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Does achievement rise fastest with school choice, school resources, or family resources? Chile from 2002 to 2013

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Debates in education policy draw on different theories about how to raise children's achievement. The *school competition* theory holds that achievement rises when families can choose among competing schools. The *school resource* theory holds that achievement rises with school spending and resources that spending can buy. The *family resources* theory holds that children's achievement rises with parental education and income. We test all three theories in Chile between 2002 and 2013, when reading and math scores rose by 0.2-0.3 standard deviations, while school competition, school resources, and family resources all increased. In a difference in differences analysis, we ask which Chilean municipalities saw the greatest increases in test scores. Test scores did not rise faster in municipalities with greater increases in competition, but did rise faster in municipalities with greater increases in school resources (teachers per student) and especially family resources (parental education, not income). Student grade point averages show similar patterns. Results contradict the school competition theory but fit the family resource theory and, to a lesser extent, the school resource theory.

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ABSTRACT

Debates in education policy draw on different theories about how to raise children's achievement. The *school competition* theory holds that achievement rises when families can choose among competing schools. The *school resource* theory holds that achievement rises with school spending and resources that spending can buy. The *family resources* theory holds that children's achievement rises with parental education and income. We test all three theories in Chile between 2002 and 2013, when reading and math scores rose by 0.2-0.3 standard deviations, while school competition, school resources, and family resources all increased. In a difference in differences analysis, we ask which Chilean municipalities saw the greatest increases in test scores. Test scores did not rise faster in municipalities with greater increases in competition, but did rise faster in municipalities with greater increases in school resources (teachers per student) and especially family resources (parental education, not income). Student grade point averages show similar patterns. Results fit the school and family resource theories, but contradict the school competition theory.

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INTRODUCTION

Scholars and advocates subscribe to different theories about how to improve schools and raise students' academic achievement. One is the *school competition* theory, which holds that schools use resources more effectively if they must compete for students who can choose between schools—perhaps especially if students can choose between schools in either the public or private sector. Another theory is the *school resource* theory, which holds that achievement rises when schools are given greater material resources such as higher revenues and salaries, smaller class sizes, and better facilities. A third theory is the *family resource* theory, which holds that children's achievement depends less on school resources than on family resources, especially parental education and income. While all these theories may be valid to some degree, they are not necessarily equal in explanatory power, and adherents of different theories compete for control of education debate, reform, and policy.

The country of Chile offers a striking opportunity to test and contrast these theories. Between 2002 and 2013, Chilean students' average scores on both national and international tests rose by approximately 0.2 standard deviations (SD) in math and 0.3 SD in reading. It is not clear why. It is often argued that the reason is Chile's system of private school choice—the largest in the world—which has grown until, by 2009, more than half of Chilean children attended private schools using government vouchers. But school choice is not the only thing that has grown in Chile. School and family resources have grown as well. Since the year 2000, Chileans' per capita income has more than doubled in real terms, increasing family resources along with the tax revenues available for education. Parental education has risen, too, in part because Chile's government has offered large subsidies to help future parents finish high school and enroll in college. As usual, rising parental education has brought falling birth rates, so that class sizes have shrunk, and increases in school spending have been magnified by the smaller number of students that money is spent on .

Which of these increases—rising school choice, rising school resources, or rising family resources—is most responsible for the increase in Chile's test scores between 2002 and 2013? In this article, we address that question by comparing trends across 328 municipalities that enroll 99 percent of Chilean elementary students. In a difference in differences analysis, we ask which municipalities have experienced the greatest rise in test scores. Has it been the municipalities with the greatest increase in school competition, the municipalities with the greatest increase in school resources, or the municipalities with the greatest increase in family resources?

Remarkably, we find no association at all between rising school competition and rising test scores. The increase in Chile's test scores has been approximately the same in municipalities with rapidly expanding choice as in municipalities with stagnant choice. Instead of school choice, we find that rising test scores have been more strongly associated with rising parental education (but not rising income) and, to a lesser degree, with falling class sizes. We also estimate the association between changes in school competition and changes in test score inequality, as well as changes in students' grade point average (GPA) and attendance rates. Results for GPA show the same pattern as results for test scores; between municipalities, rising GPAs are associated with rising parental education and shrinking class sizes, but not with increasing school choice or family income. Test score inequality and attendance rates, however, changed very little in response to school competition or school and family resources.

Our findings extend an earlier study by Hsieh and Urquiola (2006), who used a similar difference-in-differences design to estimate the effects of the expansion of Chile's voucher system from 1982 to 1996. Like us, Hsieh and Urquiola found that municipalities with greater increases in school choice did not have greater increases in test scores; in addition, municipalities with greater increases in school choice did not have greater increases in years of completed schooling and actually increased the fraction of students who had to repeat a grade. Although there are some academic outcomes that have not yet been examined, our findings and Hsieh and Urquiola's suggest that the whole history of school choice in Chile—from the voucher system's origins in 1981 until 2013—may not have improved academic outcomes at all.

In addition to extending the story into the twenty-first century, we go beyond Hsieh and Urquiola by not just estimating the effect of school choice, but also estimating the effects of rising school resources and family resources. Hsieh and Urquiola's analyses included family resources, but only as control variables, and they did not include measures of school resources. By contrast, we interpret school and family resources as variables whose rise—precipitated by changes in Chile's society, economy, and policies—have had effects that are important in their own right.

In the rest of this article, we review in more detail the theories, policies, and research that have shaped debate on school competition, school resources, and family resources in both the US and Chile. We describe our data and model, review our findings in detail, and draw conclusions about what accounts for Chile's rising test scores. For readers unfamiliar with Chilean history, Table A 1 in the Appendix provides a brief summary of key events and historical statistics.

School choice

The modern intellectual history of school choice began with Milton Friedman's (1955, revised in 1962) essay, "The Role of Government in Education." Friedman argued that, although government should *pay* for children's education—at least to a minimum level, and at least for parents who could pay for education themselves—government has no obligation to *deliver* education through a system of public schools. Instead, Friedman suggested, government could provide an education "voucher" that parents could redeem at a public or private school of their choice Although Friedman did not explicitly argue that a voucher system would improve children's academic achievement, later scholars argued that it might, and that vouchers might be especially helpful to segregated poor and black families whose choices among local public schools were limited and inadequate (Chubb and Moe 1990; Coleman 1992; Jencks 1970).

School vouchers have been slow to gain traction in the US. After Friedman's essay, it was 35 years until Milwaukee launched the first modern school voucher system in 1990 (Carpenter and Kafer 2012). Even today, in 2018-19, when there are 26 voucher systems in 15 US states (EdChoice 2019), most voucher systems have limited funds, and only 0.3 percent of US K-12 students use vouchers to attend private schools, while an additional 0.6 percent attend private schools using other government subsidies such as tax credit scholarships or education savings accounts.[1]

Friedman's voucher idea had much greater influence in Chile. Under a program sponsored by the US Department of State, between 1956 and 1973, exchange students from the elite Pontifical Catholic University of Chile earned nearly one hundred masters degrees and six PhDs from the University of Chicago, where they studied with Friedman and other free market economists (Montes 2015; Silva 1991). After Chile's 1973 military coup, several of these US-trained "Chicago boys" took influential positions in the new dictatorship of General Augusto Pinochet. Under the dictatorship, Chile's Chicago boys launched a series of free market reforms, including a nationwide school voucher system that started in 1981 (Silva 1991). By 2009, more than half of Chile's elementary and secondary students were attending private schools using government vouchers (Figure 1).

For private school vouchers to improve academic achievement, at least one of two assumptions must hold. One assumption is that private schools are generally better, in their effects on achievement, than public schools. The other assumption is that a voucher system, by

[1] These percentages were calculated by dividing the number of students using vouchers (188.424), tax credit scholarships (274,983), and education savings accounts (18,706), according to EdChoice.org, by the number of K-12 students in the US (56.6 million, including 5.9 million at private schools), according to the National Center for Education Statistics.

extending the option of private education to families who could not otherwise afford it, will increase competition between public and private schools, incentivizing both to improve.

Both of these assumptions are controversial. The first assumption—that private schools are better—is often hard to assess because the children who attend public and private schools are so different. Although average achievement is higher in private schools, it can be hard to separate the effect of private school attendance from preexisting differences between the students who attend public and private schools. After adjusting for student body differences using control variables, an early study concluded that private schools still had slightly higher achievement (Coleman, Hoffer, and Kilgore 1982), but more recent studies have concluded that, when adjusted of student body differences, test scores were no higher at private schools; in fact, public schools might even have an advantage (Elder and Jepsen 2014; Lubienski and Lubienski 2013; Reardon, Cheadle, and Robinson 2009) .

Some voucher systems offer another way to compare the causal effects of public and private schools. If the demand for vouchers exceeds the supply, some systems award vouchers by random lottery, so that, within the pool of voucher applicants, there are no systematic differences between students who receive vouchers and students who do not. A recent meta-analysis of eight US voucher lotteries (Shakeel, Anderson, and Wolf 2016) found that the effect on test scores of using vouchers to attend private schools was 0.00 SD on average, but effects varied substantially, with private schools in some voucher programs (e.g., Charlotte) showing consistently positive effects (approximately 0.2 SD in math and reading), and others (e.g., Louisiana) showing large negative effects (-0.2 SD in reading, -0.3 SD in math). Outside the US, effects varied as well; one voucher lottery, in Bogota, Colombia, showed very large positive effects of private schooling (0.8 SD in math and 1.4 SD in reading), but two voucher lotteries in India showed modest or null effects (averaging 0.0 SD in math and 0.2 SD in reading) (Shakeel et al. 2016). Voucher lottery studies have high internal validity, but participating schools are not necessarily representative of all public and private schools, so the results of voucher studies do not necessarily warrant general conclusions about the relative effectiveness of public and private schools in general.

In Chile, the supply of vouchers is unlimited, and there have been no voucher lottery studies to date. The best study of quality differences between Chile's public and private voucher schools followed students longitudinally as they transitioned from public primary schools to either public or private secondary schools. Holding the student constant as the school sector changed (Lara, Mizala, and Repetto 2011), this study reported a small and not always significant effect of private voucher schools on test scores (0.05 SD). Other researchers trying to compare the effects of Chile's public and private schools have relied on instrumental variables such as the density of population (Auguste and Valenzuela 2004) or the density of Catholic churches and clergy (Cartagena Farias and McIntosh 2018; Gallego 2013), but these instrumental variables have questionable validity, especially because most private schools in Chile are not Catholic.

