Centralized Admission Systems and School Segregation: Evidence from a National Reform*

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Abstract

This paper investigates whether centralized admissions systems can alter school segregation. We take advantage of the largest school-admission reform implemented to date: Chile's SAS, which in 2016 replaced the country's decentralized system with a Deferred Acceptance algorithm. We exploit its incremental implementation and employ a Difference-in-Difference design. Using rich administrative student-level records, we find the effect of SAS critically depends on pre-existing levels of residential segregation and local school supply. For instance, districts with prominent provision of private education experience an uptick in school segregation due to SAS. Migration of high-SES students to private schools emerges as a key driver.

Keywords: Education, Inequality, Segregation.

JEL classification: I20, I24, I28.

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1 Introduction

All over the world, governments are increasingly adopting centralized school admission systems to coordinate students' assignment to schools. Amsterdam, Boston, Chicago, New York, Antwerp (Belgium), French Community (Belgium), Finland, Hungary, England, France, Tunisia, Ghana, and Seoul have implemented versions of these mechanisms. Also, pilot programs have been initiated recently in Ecuador, Peru, and Pernambuco (Brazil), among others. These innovations are expected to improve upon existing decentralized mechanisms by increasing efficiency and welfare.

As illustrated by Gale and Shapley (1962), Abdulkadiroğlu and Sönmez (2003), Erdil and Ergin (2008) and Ashlagi and Nikzad (2016), in theory, centralized school allocation systems ensure stable and strategy-proof matching of students and educational institutions. Policymakers, in turn, have implemented and adapted these mechanisms seeking to promote diversity within educational systems. For instance, the high school allocation algorithm used in the cities of New York and Boston allows for a special priority for minority students. However, a more efficient and welfare-enhancing theoretical allocation might not lead to less segregated institutions in practice (Pathak, 2011; Abdulkadiroglu, 2013).

School segregation is critical as it affects students through multiple channels. It impacts the process of human capital formation both in the short- and long-term. The literature provides evidence of these effects. School desegregation policies in the United States have resulted in better educational outcomes for minority groups as reflected by higher academic achievement, lower drop out rates, and higher graduation percentages (Boozer et al., 1992; Guryan, 2004; Hanushek et al., 2009; Johnson, 2011). Additionally, effective desegregation has reduced deviant behavior (Weiner et al., 2009), improved health and labor market outcomes (Crain and Strauss, 1985; Ashenfelter et al., 2006). Other researchers have shown comparable results on segregation for OECD countries (Kristen, 2003; Vandenberge, 2006; Baysu and de Valk, 2012). This body of evidence is relevant even for developing countries as one of the impending challenges for them has been the increasing levels of stratification in school (Epple et al., 2017).

This paper investigates the adoption of a centralized allocation algorithm, named as School Admission System (SAS), on school segregation in Chile. While previous research has focused on the demand side of school assignment (Pathak and Sönmez, 2013; Lucas and Mbiti, 2014; Calsamiglia and Güell, 2018), we examine supply-side implications. The Chilean government put into effect a Deferred Acceptance (DA) mechanism in 2016 as the central component of a major education reform, which aimed at promoting social inclusion and reducing school segregation.[1]

[1] Hsieh and Urquiola (2006) and Epple et al. (2017) suggest that the Chilean voucher system has increased school segregation as it led to a disproportionate flight of better-off students from public to voucher schools. This led to an overcrowding of students from low socioeconomic status in public schools. More recently, even though Chile has consistently implemented initiatives to ensure better representation of students from all sections of the economic

The identification strategy follows a Difference-in-Difference approach. We exploit geographic variation as well as the sequential implementation of the new admission system to quantify its impact on school segregation. We conduct the empirical analysis using rich administrative data containing student-level information before and after the reform. Any concerns regarding the parallel trends assumption are alleviated using a series of falsification tests.

Our outcome of interest is a dissimilarity indicator, namely the Duncan index, as it is one of the commonly used constructs in the school segregation literature (Duncan and Duncan, 1955). This index measures the unevenness of schools' socioeconomic distribution compared to the community (school district). If the index equals to 0 (1), it suggests no (complete) segregation. In our setting, it can be interpreted as the share of students within a district that would have to be reassigned across schools to achieve an even distribution of a specific socioeconomic dimension, such as, parents' education level or family income. Within this set, we focus on mother's education, which is an important determinant of schooling outcomes (Carneiro et al., 2013) and has been previously used as an indicator of socioeconomic status (McLanahan, 2004; Gallego et al., 2008).

