (Tesis de licenciatura, Universidad de Chile).

Banco Interamericano de Desarrollo (2018). Financiamiento de la educación en Chile. Reporte final.

Base de Datos de la Agencia de Calidad de la Educación [2004-2018]. Santiago, Chile.

Battese, G. E. and Coelli, T. J. (1992). Frontier production functions, technical efficiency and panel data: with application to paddy farmers in India. Journal of productivity analysis, 3(1-2):153–169.

Belfield, C. R. and Levin, H. M. (2002). The effects of competition between schools on educational outcomes: A review for the united states. Review of Educational research, 72(2):279–341.

Bellei, C. (2015). El gran experimento: Mercado y privatización de la educación chilena. LOM ediciones.

Bellei, C., Canales, M., Orellana, V., & Contreras, M. (2016). Elección de escuela en sectores populares: Estado, mercado e integración social. Revista Austral de Ciencias Sociales, (31), 91-110.

Bellei, C., Muñoz, G., Rubio, X., Alcaíno, M., Donoso, M. P., Martínez, J., ... & Díaz, R. (2018). Nueva educación pública: Contexto, contenidos y perspectivas de la desmunicipalización. Santiago de Chile: LOM Ediciones.

Bell, C. (2009). Geography in parental choice. American Journal of Education, 115(4):493– 521.

Bell, C. A. (2007). Space and place: Urban parents' geographical preferences for schools.

The Urban Review, 39(4):375–404.

Bettinger, E. P. (2005). The effect of charter schools on charter students and public schools. Economics of Education Review, 24(2):133–147.

Böhlmark, A. and Lindahl, M. (2015). Independent schools and long-run educational out- comes: Evidence from Sweden's large-scale voucher reform. Economica, 82(327):508–551.

Borland, M. V., & Howsen, R. M. (1993). Students' academic achievement and the degree of market concentration in education. Economics of Education Review, 11, 31–39.

Bosetti, L. (2004). Determinants of school choice: Understanding how parents choose elementary schools in Alberta. Journal of Education Policy, 19(4):387–405.

Boterman, W. R. (2019). The role of geography in school segregation in the free parental choice context of Dutch cities. Urban Studies, 56(15), 3074-3094.

Bradford, M. (1990). Education, attainment and the geography of choice. Geography, pages 3–16.

Bradley, S., Johnes, G., and Millington, J. (2001). The effect of competition on the efficiency of secondary schools in England. European Journal of Operational Research, 135(3):545– 568.

Bravo, D., Mukhopadhyay, S., and Todd, P. E. (2008). How universal school vouchers affect educational and labor market outcomes: Evidence from Chile.

Canales, M., Bellei, C., & Orellana, V. (2016). ¿Por qué elegir una escuela privada subvencionada? Sectores medios emergentes y elección de escuela en un sistema de mercado. Estudios Pedagógicos (Valdivia), 42(3), 89-109.

Chakrabarti, R. (2008). Can increasing private school participation and monetary loss in a voucher program affect public school performance? evidence from Milwaukee. Journal of public Economics, 92(5-6):1371–1393.

Card, D., Dooley, M. D., and Payne, A. A. (2010). School competition and efficiency with publicly funded catholic schools. American Economic Journal: Applied Economics, 2(4):150–76.

Cardon, J. H. (2003). Strategic quality choice and charter schools. Journal of Public Economics, 87(3-4):729–737.

Carrasco, A., Gutiérrez, G., & Flores, C. (2017). Failed regulations and school composition: selective admission practices in Chilean primary schools. Journal of Education Policy, 32(5), 642-672.

Cartagena Farias, J. and McIntosh, S. (2019). Does the increase in competition between schools improve the quality of the service? the role of educational reform in Chile. The Journal of Development Studies, 55(8):1799–1815.

Chumacero, R. A., Gómez, D., and Paredes, R. D. (2011). I would walk 500 miles (if it paid): Vouchers and school choice in Chile. Economics of Education Review, 30(5):1103–1114.

Contreras, D., Larrañaga, O., Flores, L., Lobato, F., & Macías, V. (2005). Políticas educacionales en Chile: Vouchers, concentración, incentivos y rendimiento. Uso e impacto de la información educativa en América Latina, 61-110.