The second assumption behind school vouchers—that competition presses all schools to improve—is also difficult to assess. One approach is to compare communities with higher and lower levels of school competition, but these communities may differ in other ways, making the effects of competition difficult to identify. One article tried to overcome this limitation by using rivers and other streams as instrument for competition between school districts, arguing that metropolitan areas that are more broken up by rivers and streams tend to have more school districts and higher levels of inter-district competition. This article reported that competition had a positive effect on student achievement (Hoxby 2000). A later replication attempt, however, alleged that the instrument was questionable and that the effect of competition became nonsignificant after data errors were corrected and the streams variable was recoded (Rothstein 2007b). A vigorous debate ensued (Hoxby 2007; Rothstein 2007), but it is not clear how relevant the debate was to the question of private school vouchers. The rivers-and-streams study concerned competition among public school districts, whereas vouchers are meant to promote competition among individual public and private schools.

While much of the school choice literature concerns the effect of private schools and competition on average test scores, effects on inequality in test scores are also important (Altonji, Huang, and Taber 2015; Epple and Romano 2008; Gauri 1998). It is debatable whether vouchers should be expected to increase or decrease inequality. Vouchers would reduce inequality if, as voucher advocates hope, greater choice is especially helpful to segregated students whose options before vouchers were limited and inadequate (Chubb and Moe 1990) . But vouchers could increase inequality if, as skeptics fear, greater choice leads to greater segregation. In Chile, the voucher system has clearly led to greater segregation of schools by income (Santos and Elacqua 2016; Schneider, Buckley, and Elacqua 2006), but the effect of the voucher system on inequality in achievement has not been assessed. We will assess it here.

Our approach to the effects of Chile's voucher system is relatively direct. Holding each municipality constant, we estimate how the achievement changed as more private schools opened, more students used vouchers to attend them, and competition between schools increased within the municipality.

School resources

The *school resource* theory holds that schools, if given more resources, will increase student achievement. School resources include money and the things that money can buy, such as higher teacher salaries, smaller classes, and better and more up-to-date facilities, books, and materials. It is often argued that spending increases especially help children from poor families, so that spending increases may not just raise achievement, but also reduce achievement inequality between rich and poor children.

The school resource theory has its skeptics. Skeptics have argued that, without incentives and accountability, schools may spend new money wastefully, or in ways that a benefit teachers and administrators without necessarily benefiting children (Hanushek 1989). Skeptics support this argument by citing cross-sectional studies showing that school resources are not strongly or consistently correlated with children's achievement, especially when family background is controlled (Coleman et al. 1966; Hanushek 1989; Jencks 1972) . Skeptics also argue that a decades-long trend of higher school spending in the US has not resulted in commensurate gains on national or international tests (Hanushek 2003).

Defenders of the school resource theory have countered that, while school spending does not always raise achievement, the weight of evidence, as assessed by meta-analysis, suggests that school resources do increase achievement on average, perhaps even substantially (Greenwald, Hedges, and Laine 1996; Hedges, Laine, and Greenwald 1994). In addition, some recent scholarship argue that correlations and trends are a poor source of evidence because they leave too many confounding variables uncontrolled, while better designed studies using random assignment and exogenous spending changes more often suggest that school resources benefit achievement (Jackson 2018) . In particular, recent studies of spending increases brought about by school finance lawsuits suggest that those increases raised the achievement, attainment, and adult incomes of poor children in affected districts (Candelaria and Shores 2017; Jackson, Johnson, and Persico 2016; Lafortune, Rothstein, and Schanzenbach 2018).

On a per student basis, school resources may increase either when total spending grows or when the student population shrinks. Both have happened in Chile. Between 2002 and 2015, Chile's public education spending rose from 4 to 5 percent of GDP, while real GDP more than tripled (World Bank 2016). Over the same period, economic modernization and rising education levels, especially among women of childbearing age, lowered birth rates birth rates (Dyson 2013). Between 2000 and 2015, Chile's birth rate, which had already fallen by half between 1960 and 2000, declined further, from 17 to 13 per thousand population (Knoema 2016). Lower birth rates brought lower school enrollments, and in public schools, the decline in enrollments was accelerated by an exodus of students to private voucher schools (see Results).

As a result of these changes, Chile's school resources are considerably higher today than they were in 2000—especially when reckoned per student. Spending per student is higher, and class sizes are lower, especially in public schools. According to the school resources theory, these changes would be expected to increase student achievement.

Family resources

The *family resources* theory holds that the primary reason some children have higher achievement than others is not school choice, school resources, or anything about schools. Instead, the primary influences come from the family. Family resources such as household income, parental education, and number of siblings predict children's achievement much more strongly than school resources such as spending, teacher credentials, and class size (Coleman et al. 1966; Jencks 1972). The achievement gaps between poor and middle-class children open primarily during the first five years of life, when children's contact with their families is greatest and schools have not yet had a chance to matter (von Hippel and Hamrock 2019; von Hippel, Workman, and Downey 2018).

Family income is important to children's success. Children's educational achievement and attainment improve when parents receive income assistance (Dahl and Lochner 2012; Duncan, Morris, and Rodrigues 2011) or when families move from high-poverty areas to areas with more economic opportunity (Chetty, Hendren, and Katz 2016). Some scholars have argued that increasing the income of poorer, less educated parents, especially when children are young, can improve children's educational outcomes more than comparable investments in school resources (Whitehurst 2016). While most research on family income is focused on average effects, income inequality may also be important to the distribution of achievement. As income inequality has grown in the US, the test score gap between rich and poor children have grown on some tests (Reardon 2011), though not on others (Hanushek et al. 2019).

Parental education is also associated with children´ academic achievement (Brooks-Gunn, Duncan, and Maritato 1999; Haveman and Wolfe 1995). More educated parents spend more time with their children (Guryan, Hurst, and Kearney 2008) and have higher expectations for their children's success (Davis-Kean 2005). After women from disadvantaged backgrounds attend college, their children are more likely to finish high school and college (Attewell et al. 2007).

Yet the family resource theory has its skeptics. Although children's achievement is strongly correlated with parental resources, not all of this correlation is causal. The very endowments that help some adults to complete higher education and earn comfortable incomes might make them more effective parents even if their incomes and education remained low. Most work on parental education and children's academic success documents associations, but does not justify a causal interpretation. Some results for parental income and children's success are causal, but these causal effect is considerably smaller than the simple correlation between achievement and income. Efforts to raise the incomes of poor parents, without changing their skills as parents or workers, may have disappointing effects (Mayer 1997).

In Chile, both family incomes and parental education increased substantially after the dictatorship. After 1990, Chile experienced the fastest economic growth in Latin America; real GDP per capita grew approximately fivefold between 1990 and 2015 (World Bank 2017). Prosperity has been widely shared; poverty rates fell from 39 percent in 1990 to 8 percent in 2013 (Casen 2013), and the Gini coefficient of income inequality fell from 0.57 in 1990 to 0.47.3 in 2013 (World Bank 2019). Chile's economy has modernized, transitioning from the export of basic commodities (e.g., copper, timber, fish, and agricultural produce) to products and services with higher value-added (Weyland 1999).

Chilean parents' educational attainment has also increased. Between 1990 and 2015, Chilean adults' average years of schooling increased from nine years to eleven (MDS 2016). One reason is that economic modernization has increased the demand for more educated workers. Another reason is that, under the presidency of democratic socialist Ricardo Lagos (2000-2006), Chile enacted three reforms to increase the percentage of children who completed high school and attended college. In 2000, Chile began paying cash transfers, or "fellowships," to help highrisk students persist through high school. Fellowships targeted pregnant high school girls as well as poor teenagers who might drop out to work and support their families. In 2003, Chile made high school completion mandatory (Mineduc 2003). In 2005, Chile began to guarantee college loans by banks to students from low-income families, who previously could not receive loans because of inadequate collateral (Lavados 2016; Mineduc 2005).

Because educational attainment increased among adults who came of age in the 1990s and 2000s, the next generation—some of whom are now in elementary and secondary school—have more educated parents than past generations. According to the family resource theory, increasing parental education should have raised children's academic achievement.

Research question

Since the turn of the century, Chile has experienced dramatic increases in school choice, school resources, and family resources. In the next section, we ask which of these increases is most strongly associated with the increase in Chilean children's test scores. We do this using a difference-in-differences analysis that compares Chilean municipalities with different rates of increase in school choice, school resources, and family resources.

DATA, MEASURES, AND MODELS

Data

We assembled data on children's test scores, grades, attendance, families, and classrooms in approximately 5,500 Chilean elementary schools enrolling approximately a quarter million fourth graders per year. The data included public and private schools that accepted vouchers, as well as private schools that did not. The schools were located in 328 Chilean municipalities (*comunas*), each of which contained between one and 128 elementary schools. Although Chilean municipalities oversee schools, they are not just school districts and do not necessarily coincide with cities; for example, Chile's capital city, Santiago, which has 5 million residents, contains 32 municipalities. In all, there are 345 municipalities in Chile, but we excluded 17 very small ones, such as Easter Island, because they did not report test scores in some years. These 17 small municipalities enrolled just one percent of Chile's fourth graders. In 2002, schools with fewer than six test scores did not appear in the data for privacy reasons. For consistency, we deleted schools with fewer than six test scores from other years as well. If we did not do this, the disappearance and reappearance of small schools from year to year would have distorted trends in the number of schools and in related quantities, such as the level of competition.

Test score data came from Chile's national test, the *Sistema Nacional de Evaluación de Calidad de la Educación* (SIMCE), which since 1988 has been administered in every public and private school in Chile. Since 2002, SIMCE scores have consistently been scaled using a three parameter item response theory model (Lord 1980), which ensures comparability of scores across years. Our analyses use fourth grade math and reading scores from 2002 and 2005-2013; fourth graders did not take the SIMCE in 2003 or 2004. We standardized test scores according to the mean and SD of all years together.