We gather data from the universe of students for the period 2015-19. Our analysis focuses on the ninth-graders (approximately 250,000 individuals each year). This is because almost 50% of the eighth-graders participated in SAS every year since its inception for ninth grade admissions.[2] Apart from high participation in SAS, in order to measure school segregation, we require the student's background information to construct the dissimilarity index. Their socioeconomic information is obtained from an array of previous standardized test files in Chile, and since ninth-graders are already part of the education system, we can match them with previous test files.[3] Additionally, related research has shown that segregation in high schools is more pronounced in Chile than primary school (Valenzuela et al., 2014; Torche, 2005). Therefore, the analysis of ninth-graders informs about the implications of the reform on high school segregation.

On average, we do not find a statistically significant impact of SAS on school segregation. However, this result masks considerable and systematic heterogeneity across regions and local school districts (municipalities). Specifically, we examine heterogeneous effects by residential segregation and pre-program school supply. We find that this algorithm in Chile reduced (increased) within-school integration of students from low socioeconomic backgrounds in areas with high (low) levels of existing residential segregation.

Chile already had an existing structure of public, voucher, and private schools in place be-

strata within schools (e.g., targeted vouchers), to a large extent these efforts have not fulfilled the expectations.

[2]Participation in SAS is mandatory to students switching schools. Thus, since the ninth grade is the first year of high school, eight graders attending schools not offering that level are forced to participate in the program.

[3]The students seeking admission to the ninth grade between 2016 to 2018 are matched with their eighth grade or sixth-grade SIMCE files (array of test scores) containing detailed information on a student's background characteristics such as parent's education and household income.

fore SAS; in fact, local school competition is a long-standing debate in the literature (McEwan and Carnoy, 2000; Mizala and Torche, 2012). We exploit the existing variation in the schooling structure across districts to document how areas characterized by higher levels of competition experienced an increase in within-school segregation as a result of the reform. In particular, we find that districts with higher pre-reform market shares of public and voucher schools reported a drop in segregation to the tune of [0.4,0.7] relative to locations with a larger percentage of private schools. Our analysis identifies a potential mechanism behind this finding, namely the migration of high SES families from public and voucher to private schools. This result alerts about potential unintended consequences of centralized systems implemented in a setting in which market forces were already in place.

We contribute to the existing literature on school segregation in multiple ways. First, we analyze differences in the impact of the new system based on variation in the institutional features of school districts (supply-side characteristics). Competition among schools to attract students could be amplified due to an expansion of school choice (Gilraine et al., 2019). Under Chile's centralized system, we show the market forces might favor private providers if parents view them as superior to the alternative.

Second, rich geospatial data allows novel analyses. We use location coordinates and Chile's comprehensive road network (Open Street Maps and HERE developer API) to calculate the travel time of students to essential amenities in their neighborhoods. Using this data, we construct a measure of residential segregation based on the students' commuting time to amenities, such as hospitals and police stations within the district of residence (Massey et al., 1987). Therefore, if 100 students are residing in a municipality with ten hospitals, our residential segregation measure takes into account all the 100×10 commuting times for each student amenity combination. The interaction of this measure with SAS, captures the effect of residential segregation across communities on school heterogeneity.

In perspective, our empirical analysis unravels a complex association between centralized admission systems and changes in school segregation, particularly in areas characterized by sharp variation in neighborhood quality and schooling structure. These settings and landscapes can be found in developed and developing countries.[4] Overall, our findings suggest the need for understanding heterogeneity across school districts (supply-side pressure) before implementing major changes in school choice (Hastings et al., 2009).

The paper is organized as follows. Section 2 describes the key features of Chile's new centralized school admission system. Section 3 describes our data, while Section 4 presents our identification

[4]For instance, recent work on charter schools in the United States by Monarrez et al. (2019) documents that charter schools are relatively more segregated than the public schools. Moreover, these authors find that charter school diversity was much lower in urban districts with higher levels of minority students.

strategy. In Sections 5 and 5.4 we present our main findings and robustness checks, respectively. Section 6 concludes.

2 Background

In the early 1980s, Chile's military regime undertook a structural reform of the educational system. The reform involved a decentralization of the public school system, by transferring the administration of local school districts from the central government to municipalities.[5] It also included the establishment of a nationwide flat voucher paid directly to schools, public or private, on a per-student basis. As a result, three types of schools were established: (a) public schools, managed by local municipalities and financed by vouchers; (b) private-voucher schools, privately managed but financed by vouchers and; (c) private non-voucher schools, in which the private sector provides both funding and administration. For the rest of the paper, we refer to private voucher and private non-voucher schools as voucher and private schools respectively.