Contreras, D., Sepúlveda, P., and Bustos, S. (2010). When schools are the ones that choose: The effects of screening in Chile. Social Science Quarterly, 91(5):1349–1368.

Córdoba, C. (2014). La elección de escuela en sectores pobres: Resultados de un estudio cualitativo. Psicoperspectivas, 13(1), 56-67.

Dee, T. S. (1998). Competition and the quality of public schools. Economics of Education review, 17(4):419–427.

Egalite, A. (2013). Measuring competitive effects from school voucher programs: A systematic review. Journal of School Choice: International Research and Reform, 7(4):443–464.

Elacqua, G., & Fabrega, R. (2004). El consumidor de la educación: El actor olvidado de la libre elección de escuelas en Chile. Santiago de Chile: PREAL.

Elacqua, G. (2012). The impact of school choice and public policy on segregation: Evidence from Chile. International Journal of Educational Development, 32(3):444–453.

Falabella, A. (2014). The Performing School: The Effects of Market & Accountability Policies. education policy analysis archives, 22(70), n70.

Gajardo, F. and Grau, N. (2019). Competition among schools and educational quality: Tension between various objectives of educational policy. International Journal of Educational Development, 65:123–133.

Gallego, F. A. (2002). Competencia y resultados educativos: teoría y evidencia para chile. cuadernos de economía, 39(118):309–352.

Gallego, F. A., & Hernando, A. (2010). School choice in Chile: Looking at the demand side. Pontificia Universidad Catolica de Chile Documento de Trabajo, (356).

Garcia-Diaz, R., del Castillo, E., and Cabral, R. (2016). School competition and efficiency in elementary schools in Mexico. International Journal of Educational Development, 46:23– 34.

Gauri, V. and Vawda, A. (2004). Vouchers for basic education in developing economies: an accountability perspective. The World Bank Research Observer, 19(2):259–280.

Geller, C. R., Sjoquist, D. L., and Walker, M. B. (2006). The effect of private school competition on public school performance in Georgia. Public finance review, 34(1):4–32.

Gibbons, S., Machin, S., and Silva, O. (2008). Choice, competition, and pupil achievement. Journal of the European Economic Association, 6(4):912–947.

Gibbons, S. and Silva, O. (2006). Competition and accessibility in school markets: empirical analysis using boundary discontinuities. Improving school accountability: check-ups or choice. Advances in applied microeconomics, pages 157–184.

Glatter, R., Woods, P., and Bagley, C. (1997). Diversity, differentiation and hierarchy: School choice and parental preferences. Choice and diversity in schooling: Perspectives and prospects, pages 7–28.

González, P. (2003). Estructura institucional, recursos y gestión en el sistema escolar chileno. Políticas educacionales en el cambio de siglo. La reforma del sistema escolar en Chile, 597-660.

González, R. (2017). Segregación educativa en el sistema chileno desde una perspectiva comparada. Santiago, Chile: Centro de Estudios del Ministerio de Educación. Santiago. Chile.

Gronberg, T. J., Jansen, D. W., Karakaplan, M. U., and Taylor, L. L. (2015). School district consolidation: Market concentration and the scale-efficiency tradeoff. Southern Economic Journal, 82(2):580–597.

Grosskopf, S., Hayes, K. J., Taylor, L. L., and Weber, W. L. (2001). On the determinants of school district efficiency: Competition and monitoring. Journal of Urban Economics, 49(3):453–478.

Hofflinger, A., Gelber, D., and Tellez, S. ("in press"). School choice and parents preferences for school attributes in Chile. Economics of Education Review, x(x):x.

Hoxby, C. M. (1994). Do private schools provide competition for public schools? Technical report, National Bureau of Economic Research.

Hsieh, C.-T. and Urquiola, M. (2003). When schools compete, how do they compete? an assessment of Chile's nationwide school voucher program. Technical report, National Bureau of Economic Research.

Jepsen, C. (2003). The effectiveness of catholic primary schooling. Journal of human Re- sources, 38(4):928–941.

Kang, B.-G. and Greene, K. V. (2002). The effects of monitoring and competition on public education outputs: A stochastic frontier approach. Public Finance Review, 30(1):3–26.