Data on students' attendance and grade point average (GPA) came from the student performance (*rendimiento del estudiante*) database at Chile's Ministry of Education. GPA ranges from 1 to 7 in Chile, with 5 corresponding roughly to a B in the US. The Chilean government audits attendance data for accuracy, because under the voucher system the government pays schools according to average daily attendance.

The only available measure of school resources was class size, defined as the number of students in each fourth grade classroom. We logged class size because the effect of class size on test scores is thought to be log-linear; that is, reductions in class size matter more when class sizes are already small, so that a reduction from 30 to 25 students, for example, is less effective than a reduction from 20 to 15 (Glass 1982). We hoped to measure school spending as well, but spending data were only available for public schools, not private schools.

Measures of family resources were family income and education, as measured by a Ministry of Education questionnaire, with a 92 percent response rate, given to parents at the time of the SIMCE test. The questionnaire recorded family incomes in 13 bins such as 0-100,000, 100,001-200,000, and 200,001- 300,000 pesos per month, where 100,000 pesos is approximately equal to 150 US dollars today.[2] We set each family's income to the midpoint of its bin, except for families in the top bin, whom we set to the harmonic mean of a Pareto distribution fit to the top two bins. Using bin midpoints in this way yields reasonably accurate estimates of income statistics; estimates of mean income that are 99 percent reliable with less than 2 percent bias, and estimates of the Gini coefficient of inequality that are about 82 percent reliable with less than 3 percent bias (von Hippel, Hunter, and Drown 2017). The family questionnaire also asked for the highest educational level attained by the mother and father. The categories used for education varied across the years; to make them comparable, we collapsed answers into three levels: primary, secondary and tertiary education. While data on degree completion were available in some years, the only measure that was consistently available across all years was exposure to each level of education. So we coded parental education according to whether the parent had any exposure to primary, secondary, or tertiary education—not whether the parent had completed degrees at these levels.

Municipal-level measures

We collapsed the variables into a dataset with one row for each municipality and year. For fourth graders in each municipality, the collapsed data included each municipality's mean reading and math scores, the fraction of parents with some secondary or tertiary education, the log of mean class size, and the log of mean income.

[2] In some years, income was reported in 15 bins. To preserve comparability, we combined bins to get the same 13 bins in every year.

Because school choice has been hypothesized to affect academic inequality (either positively or negatively), the collapsed data also included several measures of inequality in academic outcomes. Specifically, for each municipality and year, the collapsed data included the SDs of test scores and grades and the within-municipality correlations of family income with test scores and grades. Because academic inequality has also been hypothesized to depend on income inequality, the collapsed data also included the within-municipality Gini coefficient of family income.

We measured school competition using different definitions that have been used in past school choice studies (Belfield and Levin 2002) . The simplest measure—used in two-thirds of prior school choice studies, including Hsieh and Urquiola's study of Chile—was the proportion p_1 of each municipality's students who attended private voucher schools. Another measure of competition, used in less than 10 percent of prior studies, was the number of schools per student. A final measure, used in 15 percent of school choice studies, was the complement of the Herfindahl index, which defined competition between sectors as

$$Competition = 1 - \sum_{1}^{3} p_s^2$$

where p_s was the proportion of students who were enrolled in school sector *s*=1 (private voucher), s=2 (private non-voucher) or *s*=3 (public). We also used the Herfindahl index to defined competition between schools rather than sectors; under this definition, where p_s was defined as the proportion of students who were enrolled in each school.[3]

[3] An alternative Herfindahl index, suggested by a reviewer, is a compromise between the between-school and between-sector Herfindahl indices. This measure is calculated using the share of the private *sector* but the shares of individual private *schools*. Using this measure, we obtained similar results—about midway between those produced by a sector-based Herfindahl index and a school-based Herfindahl index. None of the three Herfindahl indices had a significant effect on test scores.

Model

We specified our difference-in-difference analysis using a longitudinal regression model with fixed effects for each municipality and year:

$$Y_{mt} = \alpha_m + \beta_t + \boldsymbol{\gamma X}_{mt} + e_{mt}$$

Here α_m was a municipality fixed effect (a dummy for each municipality), β_t was a year fixed effect (a dummy for each year), and e_{mt} was an exogenous residual. To account for within-municipality serial correlation in e_{mt}, we clustered standard errors at the municipal level (Cameron and Miller 2015). Note that a fixed effects model can also be specified as a regression of change in the outcome *Y* on change in the regressors $\boldsymbol{X}$. The two specifications are equivalent (Allison 2009).[4]

The dependent variable Y_{mt} was a municipal-level summary of some student variable for municipality *m* in year *t*. In some models, Y_{mt} was a measure of the municipality's average math scores, reading scores, attendance rates, or GPA. In other models, Y_{mt} was a measure of inequality in academic performance, as measured by the SD of test scores or grades, or the within-municipality correlation between income and test scores or grades.

The independent variables represented by the vector $\boldsymbol{X}_{mt}$, included measures of school competition (measured four different ways; see above), school resources (measured by the log of average class size), and family resources (measured by the log of fourth graders' average family income, the Gini coefficient of income inequality among fourth graders' families, and the proportions of fourth grade mothers and fathers with some secondary or tertiary education). In our main analyses, the independent variables $\boldsymbol{X}_{mt}$ were measured in the same years as the dependent variable Y_{mt}. In auxiliary analyses, reported in the Appendix, we lagged competition by one year, hypothesizing that it might take schools and families time to respond to

[4] With more than two years of data, as here, "change" is defined as the deviation of *Y* and *X* from their municipality-specific means (Allison, 2009).

competition—this did not affect the results.[5] Relationships between changes in $\boldsymbol{X}$ and changes in Y were assumed to be linear, except for the effect of competition, where the Herfindahl index is defined as a quadratic function of school or sector enrollment shares p_s.

The advantage of a fixed effects model was that it controlled for many potential confounders, even if they were not explicitly observed (Allison 2009; Greene 2011). The municipality fixed effects controlled for omitted municipal characteristics that did not change over time, and the year fixed effects controlled for time trends that were common across municipalities. What the fixed effects model did not fully control was the effect of omitted confounders whose time trends varied across municipalities. For example, if high achieving families migrated from some municipalities to others, our model did not control for it, since changes in migration follow different trends in different municipalities.

RESULTS

Trends

Table 1 summarizes trends in enrollments. As birth rates fell in Chile, school enrollments fell as well, but only in the public sector. Between 2002 and 2013, fourth grade enrollments fell by 43 percent in public schools, but grew by 8 percent in private voucher schools. One consequence is that class sizes declined in public schools. The number of public schools and classrooms did not fall as quickly as the number of public students, so the ratio of students to classrooms in the public sector fell from 31 to 26, while changing little in other sectors (Table 1a).

As public school enrollments fell, private voucher schools displaced public schools as the predominant school sector in Chile. In 2002, 54 percent of fourth graders were enrolled in public

[5] We did not lag other independent variables because there was no reason to think their effects would be delayed. For example, this year's fourth grade students would not be affected by last year's fourth grade class sizes or the educational attainment of last year's fourth grade parents.

schools and 39 percent were in private voucher schools. By 2013, these proportions had reversed: 39 percent of fourth graders were in public schools, and 53 percent were in private voucher schools. (The proportion in private non-voucher schools remained stable at 6 to 8 percent.) Yet over this period, the between-sector Herfindahl competition barely changed, from .55 to .56. That is because the between-sector Herfindahl index is not a strictly increasing function of the private voucher share; the Herfindahl index is a quadratic function of the shares of students in each of the three sectors, and agnostic as to which sector has the largest share. Because the sector shares were approximately the same in 2002 as in 2013—although the sector with the largest share changed—the between-sector Herfindahl index was approximately the same as well.

Measured at the national level, the Herfindahl index is an imperfect measure of competition. School competition is not national but local. A public school in a small town in south Chile, for example, competes with the private voucher school in the same town; it does not compete with private voucher schools in a large northern city, hundreds of kilometers away. To measure competition locally, we calculated sector shares separately for each municipality. Average within-municipality sector shares are graphed in Figure 2. Within municipalities, the average share of students in private voucher schools rose from 24 percent in 2002 to 36 percent in 2013, and the average Herfindahl index of competition between sectors rose from .305 in 2002 to .345 in 2013.

Private voucher schools did not just compete with public schools; they also competed with each other, and public schools competed with each other as well. To measure competition among individual schools, Figure 2 also plots the Herfindahl index of competition between schools. By this measure, within-municipality competition has flatlined in Chile, on average, starting at .78 in 2002 and finishing at the same level in 2013.

Another measure of between-school competition in Figure 2 is the average number of schools per student D, which rose, within municipalities, from an average of .029 in 2002 to .036

in 2013, with most of the rise between 2002 and 2005. We should keep in mind, though, that the number of schools per student rose primarily because the student population declined and not because the number of schools increased. So the rise does not necessarily mean that students in a given municipality had more schools to choose from.

Again, a consequence of declining public enrollments was reductions in public class sizes. Within municipalities, average class size fell from 21 in 2002 to 17 in 2013 (Figure 3). We have already seen that the decline was concentrated in public schools (Table 1).

Family resources changed at least as quickly as school competition (Figure 4). Across municipalities, the average percentage of fathers with some tertiary education increased from 12.5 to 18 percent, and the fraction of mothers with tertiary education increased even more, from 12.5 to 21 percent. The fraction of fathers with secondary education also increased, from 50 to 64 percent, and the fraction of mothers with secondary education increased even more, from 50 to 70 percent. Mean income increased from 200 to 400 thousand pesos per month—a doubling in nominal terms and a 50 percent increase after adjustment for inflation.[6] The Gini coefficient of income inequality declined from .45 to .415—a typical decline for a Latin American country in the 2000s (Lustig, López-Calva, and Ortiz-Juarez 2011). US readers may notice that recent income trends in Chile are opposite to trends in the US, where over the same period median family incomes have stagnated and income inequality has grown.

Figure 5 gives trends in academic performance. Between 2002 and 2013, mean scores on the SIMCE test increased by about 0.2 SD in math and 0.3 SD in reading, with all of the math increase coming after 2008 and most of the reading increase coming after 2007. The SD of test scores declined by 5 percent in math and by 2 percent in reading. Average GPAs did not change (except for a small spike in 2013), but the standard deviation of GPA declined by 17 percent.