In 1993, the financial incentives for voucher schools to charge out-of-pocket tuition to complement the state voucher were largely extended. Public schools were also allowed to charge add on fee, but only at the secondary level and if all parents agreed.[6] Voucher schools that decide to charge add-on fees, suffer from a reduction of the state voucher, which was progressive according to the amount of tuition charged. By 2015, out of 3.5 million students in the system (from elementary to high school), 36% attended public, 55% voucher, and 9% attended private schools.

One of the crucial criticisms of the voucher system is that it has resulted in higher socioeconomic stratification, especially for high schools (Valenzuela et al., 2014). Hsieh and Urquiola (2006) show that the voucher system has encouraged the flight of students belonging to the middle part of the socioeconomic spectrum from the public to voucher schools. This, in turn, led to an overwhelming majority of low SES students in public schools, which is the principal reason of increased stratification.

Given the significance of school segregation for short- as well as long- term student outcomes, in 2008, the Chilean Congress passed the Law 20,248 of *Subvención Escolar Preferencial* (SEP), which established a targeted voucher that provided schools with an additional voucher for every priority student that they enroll. This policy aimed to address the existing segregation by socioeconomic status in the Chilean educational system and to improve educational outcomes for disadvantaged students (Sánchez, 2018; Kutscher, 2020).

[5]Before these reforms, Chile had a centralized education system where the majority of schools were publicly financed and managed directly by the Ministry of Education.

[6]By 2014, the average fee amounted US $30.23 in voucher schools and US $4 in public schools (in nominal terms).

In a new attempt to promote inclusion, in May of 2015, Congress passed the Inclusion Law (*Ley de Inclusión Escolar*, N. 20.845). There are three broad provisions under the new legislation. First, the student admission process is regulated, second, the student co-payment is to be removed within the next ten years by increasing vouchers, and third, only not-for-profit private schools could receive vouchers.

Given the provisions of the new law, the expectation was that these measures could make education in Chile more inclusive and reduce segregation. In fact, the law stated, "... [this policy] will allow us to make decisive progress in ending the high school segregation that characterizes our current system".

2.1 Centralized School Admission System (SAS)

As stated above, one of the foundations of the Inclusion Law was the regulation of the school admission system. Chile adopted a Deferred Acceptance algorithm with multiple tie breaking. This algorithm was first proposed by Gale and Shapley (1962) and modified later by Abdulkadiroğlu and Sönmez (2003).[7] This system was introduced for public and voucher schools, directly eliminating their supply-side choice. Therefore, since 2016, families are required to apply to these schools through a centralized web application platform.

The centralized web platform provides information about the schools' educational project, its facilities, extra-curricular activities, and other features. The algorithm allows for special priorities such as i) applicants that have a sibling enrolled in the school; ii) applicants classified as priority students, up to the minimum of 15% per level; iii) the children of school officials; and iv) former students of the school who had left for various reasons except for expulsion. Families indicate these priorities in their web applications.

The algorithm intends to allocate every student to the highest plausible preference conditional on the priorities and vacancies at schools. If there are fewer applications than vacancies at a school, there is no requirement for the multiple tie-breaking rules. On the contrary, if the number of applications exceed the number of vacancies, the tie-breaking rule kicks in.

The implementation of the algorithm has two stages: regular and complementary. All the applicants are allowed to participate in the regular stage, starting in August of each year. Once it ends (October), students are informed about the schools they will be attending in March of next year. Each individual has the right to turn down the assigned school, in which case he/she can submit a new list of preferences during the complementary stage (November). At this point, the

[7] For evidence from Boston, New York, Denver see Abdulkadiroğlu et al. (2005b,a); Abdulkadiroglu et al. (2006); Abdulkadiroğlu et al. (2009, 2011, 2017). For Charlotte see Hastings et al. (2009), Barcelona see Calsamiglia and Güell (2018), and Beijing see He et al. (2012).

algorithm is implemented again but only for the set of vacant seats.[8] Students are assigned to the closest participating school if the process fails to assign a student to any of the preferred choices. The process concludes in December before the beginning of the school year.[9]

The implementation of SAS has been gradual, which is critical for our identification strategy. The reform began in 2016 in Magallanes region, in 2017 it continued in the regions of Tarapacá, Coquimbo, O'Higgins, and Los Lagos, in 2018 included Arica and Parinacota, Antofagasta, Atacama, Valparaíso, Maule, Biobío, Araucanía, Los Ríos, and Aysén. Finally, in 2019 it was introduced in the Metropolitana Region (Santiago).[10]

3 Data

Our primary source of information comes from the student-level administrative files reported under Chile's new SAS system. These documents contain detailed application data for all students who are submitting their preferences to enroll in primary (pre-k to 8th grade) and secondary (9th to 12th grade) schools.