Kosunen, S., & Carrasco, A. (2016). Parental preferences in school choice: Comparing reputational hierarchies of schools in Chile and Finland. Compare: A Journal of Comparative and International Education, 46(2), 172-193.

Kumbhakar, S. C., Wang, H. J., & Horncastle, A. P. (2015). A practitioner's guide to stochastic frontier analysis using Stata. Cambridge University Press.

Lovell, C. K. (1993). Production frontiers and productive efficiency. The measurement of productive efficiency: Techniques and applications, 3, 67.

Marcel, M. y Raczynski D. (2009). La asignatura pendiente, claves para la revalidación de la educación pública de gestión local en Chile. Santiago, Chile: Uqbar Editores.

McEwan, P. J. and Carnoy, M. (2000). The effectiveness and efficiency of private schools in Chile's voucher system. Educational evaluation and policy analysis, 22(3):213–239.

McMillan, R. (2000). Competition, parental involvement and public school performance. In Proceedings. Annual Conference on Taxation and Minutes of the Annual Meeting of the National Tax Association, volume 93, pages 150–155. JSTOR.

McMillan, R. (2004). Competition, incentives, and public school productivity. Journal of Public Economics, 88(9-10):1871–1892.

Méndez, M. L., & Gayo, M. (2018). Upper middle class social reproduction: Wealth, schooling, and residential choice in Chile. Springer.

Millimet, D. L. and Collier, T. (2008). Efficiency in public schools: Does competition matter? Journal of Econometrics, 145(1-2):134–157.

Misra, K. and Chi, G. (2011). Measuring public school competition from private schools: A gravity-based index. Journal of Geographic Information System, 3(04):306.

Misra, K., Grimes, P. W., and Rogers, K. E. (2012). Does competition improve public school efficiency? a spatial analysis. Economics of Education Review, 31(6):1177–1190.

Mizala, A. and Romaguera, P. (2002). Evaluación del desempeño e incentivos en la educación chilena. Cuadernos de Economía, 39(118):353–394.

Mizala, A., Romaguera, P., & Farren, D. (2002). The technical efficiency of schools in Chile. Applied Economics, 34(12), 1533-1552.

Mizala, A. and Torche, F. (2012). Bringing the schools back in: the stratification of educational achievement in the Chilean voucher system. International Journal of Educational Development, 32(1):132–144.

Munoz, D.A. and Queupil, J.P. (2016), "Assessing the efficiency of secondary schools in Chile: a data envelopment analysis", Quality Assurance in Education, Vol. 24 No. 3, pp. 306-328.

Ni, Y. (2009). The impact of charter schools on the efficiency of traditional public schools: Evidence from Michigan. Economics of Education Review, 28(5):571–584.

Noailly, J., Vujić, S., and Aouragh, A. (2012). The effects of competition on the quality of primary schools in the Netherlands. Environment and Planning A, 44(9):2153–2170.

Oberti, M. (2007). Social and school differentiation in urban space: inequalities and local configurations. Environment and Planning A, 39:208–227.

Ortiz Cáceres, I. (2012). En torno a la validez del Sistema de Medición de la Calidad de la Educación en Chile. Estudios Pedagógicos (Valdivia), 38(2), 355-373.

Paredes, R. D., & Pinto, J. I. (2009). ¿El fin de la educación pública en Chile?. Estudios de economía, 36(1), 47-66.

Raczynski, D., & Salinas, D. (2008). Fortalecer la educación municipal. Evidencia empírica, reflexiones y líneas de propuesta. La agenda pendiente en educación. Profesores, administradores y recursos: propuestas para la nueva arquitectura de la educación chilena, 105-133.

Rodríguez, J., & Arriagada, C. (2004). Segregación residencial en la ciudad latinoamericana. Eure (Santiago), 30(89), 05-24.

Román, M., & Corvalán, J. (2016). Dicen que esta escuela es mala, pero nosotros la encontramos buena. Elección de escuela en familias pobres. En J. Corvalán, A. Carrasco y JE García-Huidobro (Eds.), Mercado escolar y oportunidad educacional. Libertad, diversidad y desigualdad, 209-231.