[6] Our analyses did not adjust explicitly for inflation, which should be controlled implicitly by the inclusion of year fixed effects.

Average attendance rates declined by one percentage point, and the standard deviation of attendance rates increased by about the same amount.

Figure 7 gives trends in the correlations between incomes and different measures of academic performance. All the correlations are positive, implying that higher-income students outperform lower-income students, but the correlations change with time. The correlations between income and reading or math scores declined from .20 to .17, indicating that the test score gaps between low- and high-income students shrank slightly. The correlation between income and GPA bounced around from year to year, but ended at .18, which was approximately where it began. The correlation between income and attendance was very low, between .015 and .035 in every year.

Bivariate association between changes in explanatory variables and changes in test scores

What explained the increase in Chile's test scores? Was it increases in family resources, school resources, or school competition? Figure 8 addresses this question by graphing the average increase in test scores separately for municipalities for small, medium, or large changes in key measures of family resources, school resources, and school competition between 2002 and 2013.

Contrary to the school choice theory, score increases were not larger in municipalities with larger increases in the share of students attending private voucher schools. The upper left of Figure 8 breaks municipalities into three tertiles of change in the private voucher share. The highest tertile, where the private voucher share increased by 23 percentage points on average, saw score increases no larger than the lowest tertile, where the private share decreased by one percentage point on average.

Consistent with the school resource theory, score increases were larger in municipalities with larger decreases in class size. The lower right of Figure 8 divides municipalities into three tertiles of change in class size. The middle tertile, where class sizes shrank by 20 percent on average, had score increases about 0.15 SD larger than the bottom tertile, where average class sizes increased by 1 percent on average. The upper tertile, where class sizes shrank by 46 percent on average, had even larger score increases in reading, and comparable increases in math.

Consistent with the family resource theory, score increases were larger in municipalities with larger increases in parental education. The upper right of Figure 8 breaks municipalities into three tertiles of change in the percentage of mothers with secondary education. The highest tertile, where the percentage of mothers with secondary education grew by 28 percentage points, had score increases nearly 0.2 SD larger than the lowest tertile, where the percentage grew by only ten percentage points, and the middle tertile was in between. But the same pattern did not apply to family income. Instead, the highest tertile, where nominal family incomes increased by 152 percent on average, had score increases no larger than the lowest tertile, where incomes increased by 68 percent. So score increases were associated with increases in parental education but not in family income.

Fixed effects estimates

Figure 8 is suggestive, but it only addresses one explanatory variable at a time. If changes in some explanatory variables are correlated with changes in others, then the bivariate relationships in Figure 8 may be misleading. For example, between 2002 and 2013, the municipal-level correlation between the change in log class size and the changes in the percentage of parents with secondary education is about -0.3.[7] This is not surprising since more educated parents tend to have fewer children, and it suggests that to estimate the effect of class size, we need to control for parental education, and vice versa.

[7] A correlation matrix among changes in the independent and dependent variables appears in the Appendix.

Table 2 estimates the effects of changes in the explanatory using a fixed effects model that incorporates all the explanatory variables at once.

Effects on mean test scores

What stand out immediately in Table 2 are the large coefficients for the percentages of fathers and mothers with secondary education. These coefficients average about 0.4, implying that if the percentages of fathers and mothers with secondary education rose from 0 to 100 percent, children's math and reading scores would rise by about .8 SD (=.4 because of fathers + .4 because of mothers). Although the percentages of parents with secondary education did not rise by 100 percentage points, it did rise by 14 points for fathers and 20 points for mothers between 2002 and 2013 (Figure 4), and these increases together would predict an increase in average test scores of about .13 SD in math and .14 SD in reading (≈.4*(.14+.20)). The predicted increase is about half of the increase that was actually observed in reading scores over this period, and about two-thirds of the increase that was observed in math (Figure 5).

In contrast to parents' secondary education, the effects of parents' *tertiary* education were not statistically. The estimated coefficients of tertiary education were not trivial in size, at least for math, but when multiplied by the increases in tertiary education, which are small compared to increases in primary education, the coefficients predict only a .02 SD rise in math scores[8] and a .01 SD rise in reading scores. The effects of family income and income inequality are also nonsignificant and trivial in size.

In short, it appears that at least half of the increase in Chile's test scores can be explained by increases in parents' secondary education, but not by increases in tertiary education or income.

[8] The math coefficients of .15 and .18 for fathers' and mothers' tertiary education imply that if the percentages of parents with tertiary education were to rise from 0 to 100%, children's test scores would be expected to rise by.33 SD (=.15+.18). But in fact, the percentages of parents with secondary education only rose by 6 points for fathers and 8 points for mothers. These increases predicts an increase in average math scores of just .02 SD (=.15*.06+.18*.08). The implied increase in reading scores is even smaller because the coefficients are smaller.

The effect of logged class size was highly significant, but small. The coefficient was -.10 for mean and reading scores, implying that each 10 percent reduction in class size would predict a .01 SD increase in mean scores. In fact, average class size fell by about 20 percent between 2002 and 2013, implying a .02 SD increase in test scores—about one tenth of the increase that was observed in math, and less of the increase in reading.

Competition had no significant effect on reading or math scores. This was true no matter how we defined competition. Table 2a estimates the effect of competition as defined by the fraction of students in private voucher schools, while Table 2b-d refit the same model with different measures of competition substituted: the Herfindahl index between sectors, the Herfindahl index between schools, and the number of schools per student. Under every definition, the coefficient of competition was not statistically significant, and trivial in size. Each model in Table 2 uses the same covariates except for the measure of competition; the coefficients of other covariates barely change from one model to another. Table A 3 and Table A 4 in the Appendix give results for an alternative specification that lags the effect of competition by one year. The results were not materially different.

In short, contrary to some popular accounts, it appears that the growth of Chile's choice system is not responsible for the rise in Chile's average test scores. Instead, about half the rise in test scores is due to increases in parental education.

Effects on GPA and attendance

Both class size and parents' secondary education have about the same effect on GPA as they do on test scores. The coefficients are half as large for GPA as they are for test scores, but if GPA were standardized (as test scores are), the GPA coefficients would double[9] and equal the coefficients for test scores.

[9] GPA has an SD of .5 but if standardized it would have an SD of one.

Like test scores, GPA did not increase with school competition. Three different measures of competition had no significant effect on GPA. A fourth measure of competition (the between-sector Herfindahl index) had a marginally significant coefficient (p<.10) but was trivial in size. The coefficient was .10 which, when multiplied by the 2002-2013 increase in the Herfindahl index (.04), would imply an increase in mean GPA of just .004. The non-effect of competition on GPA is remarkable since grades are easier to inflate than test scores. It would not be surprising if schools responded to competition by inflating grades—but this is not what happened.

Attendance was significantly affected by several variables, including competition, but the effects were trivial in size. Consider the effect of competition as measured by the share of children in private voucher schools. The coefficient of .02, if multiplied by the .1 increase in the voucher share, would predict an increase in attendance of .002, or 0.2 percent. In Chile's 190-200 day school year, this would amount to less than half a day of additional attendance. Other variables' effects on attendance were just as small. Neither attendance not GPAs improved in Chile between 2002 and 2013 (Figure 6).

Effects on inequality

Chile did not just experience increases in average academic performance; it also experienced declines in academic inequality. The SDs of grades and test scores declined by 3 to 5 percent (Figure 5), and so did the correlations between test scores and income (Figure 7).

What explains these declines in academic inequality? Table 2 suggests that rising parental education played a role. The fraction of fathers with secondary education had a significant and negative effect on the SD of math scores, and the fraction of mothers with secondary education had a significant and negative effect on the SD of reading scores. Together, increases in parents' secondary education could explain a 2 percent decline in the SD of math scores (two-fifths of the total decline) and a 3 percent decline in the SD of reading scores (essentially all of the decline observed between 2002 and 2013). Increases in tertiary education, by contrast, had no significant effect on the SD.

The Gini coefficient of income inequality had a significant but small effect on the SD of reading scores. The coefficient was positive, as expected, suggesting that a decrease in the Gini causes a decrease in the SD of reading scores. But the size of the coefficient (.10), when multiplied by the decline in the Gini (.04), explained only a fifth (.004) of the observed decline in the SD of reading scores (.02). The effect of the Gini on the SD of *math* scores was similar, except that the coefficient was not significant. Other measures of family resources and school resources—i.e., class size and mean family income—had no significant effect on the SD of test scores.

Among the four competition measures, only one had a significant effect on the SD of math scores, and only one competition measure (not the same one) had a significant effect on the SD or reading scores. In both cases the coefficient was positive, suggesting that increasing competition increased the SD.

Another measure of inequality is the correlations between income and different academic outcomes (test scores, GPA, attendance). We predicted changes in these correlations using our fixed effects model as well (Table 3). While changes in some independent variables were associated with changes in the correlations between incomes and GPA or test scores, the coefficients were modest in size. Class size had significant positive coefficients, implying that decreases in class size were associated with decreases in the correlation between income and math scores, GPA, and attendance (though not reading scores). The effect size of 0.05 was quite small, though, implying that the 20 percent reduction in class sizes that occurred over 2002-2013 would cause just a .025 decrease in the correlation between income and academic success.

The fraction of mothers with some tertiary education also had a significant effect on the correlation between test scores and income, but again the effect size was small. The coefficient of 0.3 implied that the nine percentage point increase in the fraction of mothers with tertiary education—which is what occurred between 2002 and 2013—would predict just a .03 increase in the correlation between income and achievement.

Increases in the log of mean family income were associated with reductions in income's correlation with GPA and attendance. The effect sizes of -.05 to -.06 were small, though, implying that the 50 percent increase in mean real income that occurred in 2002-2013 would predict just a .02 reduction in income's correlation with attendance ($-.05 \times ln(1.5)$).

Changes in the Gini coefficient of inequality were also associated with changes in income's correlation with test scores and GPA (but not attendance). The effect is negative, though, suggesting that a higher Gini coefficient predicts a lower correlation between income and achievement. The typical effect size of -.36 is modest, implying that the .04 decrease in the Gini that occurred in 2002-2013 would predict about a .014 increase in income's correlation with test scores and GPA.