Figure 1 illustrates the differences in program participation by grade. As expected, the number of participants in the new policy is largest for the ninth grade (first year of secondary school) and pre-k (first year of primary school). All parents seeking admission for their children to pre-k in public or voucher schools are required to enter the system using SAS. In 2018, about 274,000 students participated in the system, out of which 84,626 (31%) were seeking admission into that grade. The corresponding percentage for 2017 is 30% and 35% for 2016.[11]

For ninth-graders, a notable percentage of students switch schools between eighth (last year of primary education) and ninth grade. Some students are forced to do so as their primary schools do not offer secondary education. Others might want to shift as they want to get themselves enrolled in a better institution. Table 1 provides details on the participation of students and schools for 2016, 2017, and 2018. On average, 46% of eighth-graders participated in SAS for ninth grade admissions in 2016 in the region where SAS was implemented. This increased to 51% in 2017 and 52% in 2018.

Pre-k and ninth-graders show the largest participation levels, but we focus our study on the

[8]The students who did not participate in the regular stage do have the option to participate in the complementary stage for the remaining seats.

[9]It is mandatory for students seeking admission to pre-k to participate to enter the education system for admission in a public or voucher school.

[10]Web appendix Table A1 shows the number of schools that participated in each region and the year of introduction of SAS. This information is later used to construct the policy treatment indicator. Web Appendix: http://econweb.umd.edu/~urzua/WebAppendix_KSU.pdf

[11]2016 percent is not representative of Chile as a whole as only 63 schools in Magallanes participated in SAS this year.

latter group. Primarily, data limitations force us to move away from pre-k. The dissimilarity index construction requires background information on a student's socioeconomic status, which we gather by matching students to their previous records from administrative sources. We use data from the Education Quality Measurement System (*Sistema de Medición de Calidad de la Educación* or SIMCE). It contains detailed individual-level information, including mother's education, father's education, and household income. Chile's SIMCE is generally administered twice during the students' educational history, either in second, fourth, sixth, eighth, or tenth grade. Therefore, despite its richness, no background information for students seeking admission in pre-k is available. In addition, there is evidence suggesting that the increase in school-segregation levels is more pronounced in secondary than in primary education (Valenzuela et al., 2014; Torche, 2005). Hence, studying ninth-grade students is more appealing as they face higher levels of segregation.

Thus, we focus on the entire universe of ninth graders in 2015, 2016, 2017, 2018, and 2019 in Chile, so we examine the school preferences of approximately 250,000 students per year. Table 2 provides details on the information obtained from SIMCE files.[12] We complement this data with multiple sources of longitudinal information. We gather pre- and post-reform student-level enrollment information from the administrative records provided by the Ministry of Education in Chile. These files contain precise records on student's residential addresses, school characteristics, and school locations before and after SAS. Critical for our paper, these files can be linked to official information collected under the new admission system.

3.1 Measuring segregation and school market structure

Any measure of school segregation is constructed relative to a specific geographical area. In this paper, we use the school district, defined by the municipality of student' school, as the unit of analysis.[13] Multiple reasons explain this decision. First, a local district can be conceptualized as a proxy for a school market as 78% of students in Chile choose a school within this area (see Table 3).[14] Importantly, we do not observe any notable difference in this fraction pre and post the inception of SAS, which suggests most of the parents were choosing among schools within their municipality both before and after the reform. Second, by examining school segregation across municipalities, we can capture significant within-region heterogeneity, hidden under broader defini-

[12]To obtain the socioeconomic background information on students, we match every ninth-grade cohort to the previous SIMCE available, either sixth or eighth depending on the cohort. We can match at least 80% of the students in enrollment files with SIMCE data for each year as shown in Table 2.

[13]Although the funding for public education comes from the central government, local authorities (majors) are responsible for the management of public schools. Contrary to the school districts in the United States, students in Chile can attend public schools outside their local school districts. The robustness of our findings to this complexity is discussed in Section 5.4.

[14]The corresponding percentage for ninth graders, the group we focus our analysis on, is approximately 66%.

tions of local schooling markets. Third, importantly, this is the most commonly used definition of school markets in related work in Chile and other countries (Parry, 1997; Hsieh and Urquiola, 2002, 2006). This helps us to compare the implications of the current policy change with segregation related research on earlier policies of the government and other geographies.