Sander, W. (1999). Private schools and public school achievement. Journal of Human resources, pages 697–709.

Sandström, F. M. and Bergström, F. (2005). School vouchers in practice: Competition will not hurt you. Journal of Public economics, 89(2-3):351–380.

Santos, H., & Elacqua, G. (2016). Segregación socioeconómica escolar en Chile: elección de la escuela por los padres y un análisis contrafactual teórico.

Sapelli, C. (2003). The Chilean voucher system: some new results and research challenges. cuadernos de economía, 40(121):530–538.

Sapelli, C., & Torche, A. (2002). Subsidios al alumno oa la escuela: efectos sobre la elección de colegios públicos. Cuadernos de economía, 39(117), 175-202.

Sapelli, C. and Vial, B. (2002). The performance of private and public schools in the Chilean voucher system. Cuadernos de Economía, 39(118):423–454.

Schmidt, P. and Sickles, R. C. (1984). Production frontiers and panel data. Journal of Business & Economic Statistics, 2(4):367–374.

Stock, J. H. and Yogo, M. (2005). Testing for weak instruments in linear iv regression. In Identification and Inference for Econometric Models: Essays in Honor of Thomas Rothenberg, pages 80–108. Cambridge University Press.

Taylor, C. (2001a). The geography of choice and diversity in the 'new' secondary education market of England. Area, 33(4):368–381.

Taylor, C. (2001b). Hierarchies and 'local' markets: the geography of the 'lived' market place in secondary education provision. Journal of Education Policy, 16(3):197–214.

Thapa, A. (2013). Does private school competition improve public school performance? the case of Nepal. International Journal of Educational Development, 33(4):358–366.

Theobald, R. (2005). School choice in Colorado springs: The relationship between parental decisions, location and neighborhood characteristics. International Research in Geographical & Environmental Education, 14(2):92–111.

Thieme, C., Prior, D., & Tortosa-Ausina, E. (2013). A multilevel decomposition of school performance using robust nonparametric frontier techniques. Economics of Education Review, 32, 104-121.

Tokman, A. (2002). Is private education better? Evidence from Chile. Central Bank of Chile.

Torche, F. (2005). Privatization reform and inequality of educational opportunity: The case of Chile. Sociology of education, 78(4), 316-343.

Valenzuela, J. P., Bellei, C., and de los Ríos, D. (2008). Socioeconomic school segregation in a market-oriented educational system. the case of Chile.

Table 1: Summary statistics for public schools, 2016-2018.

Variables	Mean	Std. Dev.	Min	Max	N
Reading score	235.46	21.72	0	326	1843
Mathematics score	234.15	25.60	0	379	1843
Log of competition index (3 km)	3.72	1.70	-4	16	1718
Number of students per teacher	13.15	3.66	2	31	1843
Number of school elements	354.80	271.67	5	4181	1812
Total subsidy income (in millions)	282.91	211.67	4	2385	1843
Number of teachers with education degree	35.65	18.86	2	197	1843
Teachers' experience	15.77	3.45	4	27	1843
Number of principals	0.98	0.13	0	1	1843
Percentage of male teachers	0.28	0.13	0	1	1843
Number of priority students	267.38	156.34	3	1398	1843
Number of preferential students	139.02	130.10	1	1477	1843
Total number of vulnerable students	406.40	260.75	5	2446	1843
Students with low socioeconomic status (%)	0.23	0.37	0	1	1843
Students with medium-low socioeconomic status (%)	0.52	0.43	0	1	1843
Students with medium socioeconomic status (%)	0.22	0.38	0	1	1843
Students with high socioeconomic status (%)	0.03	0.17	0	1	1843

Table 2: FE models for public schools' efficiency. Schmidt and Sickles (1984) model.

Inputs/Output	(1) Reading	(2) Math	(3) Both
Log of subsidy income per student	-0.0095**	-0.018***	-0.014***
	(0.0038)	(0.0035)	(0.0033)
Log of school elements per student	0.029***	-0.0059	0.012**
	(0.0059)	(0.0047)	(0.0047)
Log of number of teachers with education degree per student	0.027*	0.025*	0.026**
	(0.0147)	(0.0129)	(0.0127)
Within R2	0.050	0.030	0.039
Between R2	0.160	0.056	0.134
Number of observations	1811	1811	1811
Technical efficiency summary			
Mean	0.723	0.629	0.672
Std. Dev.	0.062	0.065	0.062
Min	0.573	0.453	0.509
Max	1	1	1

Standard errors clustered by school in parentheses.