CONCLUSION

Chile has the largest system of private school choice in the world, and the fastest-rising test scores in Latin America. This has understandably led many observers to conclude that Chile's choice system is responsible for its high test scores.

But our results suggest that this is not the case. The Chilean municipalities that have experienced the greatest growth in school choice have not experienced above average growth in test scores. Our results show this for the period 2002-2013, and earlier research produced similar results for the period 1982-1996 (Hsieh and Urquiola 2006). While there are eight years that have not been studied (1997-2001 and 2014-2017), it may be that the four-decade expansion of Chile's voucher system, from its start in 1981 until the present, has not raised test scores.

So why have Chile's test scores risen? Class size reduction has played a small role. The municipalities with greater reduction in class sizes have experienced greater increases in tests scores, but class size reductions explain only about a tenth of the rise in Chile's math scores, and less of the rise in reading scores. More of the rise is due to increases in parental education. The modernization of Chile's economy has increased the incentives for young people to complete their education, and since the early 2000s Chile has instituted major reforms to help poor youth complete high school and college. As a result, since 2002, the percentage of fourth graders whose mothers have secondary education has increased by 20 percentage points, and the percentage whose fathers have secondary education has increased by 14 points. Chilean municipalities with faster increases in parents' secondary education have experienced faster rises in test scores. Our estimates suggest that increases in parents' secondary education explain about half of the rise in Chile's reading scores, and two-thirds of the rise in math scores. Parents' secondary education is the most important parental resources; net of secondary education, increase in parents' tertiary education and incomes have not increased children's test scores.

In a sense, these results replicate the classic finding that children's test scores are strongly correlated with their parents' education (Coleman et al. 1966). But our results are more hopeful. The classic finding is often viewed as depressing (Grant 1973), since in the US it is often assumed that not much can be done about parents' education levels, and there is concern that increasing parents' education might have disappointing effects if, in fact, education is mainly a proxy for other parental endowments. Our results are more hopeful, suggesting that major policy investments can increase parental education, and that substantial increases in children's test scores can follow. There may be less room to increase educational attainment in the US than in a developing country like Chile, but some progress can be made. Efforts to increase adolescents' educational attainment may have a substantial return on investment if we include their effects on the next generation.

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TABLES

Table 1. Fourth grade enrollments in public, private voucher, and private non-voucher schools in 328 Chilean municipalities

a. Counts

	Public				Private voucher				Private non-voucher			
Year	Schools	Classrooms	Students	Students /classroom	Schools	Classrooms	Students	Students /classroom	Schools	Classrooms	Students	Students /classroom
2002	2,992	4,987	153,657	31	2,097	3,353	112,827	34	426	790	19,219	24
2005	2,855	4,466	128,674	29	2,337	3,612	116,704	32	359	665	16,496	25
2006	2,779	4,243	121,948	29	2,351	3,628	117,653	32	357	657	16,451	25
2007	2,726	4,084	115,414	28	2,398	3,653	117,703	32	365	671	16,475	25
2008	2,693	3,986	110,590	28	2,455	3,712	119,248	32	366	671	16,565	25
2009	2,550	3,745	102,802	27	2,455	3,696	118,469	32	369	681	16,690	25
2010	2,624	3,747	101,914	27	2,517	3,843	124,138	32	372	705	17,824	25
2011	2,502	3,519	93,576	27	2,515	3,828	121,500	32	374	712	17,895	25
2012	2,487	3,439	91,714	27	2,550	3,865	122,734	32	374	720	17,944	25
2013	2,492	3,361	88,157	26	2,558	3,864	122,250	32	375	738	18,394	25

b. Shares of students

Year	Public schools	Private voucher schools	Private non-voucher schools	Competition between sectors (=1 – Herfindahl index)
2002	54%	39%	7%	.55
2005	49%	45%	6%	.56
2006	48%	46%	6%	.56
2007	46%	47%	7%	.56
2008	45%	48%	7%	.56
2009	43%	50%	7%	.56
2010	42%	51%	7%	.56
2011	40%	52%	8%	.56
2012	39%	53%	8%	.56
2013	39%	53%	8%	.56

Table 2. Effects on scores, grades, and attendance, 2002-2013.

a. Model 1, which codes competition as the voucher share

	Dependent variables							
	Math scores		Reading scores		GPA		Attendance	
Independent variables	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Ln of mean family income	-.02	-.00005	-.02	-.002	-.03	.01	-.004*	.01*
	(.03)	(.01)	(.03)	(.01)	(.02)	(.01)	(.002)	(.002)
Gini of family income	.03	.02	.08	.10*	.16*	-.04	.01+	-.01
	(.10)	(.03)	(.09)	(.04)	(.07)	(.03)	(.01)	(.01)
Fraction of fathers with secondary education	.37**	-.10**	.30**	.06	.18**	-.06	.02**	-.02*
	(.12)	(.04)	(.10)	(.06)	(.06)	(.04)	(.01)	(.01)
Fraction of mothers with secondary education	.41**	-.03	.49***	-.18**	.24***	-.10*	.01	-.01
	(.13)	(.04)	(.10)	(.06)	(.06)	(.05)	(.01)	(.01)
Fraction of fathers with tertiary education	.15	.13	.04	.02	.002	.01	-.04***	.03**
	(.19)	(.08)	(.14)	(.07)	(.11)	(.06)	(.01)	(.01)
Fraction of mothers with tertiary education	.18	.04	.05	.02	-.09	.16**	-.02+	.004
	(.19)	(.08)	(.13)	(.07)	(.11)	(.06)	(.01)	(.01)
Ln of mean class size	-.10***	.02	-.10***	-.0005	-.04*	.01	-.002	.001
	(.03)	(.01)	(.03)	(.01)	(.02)	(.01)	(.002)	(.002)
Competition =	-.05	-.01	-.02	-.02	-.02	.02	.02**	.004
Fraction of students in private voucher schools	(.07)	(.03)	(.06)	(.03)	(.05)	(.02)	(.01)	(.01)
R^2 (within municipalities)	.43	.29	.54	.10	.07	.37	.24	.04
Number of municipalities	328	328	328	328	328	328	328	328

b. Alternative models, same covariates, with competition coded different ways

Model 2

	Math scores		Reading scores		GPA		Attendance	
Competition variable	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Herfindahl index, between sectors	.08	.02	.04	.07*	.10+	-.05**	.02***	-.01*
	(.06)	(.03)	(.05)	(.03)	(.05)	(.02)	(.01)	(.01)

Model 3.

Herfindahl index, between schools	.04	.08*	.05	-.01	.01	.03	.01*	-.002
	(.09)	(.04)	(.05)	(.04)	(.05)	(.02)	(.01)	(.01)

Model 4.

Schools per student (X 10)	-.0005	.05	.03	-.04	.04	.01	.01	-.002
	(.08)	(.03)	(.06)	(.03)	(.05)	(.02)	(.01)	(.01)

*+p<.10, *p<.05, **p<.01, ***p<.001*. Longitudinal regressions with fixed effects for municipalities and years. The unit of analysis is the municipality-year, and standard errors are clustered by municipality. Data come from two data sets maintained by Chile's Ministry of Education: (1) the Student Performance data set for GPA and attendance and (2) the National Measurement System for Education Quality (SIMCE) for other variables.

Table 3. Effects on the correlations of income with scores, grades, and attendance, 2002-2013

a. Model 1, which codes competition as the voucher share

	Correlation of income with			
Independent variables	Math	Reading	GPA	Attendance
Ln of mean family income	-.04	-.02	-.06**	-.05*
	(.03)	(.02)	(.02)	(.02)
Gini of family income	-.34***	-.30***	-.44***	-.10
	(.08)	(.08)	(.07)	(.08)
Fraction of fathers with secondary education	-.08	-.12	-.08	-.01
	(.08)	(.09)	(.09)	(.10)
Fraction of mothers with secondary education	.02	.08	.01	.02
	(.07)	(.06)	(.07)	(.08)
Fraction of fathers with tertiary education	.05	.11	.07	-.05
	(.13)	(.13)	(.10)	(.09)
Fraction of mothers with tertiary education	.29*	.27+	.40***	.33**
	(.13)	(.14)	(.11)	(.10)
Ln of mean class size	.05*	.01	.05**	.05**
	(.02)	(.02)	(.02)	(.02)
Competition =	.05	.06	.06+	-.02
Fraction of students in private voucher schools	(.04)	(.04)	(.03)	(.05)
R^2 (within municipalities)	.07	.06	.09	.03
Number of municipalities	328	328	328	328

b. Alternative models, same covariates, with competition coded different ways

Model 2

	Correlation of income with			
Competition variables	Math	Reading	GPA	Attendance
= 1 – between-sector Herfindahl index	.02	.06	-.02	-.02
	(.04)	(.05)	(.03)	(.05)

Model 3.

= 1 – between-school Herfindahl index	-.04	-.02	-.03	.04
	(.05)	(.05)	(.05)	(.06)

Model 4.

Schools per student (X 10)	-.09+	-.06	.003	.03
	(.05)	(.06)	(.06)	(.06)

*+p<.10, *p<.05, **p<.01, ***p<.001*. Longitudinal regressions with fixed effects for municipalities and years. The unit of analysis is the municipality-year, and standard errors are clustered by municipality. Data come from two data sets maintained by Chile's Ministry of Education: (1) the Student Performance data set for GPA and attendance and (2) the National Measurement System for Education Quality (SIMCE) for other variables.