After setting our unit of analysis, we proceed to combine the information from the sources listed above. This process results in a panel of 346 municipalities covering the period 2015-19. For each municipality and year, we construct the Duncan index for school segregation, which measures the percentage of students belonging to low socioeconomic status who have to be reallocated across schools for equal representation of students from all socioeconomic backdrops within the district. Formally, we follow Duncan and Duncan (1955) and compute:

$$y_{ct} = \frac{1}{2}\sum_{j=1}^{n_{ct}}\left|\frac{P_j}{P} - \frac{NP_j}{NP}\right|,$$

where c and t correspond to municipality and year, respectively, whereas P_j (NP_j) is the number of students reporting low (non-low) socioeconomic status in school $j \in \{1, 2, ..., n_{ct}\}$ with n_{ct} denoting the number of schools in municipality c in year t. N and NP represent the total number of poor and non-poor students for the municipality.

We use the Duncan index for our main analysis as it is the most commonly used segregation index. However, we acknowledge that it suffers from various limitations. First, it does not always satisfy the transfers principle. Second, we can compare the disparity of only two groups in this index. Third, Duncan index does not account for the segregation resulting from randomness (Winship, 1978; Carrington and Troske, 1997; Hellerstein and Neumark, 2008; Söderström and Uusitalo, 2010; Allen et al., 2015). Fourth, it cannot be decomposed. Thus, to confirm the robustness of our findings, we complement our primary analysis using an alternative measure of segregation in Section 5.4.

As for the definition of socioeconomic status, we classify students who have mothers without a high school degree as low SES. This dimension has been identified as a crucial socioeconomic marker (McLanahan, 2004). Figure 2 displays the resulting Duncan index for Chile's 15 regions for 2017 and 2019, documenting significant variation.[15,16] To put this in context, Jenkins et al. (2008) argue that school segregation in OECD countries during the last decade varied between [0.2,0.5] with countries such as Belgium, Germany, and Hungary being at the upper end of the spectrum, while Nordic countries reported lower levels than others in this group. Similarly, Reardon and Yun

[15] In 2019, all regions in Chile had the policy in place except for Metropolitana. Metropolitana initiated the policy in 2019, and the new student enrollment through the policy will be reflected in 2020 enrollment files.

[16] Chile created the sixteenth region Nuble, formerly part of Biobio in 2018. We merge Nuble with Biobio for our analysis.

(2001) demonstrate that dissimilarity index estimates on racial lines varied between [0.38,0.46] for 323 Metropolitan Statistical Areas in the United States. For Chile, Valenzuela et al. (2014) report segregation levels varying between 0.4 and 0.6 for the period 1999 and 2008. According to our estimations, in 2019, the Duncan index ranges between 0.3 and 0.5 for the fifteen regions in Chile.

In addition, we intend to capture heterogeneous effects of SAS. First, we explore them with respect to residential segregation. To this end, we construct a measure of student residential segregation based on the commuting time to amenities such as hospitals and police stations. We take advantage of the geospatial student-level data and the comprehensive road network of Chile.

The official enrollment files contain information on student's home addresses. In collaboration with the Ministry of Education of Chile, the HERE geocoder API was used for forward geocoding the residential addresses of the complete ninth-grade cohort in Chile in 2018 (246,937 individuals). Furthermore, to obtain precise measures of student's travel duration to basic amenities, we employ the Open Source Routing Machine (OSRM) service for travel time calculation. The OSRM API uses open street maps to measure the shortest travel time using a car, bicycle, or foot between two location coordinates. Our measure of travel time or travel distance using the open street maps has much higher precision than geodetic measures of distance employed in related research.[17]

We define an amenity as accessible if the driving time is within an hour for a student. Since the regression analysis is done at the municipality level, we construct measures of variation for access to amenities for ninth graders within a municipality in the year 2018. Figure 3 illustrates that access to amenities varies to a large extent across municipalities in Chile. If residential segregation is correlated with the distribution of schools (public, voucher and private), then a parental preference for shorter travel time to schools can affect reallocation under the new policy. In fact, Figure 4 shows that the majority of ninth graders' travel time to schools is less than 1000 seconds (2018).