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Table 3: Public schools' efficiency and spatial competition: OLS estimates.

	Reading			Math		
	2016	2017	2018	2016	2017	2018
Log of competition index (3km)	-0.0073***	-0.0080***	-0.0079***	-0.0054***	-0.0063***	-0.0060**
	(0.0018)	(0.0019)	(0.0021)	(0.0019)	(0.0022)	(0.0024)
Log of teachers' experience	-0.10	-0.046	-0.16	-0.25	-0.078	-0.33
	(0.2665)	(0.2571)	(0.3563)	(0.4272)	(0.3964)	(0.5566)
Squared log of teachers' experience	0.015	0.0078	0.025	0.039	0.012	0.055
	(0.0490)	(0.0473)	(0.0657)	(0.0779)	(0.0729)	(0.1021)
Log of teachers' working hours	-0.049***	-0.046***	-0.057***	-0.051***	-0.042***	-0.068***
	(0.0117)	(0.0112)	(0.0145)	(0.0149)	(0.0140)	(0.0170)
Number of principals	0.045***	0.025	0.031***	0.073***	0.036	0.094***
	(0.0127)	(0.0175)	(0.0077)	(0.0182)	(0.0277)	(0.0119)
Percentage of male teachers	-0.12***	-0.14***	-0.18***	-0.060**	-0.074**	-0.096***
	(0.0213)	(0.0220)	(0.0263)	(0.0299)	(0.0289)	(0.0277)
Log of priority and preferential students	0.022***	0.022***	0.030***	0.030***	0.027***	0.042***
	(0.0049)	(0.0044)	(0.0059)	(0.0069)	(0.0060)	(0.0073)
Medium-low socioeconomic status	0.044***	0.043***	0.030***	0.048***	0.047***	0.035***
	(0.0090)	(0.0077)	(0.0090)	(0.0079)	(0.0087)	(0.0095)
Medium socioeconomic status	0.12***	0.12***	0.091***	0.13***	0.13***	0.10***
	(0.0159)	(0.0128)	(0.0147)	(0.0178)	(0.0163)	(0.0169)
High socioeconomic status	0.23***	0.24***	0.18***	0.26***	0.26***	0.19***
	(0.0294)	(0.0220)	(0.0230)	(0.0355)	(0.0270)	(0.0271)
Municipality Fixed Effects	✓	✓	✓	✓	✓	✓
Adjusted R-Squared	0.613	0.630	0.608	0.575	0.575	0.559
F-statistic (p-value)	0.000	0.000	0.000	0.000	0.000	0.000
Number of observations	588	574	526	588	574	526

Standard errors clustered by municipality in parentheses.
$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Table 4: OLS first-stage estimation. Dependent variable: Log of competition index (3 km).

	OLS		
	2016	2017	2018
Distance to the center of the commune	-0.18***	-0.18***	-0.17***
	(0.0509)	(0.0477)	(0.0520)
Municipality Fixed Effects	✓	✓	✓
Adjusted F-Squared	0.366	0.374	0.379
F-statistic (Power)	12.25	13.72	9.44
N	588	574	526

Standard errors are in parentheses and clustered by municipality.
Same controls as in Table 3.
$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Table 5: Distance school-municipality center and additional neighborhood characteristics.

	(No controls)			(Controls)		
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Log of average of property fiscal values	-0.60			0.56		
	(0.4941)			(0.5279)		
Log of municipality income		-0.70			0.59	
		(0.6755)			(0.6062)	
Percentage of poor population			0.12			-0.084
			(0.1876)			(0.1457)
Number of observations	642	642	642	542	542	542

Standard errors are in parentheses and clustered by municipality.
Same controls as in Table 3.
$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Table 6: IV estimates for public schools' efficiency and spatial competition (Reading).