FIGURES

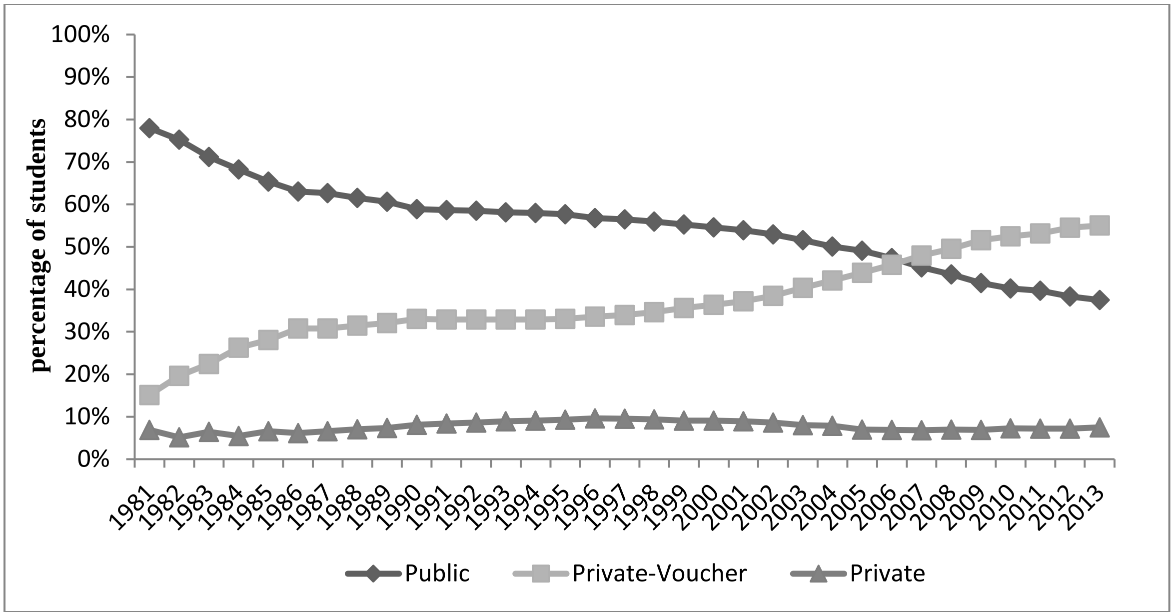

Figure 1. Primary and Secondary Enrollment, 1981-2003 (reprinted from Hofflinger 2015)

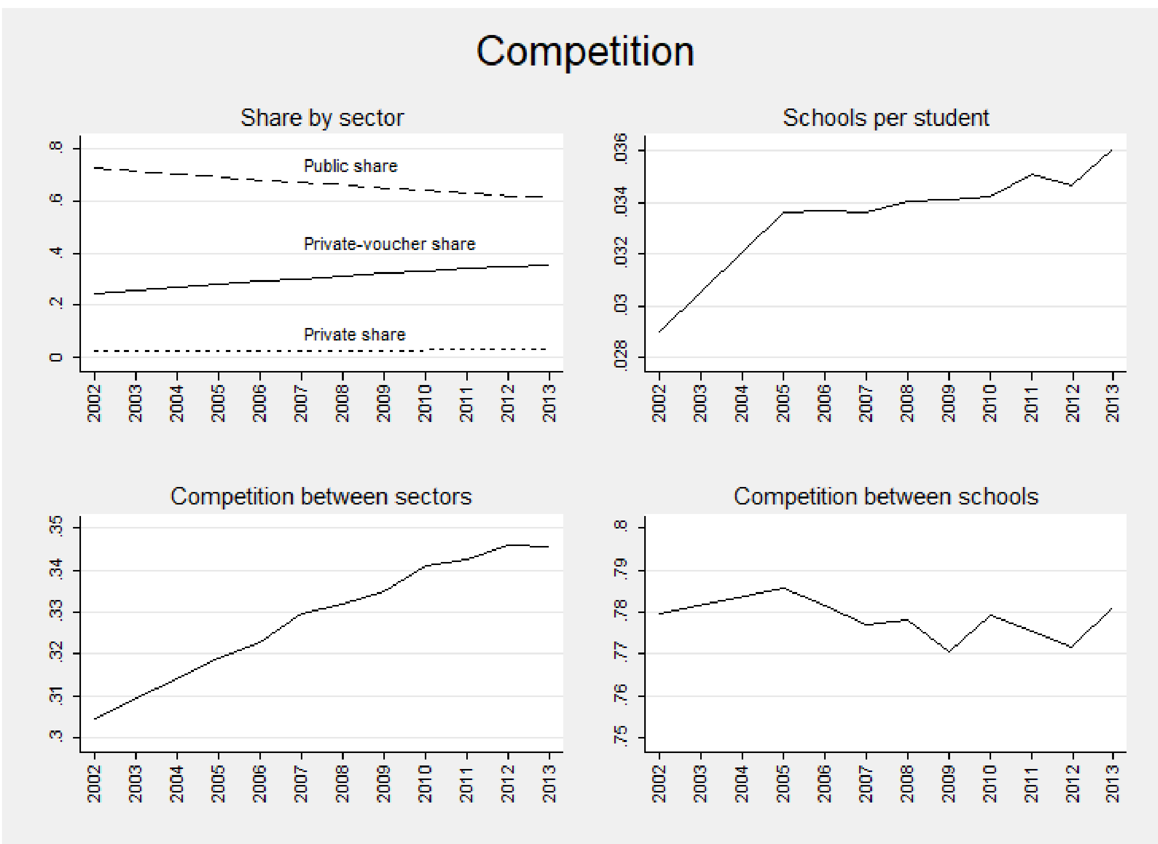

Figure 2. Within-municipality trends in competition between schools and school sectors.

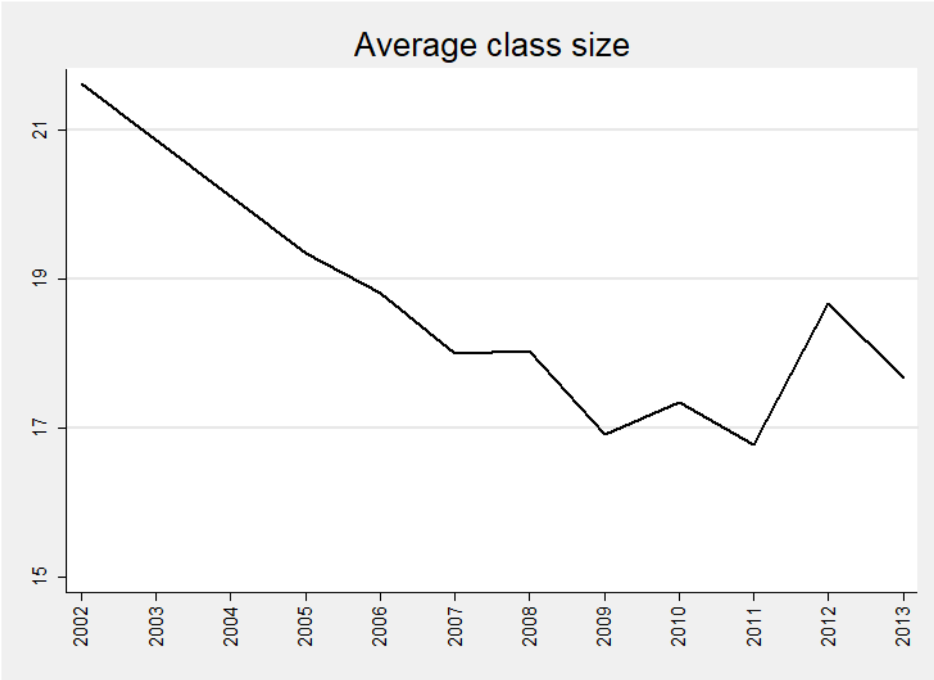

Figure 3. Trend in average class size

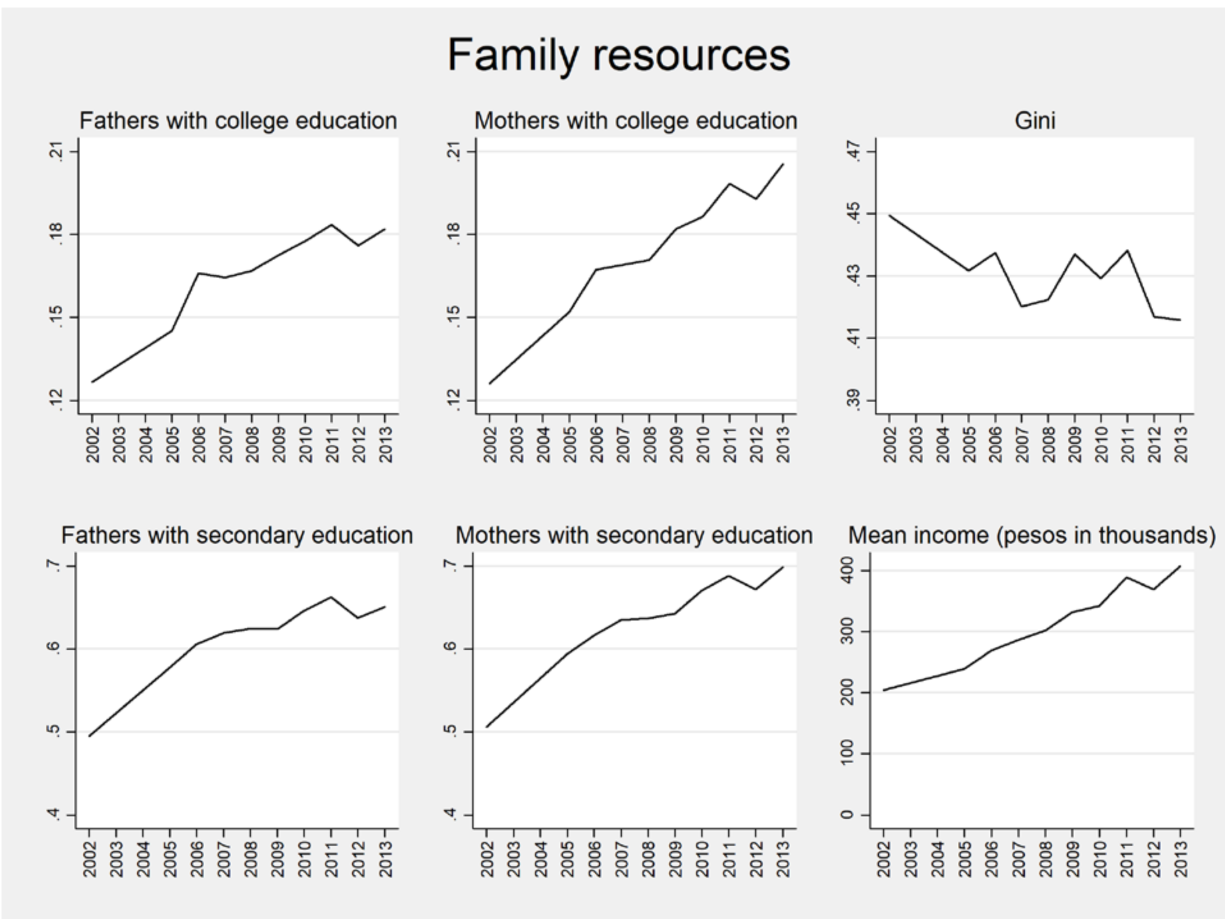

Figure 4. Trends in family resources: parental education, mean income, and income inequality.