These idiosyncrasies also characterize the local provision of education throughout the country. Table 4 shows that, on average, public and voucher schools enroll the vast majority of students (approximately 91%). Private schools enroll the remaining 9% and represent approximately 15% of all schools. These percentages, however, mask significant within and between regional heterogeneity in schools' spatial distribution. By exploiting data from Metropolitana (the largest region with more than 7 million residents) and Coquimbo (a region with less than one-tenth of Metropolitana's population), Figure 5 confirms this idea. Panel (A) shows that while private schools are more common in municipalities belonging to the north-eastern sector of the Santiago province, it is almost non-existent in the southern districts. Therefore, even though the participation of the private schools in Chile's capital is 13.7% (close to the national average), its distribution among

[17] See our Web Appendix B for further details. Its figures B1 and B2 illustrate why it is pertinent to examine distance to schools using the actual travel time.

districts is far from being homogeneous. For Coquimbo, Panel (B) offers quite a different picture. In this case, the distribution of the different types of institutions is appreciably more homogeneous. These differences shed light on an obvious point and well-known fact: public and private schools are strategically located in the territory (Epple and Romano, 2000). Figure 6 examines this further as it presents spatial density plots of the different types of schools for Concepcion, Chile's second-largest region. It documents very distinctive patterns: higher concentrations of public (panel B), voucher (C), and private (D) in certain areas. Our empirical analysis exploits these differences.

We anticipate that a higher fraction of public and voucher schools in the municipality relative to private should result in lower school segregation. On the contrary, neighborhoods with a higher representation of private schools would favor students from high socioeconomic status as there are excessive cost barriers to entry in private schools. We observe in Figure 7 that the representation of students from low SES is much more dismal in private than public or voucher schools.

Table 5 provides the summary statistics for the variables used in the primary regression. The mean for the municipality Duncan index is 0.25, with a standard deviation of 0.19, which is larger than the variation observed across regions. Additionally, we observe significant variation in residential segregation and the local schooling systems across municipalities in Chile. Moreover, a student from high SES might be responding differently to the policy than low SES. The plausibility of such differential responses due to the new policy has been explored in Section 5.2.

4 Empirical Strategy

We take advantage of the longitudinal dimension of our data as well as the gradual implementation of SAS to estimate its impact on school segregation. In particular, we follow a standard Difference-in-Difference strategy where the outcome variable is the Duncan index in municipality c, located in the region r, constructed at time t, y_{crt}. Thus, we estimate:

$$y_{crt} = \delta_0 \times D_{rt} + Z_{1cr}\beta + \gamma_r + \lambda_t + \epsilon_{crt}, \tag{1}$$

where D_{rt} is the treatment variable, which takes a value of one if the program is implemented in the region r in year t and zero otherwise. Since the Chilean government stepped up the new program gradually across regions, we add region fixed effects (γ_r) to account for time-invariant heterogeneity at that level. Moreover, to account for any aggregate variation in segregation over time, we control for year fixed effects (λ_t). The covariates Z_{1cr} comprise of the pre-SAS measures of local schooling structure such as the fraction of public, voucher and private schools, and the fraction of rural schools in the municipality. ϵ_{crt} is the error term. Throughout our analysis, we cluster the standard errors at the school district, as this accounts for serial correlation (Bertrand et al., 2004).[18] The policy parameter of interest is δ_0.

The identification of δ_0 depends on the following assumptions (Athey and Imbens, 2018; Goodman-Bacon, 2018). First, the adoption date of the policy for every region in Chile should be random to existing levels of school segregation before the policy.[19] Second, there should not be any responses in anticipation of the treatment. This suggests that if region r has not adopted the policy, then the exact date at which it intends to adopt the policy should not affect the current outcomes. Third, school choices for students entering high school in a region in year t depends on SAS in year t and not on SAS's availability in previous years. Finally, we rely on the common trends assumption. We assess each of these assumptions in Section 5.

Under these assumptions, equation (1) secures the identification of the average effect of SAS for all school districts. However, as indicated in Section 3.1, there are considerable differences across communities in terms of the spatial location of amenities, local schooling structure, and spatial distribution of students belonging to different socioeconomic categories. To capture these effects, we extend expression (1) and allow for heterogeneous responses by residential segregation and local school market conditions.

Residential segregation. Work in urban economics has illustrated that neighborhood quality is a function of access to amenities such as health care, police stations, and good quality schools (Cheshire and Sheppard, 2004; McKenzie, 2013). The literature has also established that access to amenities varies significantly across geographies, with higher variation suggesting higher levels of residential segregation. In other words, higher variation in access to amenities indicates the concentration of individuals from different sections of the socioeconomic strata in specific pockets or clusters. In this context, school segregation could emerge as a result of residential segregation (Massey and Denton, 1985).

Figure 8 illustrates this point for the second largest region of Chile. For Biobio region, it shows that students from the highest and lowest income categories are clustered in different non-overlapping pockets. In particular, students from low socioeconomic backgrounds enroll in the overpopulated public schools of their neighborhoods. Thus, residential segregation could translate into higher levels of segregation in schools (Maloutas, 2007; Bonal et al., 2019).