	(1)			(2)		
	2016	2017	2018	2016	2017	2018
Log of competition index (3km)	-0.040***	-0.045***	-0.032***	-0.0078	-0.011	-0.0061
	(0.0133)	(0.0152)	(0.0119)	(0.0097)	(0.0104)	(0.0124)
Municipality Fixed Effects				✓	✓	✓
Number of observations	588	574	526	588	574	526
Hausman test (Ho: A_i is exogenous)	0.036	0.032	0.080	0.956	0.768	0.871
Exclusion test	0.036	0.032	0.080	0.956	0.768	0.871

Standard errors are in parentheses and clustered by municipality.
Same controls as in Table 3.
$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Table 7: IV estimates for public schools' efficiency and spatial competition (Mathematics)

	(1)			(2)		
	2016	2017	2018	2016	2017	2018
Log of competition index (3km)	-0.040**	-0.047**	-0.031**	0.0041	0.00024	0.0067
	(0.0160)	(0.0183)	(0.0145)	(0.0116)	(0.0118)	(0.0140)
Municipality Fixed Effects				✓	✓	✓
Number of observations	588	574	526	588	574	526
Hausman test (Ho: A_i is exogenous)	0.052	0.035	0.129	0.373	0.574	0.281
Exclusion test	0.052	0.035	0.129	0.373	0.574	0.281

Standard errors are in parentheses and clustered by municipality.
Same controls as in Table 3.
$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Table 8: IV estimates for public schools' efficiency and competition based on density

	Reading			Math		
	2016	2017	2018	2016	2017	2018
Log of competition index (3km)	-0.013	-0.019	-0.0095	0.0070	0.00034	0.010
	(0.0146)	(0.0168)	(0.0182)	(0.0201)	(0.0203)	(0.0225)
Municipality Fixed Effects	✓	✓	✓	✓	✓	✓
F-statistic (Power)	5.85	6.68	5.86	5.85	6.7	5.86
Number of observations	589	575	527	589	575	527

Standard errors are in parentheses and clustered by municipality.
Same controls as in Table 3.
$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Table 9: RE models for public schools' efficiency. Battese and Coelli (1992) model.

Variables/dependent variable	(1) Reading	(2) Math	(3) Both
Log of subsidy income per student	0.020***	-0.011**	0.0059
	(0.0060)	(0.0054)	(0.0051)
Log of school elements per student	-0.019**	-0.024***	-0.020***
	(0.0078)	(0.0062)	(0.0061)
Log of number of teachers with education degree per student	-0.035***	-0.039***	-0.034***
	(0.0101)	(0.0096)	(0.0093)
Log likelihood function	2341	2382	2492
Number of observations	1811	1811	1811
Technical efficiency summary			
Mean	0.750	0.645	0.701
Std. Dev.	0.052	0.057	0.055
Min	0.612	0.511	0.563
Max	0.957	0.963	0.969

Standard errors clustered by school are in parentheses.

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Table 10: RE-IV estimates for public schools' efficiency and spatial competition.

	Reading		Math	
	RE	RE-2SLS	RE	RE-2SLS
Log of competition index (3km)	-0.012***	-0.0054	-0.015***	0.0069
	(0.0019)	(0.0077)	(0.0019)	(0.0107)
Municipality Fixed Effects	✓	✓	✓	✓
Between R2	0.419	0.441	0.363	0.320
Within R2	0.342	0.310	0.449	0.300
F-statistic		29.37		32.47
Number of observations	1688	1688	1688	1688

Standard errors are in parentheses and clustered by municipality.
Same controls as in Table 3.
$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Table 11: IV estimates for public schools' performance and spatial competition.

	Reading			Math		
	2016	2017	2018	2016	2017	2018
Log of competition index (3km)	-0.0053	-0.0030	-0.022*	0.0034	0.0028	-0.0020
	(0.0117)	(0.0126)	(0.0116)	(0.0135)	(0.0105)	(0.0176)
Municipality Fixed Effects	✓	✓	✓	✓	✓	✓
F-statistic (Power)	12.24	13.10	9.39	12.24	13.10	9.39
Hausman test (Ho: A_i is exogenous)	0.818	0.800	0.260	0.434	0.482	0.786
Number of observations	588	589	541	588	589	541

Standard errors are in parentheses and clustered by municipality.
Same controls as in Table 3.
$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$