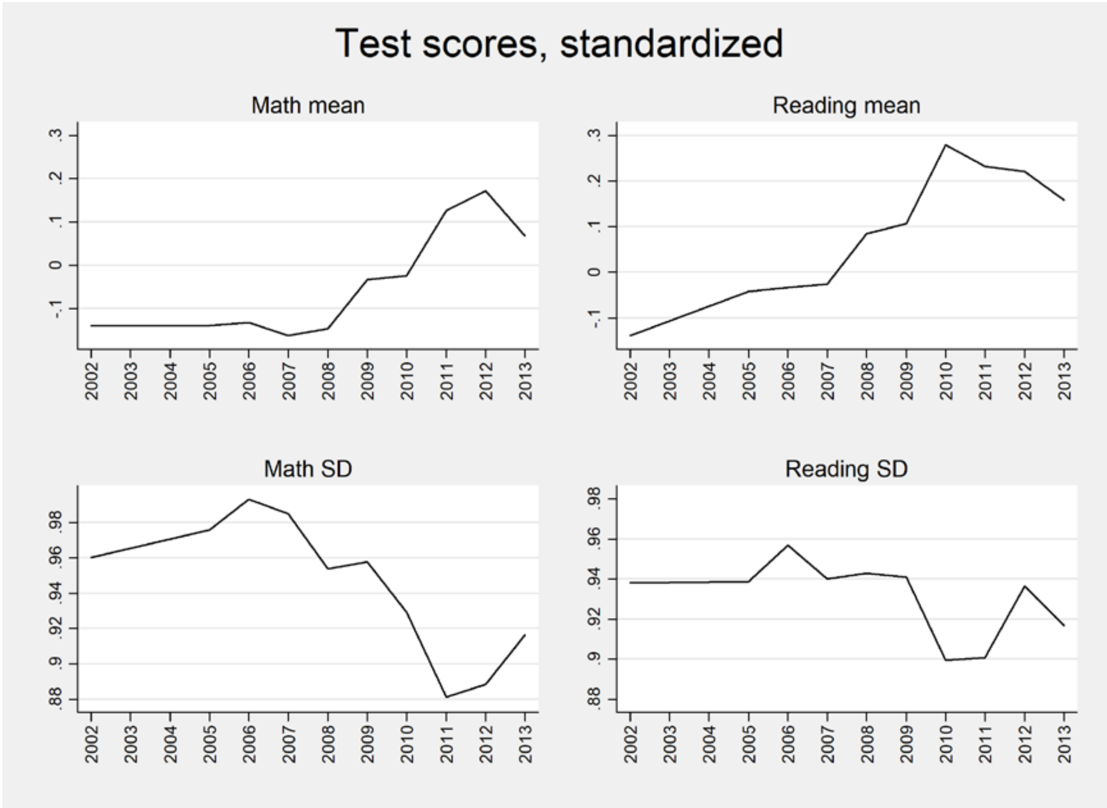

Figure 5. Trends in the mean and standard deviation of test scores.

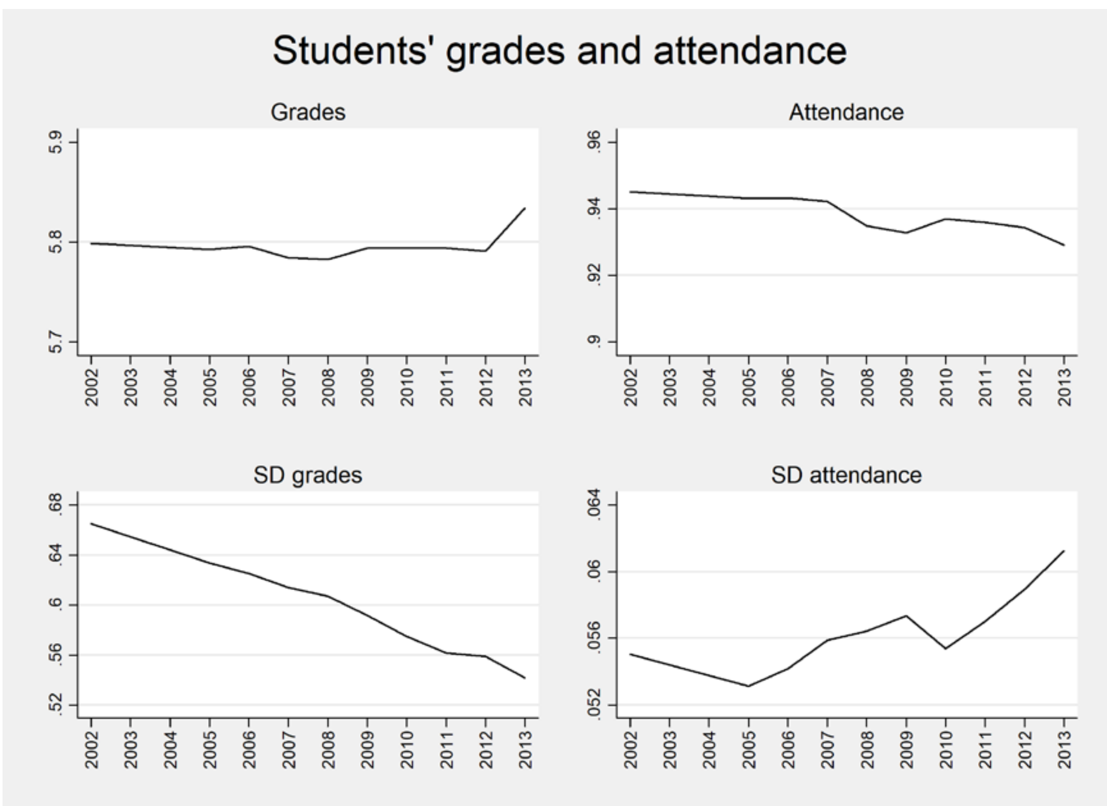

Figure 6. Measures of school performance.

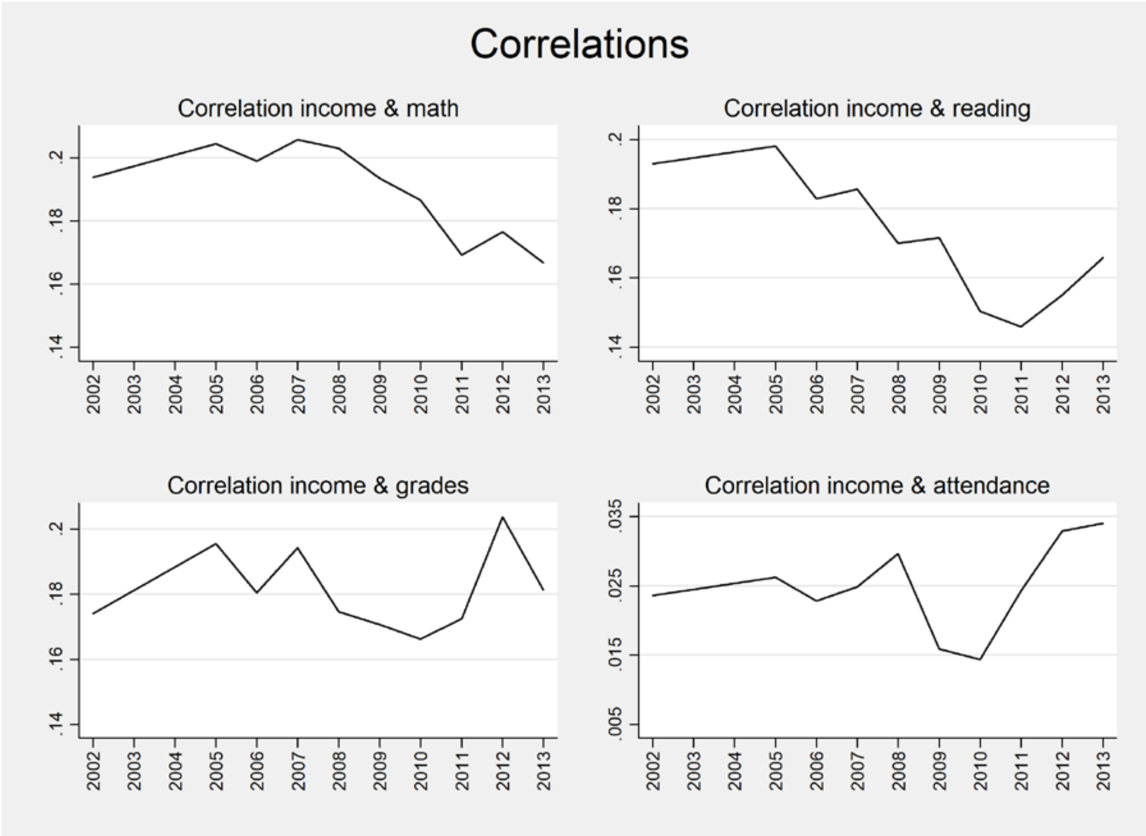

Figure 7. Trends in correlations with income.