As a first step towards breaking down the source of school segregation, we document the association between school and residential segregation for Chile. We use access to hospitals and police stations as our primary measure of residential segregation (see Section 3.1 for details on

[18] Wild cluster bootstrapping is not required for our analysis as we have 346 clusters for school districts, and this adjustment is required if the number of clusters is between 5 and 30, as illustrated by Cameron et al. (2008).

[19] Table A2 in Web Appendix illustrates that the start date of the program was not correlated with the existing levels of school segregation n 2015.

the construction of this measure). We do not use access to schools for the construction of this measure as it is an outcome of the new policy. On the contrary, the spatial location of essential amenities such as hospitals and police stations did not depend on the new policy[20]. Hence, these observations alleviate endogeneity concerns about our measure of residential segregation.[21] We examine the impact of SAS for regions with varying levels of residential segregation for ninth graders using the expression:

$$\begin{aligned} y_{crt} &= \delta_0 \times D_{rt} + \delta_1 \times D_{rt} \times \text{Residential Segregation}_c \\ &+\delta_2 \times \text{Residential Segregation}_c + Z_{2cr}\beta + \gamma_r + \lambda_t + \epsilon_{crt}, \end{aligned} \tag{2}$$

where residential segregation corresponds to the municipality level variation in access to amenities. From this expression, we explore the interplay of SAS and residential segregation using the interaction between the two variables. The coefficient of interest is δ_1. A positive δ_1 would imply that municipalities with higher residential segregation experienced an increase in school segregation due to the policy's implementation. The additional covariate Z_{2cr} is the measure of pre-SAS local schooling structure in municipality c in region r.

Although δ_1 informs about the heterogeneity in SAS impact by residential segregation, we are also interested in learning about the main effect of residential segregation on school segregation, which is captured by δ_2 (Graham, 2018). This since, as Figure 3 shows for Chile's two largest cities (Santiago and Concepción), there might exist extensive variation in the spatial location of amenities within metropolitan areas affecting the levels of school segregation. Furthermore, since Metropolitana did not have the new policy in place until 2019, from equation (2) we recover the effect of residential segregation in the absence of the new policy. Region and year fixed effects account for variation across municipalities within a region, warranting the identification of δ_2.

School choice, competition, and segregation. The new centralized student assignment system expanded school choices for Chilean families. However, under a schooling system characterized by heterogeneous quality and with private schools operating outside SAS, this might lead to complex changes in incentives and strategic behaviors (Gilraine et al., 2019; Hsieh and Urquiola, 2006).

We explore pre-reform variation in local school supply across districts – the result of almost four decades of school competition – to investigate systematic differences in parental responses to SAS. Moreover, we exploit the potential association between these responses and socioeconomic

[20]See Table A3 in Web Appendix for evidence suggesting no association between the new policy and the measure of residential segregation used in this paper.

[21]We show later in the paper that there is no significant internal migration of students in response to the policy for targeting the schools of their choice.

background to identify the underlying mechanism behind our findings.

As illustrated in Section 3.1, the market structure of schools across municipalities vary as schools are strategically located throughout school districts. We will examine whether the impact of SAS may differ across municipalities as a function of the proportion of private schools. We cannot use the contemporaneous fraction for our analysis, as it could be correlated with the new policy. This since, for instance, schools could have responded to the new policy by changing their status (for example, private schools could adjust tuition-fees). To counter any of these issues, we construct the schooling measure using data from 2015 (i.e., pre-SAS).

We approach the heterogeneity by local schooling structure in two ways. First, we construct the Herfindahl index (HHI) of school market concentration and examine how market concentration affects school segregation. To this end, we include HHI and its interaction with SAS (D_{rt}) as additional controls in equation (1). Any influence of market concentration on school segregation would indicate that the market structure can explain some of the policy variations.

This strategy, however, is silent about the specific pre-SAS supply-side characteristics, potentially affecting the impact of the reform. Therefore, in addition, we exploit the complexities of the Chilean schooling system to shed light on this. In particular, we interact D_{rt} and the fraction of school types in 2015 and estimate:

$$
\begin{aligned}
y_{crt} \quad &= \delta_0 \times D_{rt} + \delta_{1p} \times D_{rt} \times \text{Public}_c + \delta_{1v} \times D_{rt} \times \text{Voucher}_c \\
&+ \delta_{2p} \times \text{Public}_c + \delta_{2v} \times \text{Voucher}_c + X_{crt}\beta + \gamma_r + \lambda_t + \epsilon_{crt},
\end{aligned} \tag{3}
$$

where now the coefficients of interest are δ_{1p} and δ_{1v}. The baseline category for this specification is the percentage of private schools pre-reform. Notice that $\delta_{1p} < 0$ and $\delta_{1v} < 0$ would hint the plausibility that SAS enabled easier school switches for higher SES compared to low SES students as it could be easier for the former to overcome the constraints of school fees and transport costs. This unbalanced relocation would result in a disproportionate flight of non-poor students from public and voucher schools to private schools. Hence, municipalities with a higher fraction of private schools could witness an increase in school segregation due to SAS. In addition to the interaction effect, $\delta_{2p} < 0$ and $\delta_{2v} < 0$ would suggest that municipalities with more public and voucher schools relative to private report lower levels of school segregation even without the new policy.