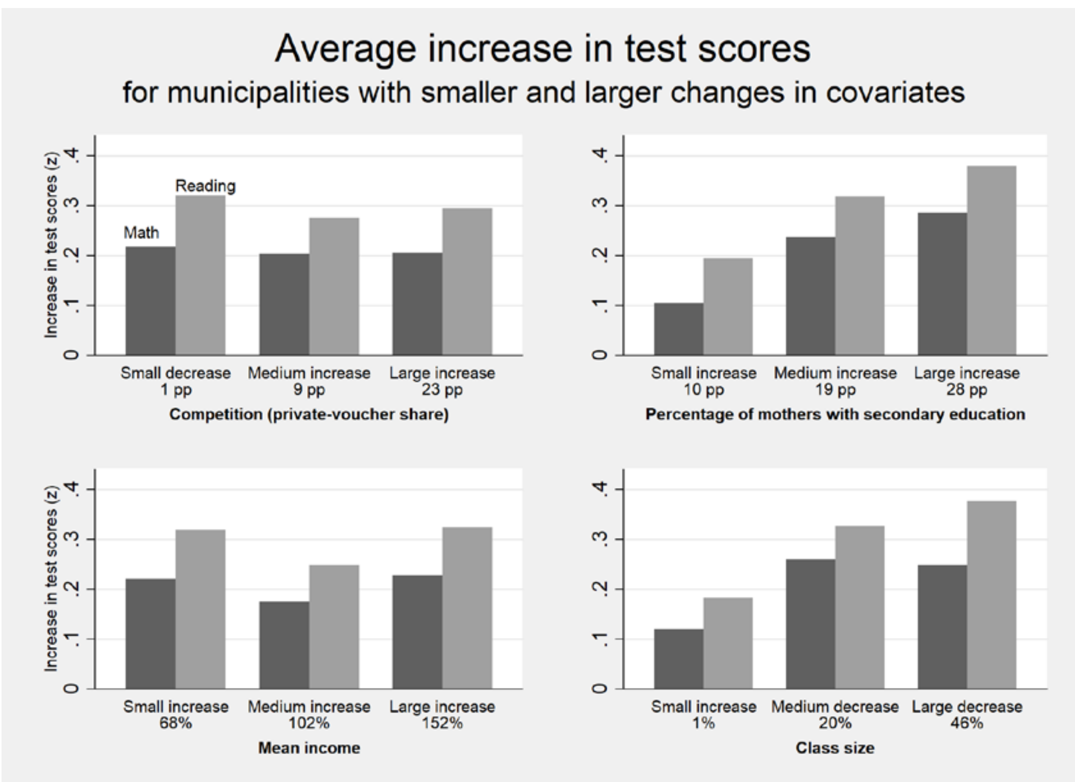

Figure 8. Average increase of test scores by municipality for municipality tertiles with smaller and larger changes in covariates, 2002 to 2013. pp=percentage points

APPENDIX

Table A 1. Key events and statistics in Chilean history

	Military dictatorship (1973-1989)		**Democratic period (1990-present)**					
	1973	1981	1990	2000	2002	2003	2005	2013
School competition	Military coup	National school voucher system begins						
School resources					Education spending: 4% of GDP			Education spending: 5% of GDP
Family resources	Birth rate: 27 per thousand		Poverty rate: 39% GDP per capita: US $4,507	Fellowships for students to finish high school		Government makes high school completion mandatory	Government guarantees college loans for low income students	Poverty rate: 8% GDP per capita: US $22,578 Birth rate: 13 per thousand

Table A 2. Correlations among changes in independent and dependent variables at the municipal level from 2002 to 2013

	1)	2)	3)	4)	5)	6)	7)	8)	9)	10)	11)	12)	13)	14)	15)	16)	17)	18)	19)
1) Math scores (mean)	-																		
2) Math scores (SD)	-.24	-																	
3) Reading scores (mean)	.84	-.21	-																
4) Reading scores (SD)	-.22	.36	-.23	-															
5) GPA (mean)	.22	-.04	.23	.06	-														
6) GPA (SD)	-.20	.18	-.23	.22	-.50	-													
7) Attendance (mean)	.21	-.15	.24	-.03	.39	-.27	-												
8) Attendance (SD)	-.13	.06	-.12	.00	-.18	.29	-.72	-											
9) Ln of mean family income	.07	.01	.06	.07	.03	.00	-.13	.08	-										
10) Gini of family income	.02	.11	.01	.13	.04	.09	-.02	.09	.52	-									
11) Fraction of fathers with secondary education	.35	-.14	.39	-.01	.29	-.20	.20	-.11	.25	-.04	-								
12) Fraction of mothers with secondary education	.36	-.08	.40	-.06	.29	-.25	.18	-.11	.14	-.17	.74	-							
13) Fraction of fathers with tertiary education	.03	.06	.03	-.07	-.03	.03	-.12	.09	.40	.17	.05	-.06	-						
14) Fraction of mothers with tertiary education	.03	.06	.00	-.07	-.16	.11	-.21	.13	.38	.15	.01	.07	.62	-					
15) Ln of mean class size	-.20	.12	-.34	-.02	-.29	.23	-.25	.11	.00	-.02	-.25	-.33	.26	.23	-				
Competition																			
16) Fraction of students in private voucher school	-.04	.01	-.05	-.07	-.11	.05	-.03	.07	-.02	-.03	-.04	-.08	.09	.15	.26	-			
17) Herfindahl index, between sectors	.07	-.05	.08	.04	.14	-.20	.13	-.07	.00	-.11	.19	.18	-.13	-.08	-.04	.46	-		
18) Herfindahl index, between schools	-.10	.16	-.17	.14	-.09	.19	-.07	.09	-.10	-.03	-.25	-.22	-.05	-.05	.17	.26	.27	-	
19) Schools per student	-.08	.09	-.04	.09	.06	-.01	-.01	.01	-.05	-.02	-.02	.03	-.19	-.22	-.28	-.03	.03	.34	-

Note: To measure change, we subtracted the 2002 value from the 2013 value, and then we calculated correlations among the changes between independent and dependent variables.

Table A 3. Models with competition lagged by one year: Effects on scores, grades, and attendance, 2005-2013

a. Model 1, which codes competition as the voucher share

	Dependent variables							
	Math scores		Reading scores		GPA		Attendance	
Independent variables	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Ln of mean family income	.004	-.003	.003	-.01	-.03	.02+	-.004+	.01*
	(.03)	(.01)	(.03)	(.01)	(.02)	(.01)	(.002)	(.002)
Gini of family income	-.03	.02	.02	.11**	.17*	-.06+	.01	-.02+
	(.12)	(.03)	(.10)	(.04)	(.08)	(.03)	(.01)	(.01)
Fraction of fathers with secondary education	.37**	-.10**	.28**	.05	.15*	-.04	.01*	-.01*
	(.13)	(.04)	(.10)	(.06)	(.07)	(.04)	(.01)	(.01)
Fraction of mothers with secondary education	.39**	-.03	.44***	-.19**	.23***	-.10+	.01	-.01
	(.14)	(.04)	(.11)	(.07)	(.06)	(.05)	(.01)	(.01)
Fraction of fathers with tertiary education	.11	.14+	.03	.07	.01	-.002	-.03***	.03*
	(.21)	(.09)	(.15)	(.08)	(.11)	(.06)	(.01)	(.01)
Fraction of mothers with tertiary education	.13	.04	.03	.04	-.07	.14**	-.01	-.001
	(.20)	(.08)	(.13)	(.07)	(.11)	(.05)	(.01)	(.01)
Ln of mean class size	-.13***	.004	-.09**	-.004	-.01	-.003	.001	-.004
	(.04)	(.01)	(.03)	(.01)	(.02)	(.01)	(.005)	(.005)
Competition	.01	-.04	.03	-.05+	.004	.01	.01	.001
= Fraction of students in private voucher schools	(.07)	(.03)	(.06)	(.03)	(.05)	(.02)	(.005)	(.005)
R^2	.43	.32	.49	.12	.06	.30	.23	.05

b. Alternative models, same covariates, with competition coded different ways

Model 2

	Math scores		Reading scores		GPA		Attendance	
Competition variable	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Herfindahl index, between sectors	.05	.01	.03	.03	.07	-.02	.01**	-.003
	(.06)	(.03)	(.05)	(.02)	(.04)	(.02)	(.005)	(.005)

Model 3.

Herfindahl index, between schools	-.05	-.07	-.01	-.05+	.008	-.02	.002	-.004
	(.08)	(.03)	(.06)	(.02)	(.05)	(.03)	(.005)	(.005)

Model 4.

Schools per student (× 10)	-.22*	.01	-.07	.01	.01	-.02	.004	-.001
	(.09)	(.03)	(.07)	(.03)	(.04)	(.03)	(.006)	(.004)

+p<.10, *p<.05, **p<.01, ***p<.001. This table is like Table 2, except that here we have lagged the competition measures by one year.

Table A 4. Models with competition lagged by one year: Effects on the correlations of income with scores, grades, and attendance, 2005-2013

a. Model 1, which codes competition as the voucher share

	Effects on correlation of income with…			
Independent variables	Math	Reading	GPA	Attendance
Ln of mean family income	-.03	-.02	-.06**	-.06*
	(.02)	(.02)	(.02)	(.03)
Gini of family income	-.37***	-.33***	-.41***	-.08
	(.09)	(.08)	(.07)	(.08)
Fraction of fathers with secondary education	-.07	-.15+	-.05	.02
	(.09)	(.09)	(.09)	(.11)
Fraction of mothers with secondary education	-.02	.07	-.01	.01
	(.07)	(.06)	(.07)	(.08)
Fraction of fathers with tertiary education	.10	.14	.09	-.04
	(.13)	(.14)	(.11)	(.10)
Fraction of mothers with tertiary education	.25+	.30*	.31**	.28*
	(.13)	(.15)	(.12)	(.11)
Ln of mean class size	.05*	.03	.05+	.05*
	(.03)	(.03)	(.02)	(.02)
Competition	.02	-.01	.01	.003
= Fraction of students in private voucher schools	(.05)	(.04)	(.05)	(.05)
R^2	.22	.19	.15	.13

b. Alternative models, same covariates, with competition coded different ways

Model 2

	Effects on correlation of income with…			
	Math	Reading	GPA	Attendance
= 1 – between-sector Herfindahl index	.05	.04	.04	-.01
	(.05)	(.05)	(.05)	(.05)

Model 3.

= 1 – between-school Herfindahl index	.06	-.01	.04	.11
	(.06)	(.06)	(.07)	(.09)

Model 4.

Schools per student (× 10)	.01	-.001	.04	.13*
	(.05)	(.05)	(.06)	(.06)

+p<.10, *p<.05, **p<.01, ***p<.001. This table is like Table 3, except that here we have lagged the competition measures by one year.