Equations (1), (2) and (3) use the binary treatment status of each region under SAS. However, the new policy's impact could vary depending on the number of schools that participated in the new system. In other words, a binary indicator of policy veils these participation differences across municipalities. To account for such variation, we construct a treatment intensity variable using the information on the number of schools that participated in SAS every year within each region. Specifically, we define $I_{rt} \in [0, 1]$ as the fraction of schools that participated in SAS in region r in period t. Thus, while the treatment dummy D_{rt} for region r is 1 if SAS was in place in year t, I_{rt} would be a continuous variable between [0,1]. Notice that a school participates if it has non zero vacancies for at least one school grade in year t, and the school accepts student applications for these vacancies. We complement our analysis with this intensity variable along with binary SAS dummy.

5 Main Results

We begin by exploring the overall impact of the new policy on school segregation. Table 6 presents the results for equation (1). The coefficient δ_0, which captures the average impact of the new policy (SAS dummy, D_{rt}), is extremely small in magnitude ($\sim$ -0.001) and statistically insignificant. This finding does not change if we use treatment intensity (Intensity of SAS, I_{rt}) instead of the treatment dummy. Additionally, this result is robust to controlling for a rich set of other pre-SAS covariates.

The absence of an overall effect of SAS is not surprising. Some regions could have witnessed an increase in school segregation, and others might have observed a decrease. The Difference-in-Difference parameter δ_0 gives us the average treatment effect on treated across regions (Abadie, 2005). Consequently, it is plausible that the increased segregation in some regions is offsetting the decrease in other regions.

Apart from SAS dummy (D_{rt}), it is interesting to examine the effect of other covariates on segregation in columns (3) and (4) of Table 6. We have decomposed the school market structure within a municipality into the pre-SAS fraction of public, voucher, and private schools. A higher fraction of public schools relative to private schools in a municipality drives down segregation. Additionally, voucher schools also affect segregation in the same negative direction, but the magnitude of the coefficient on the fraction of public schools is considerably higher than voucher schools. The primary reason behind this difference in coefficients is that although all public schools are free, some voucher schools might charge a small school fee. This small add on fee might act as a cost barrier for low SES students in voucher schools.

5.1 Heterogeneous effects

The previous results document small estimates for δ_0 in equation (1). In this Section, we disentangle systematic differences in the impact of the policy by residential segregation and local school supply.

First, we report the estimated coefficients for equation (2). The coefficient of interest corresponds to the interaction of treatment dummy and variation in access to amenities (δ_1). Table 7 presents these results. The estimated value for δ_1 is positive (0.008) and statistically significant, suggesting that municipalities with higher variance in the access to these public goods experienced an increase in school segregation due to the policy. This finding of a positive association between residential segregation and school segregation has been observed in other geographies as well. Rivkin (1994) finds that schools remained segregated due to the persistent residential segregation in the United States and Boterman (2019) reveals that most of the variation in school segregation in Netherlands is explained by existing residential segregation levels.

We also observe that school segregation levels at baseline (without the policy) are consistently higher in more residentially segregated municipalities. This is consistent with the evidence for the United States, showing that the disadvantaged groups face higher constraints in accessing better quality neighborhoods. For instance, the clustering of minorities in specific neighborhoods often results in them having access to public schools overpopulated with minority students. In other words, the higher concentration of minorities in certain neighborhoods results in higher levels of school segregation in those areas (Massey et al., 1987).[22]

As highlighted above, income-based clusters are one of the precursors to the high variation in access to amenities (our measure of residential segregation). We depict this feature in Figure 8. Such income-based residential clusters can translate into higher segregation in school if families prefer to send their children to nearby schools. Figure 4 confirms this inclination. Since travel costs might be binding for low-income families, students from those families are often forced to attend public schools in their neighborhoods.

The centralized system does expand school choice. As argued in Section 4, this process can translate into complex strategic responses by parents. Some parents from low socioeconomic backgrounds could likely use the new system to send their children to better quality public or voucher schools farther away from their residences. However, such new admissions need not necessarily reduce school segregation if students from high SES anticipate this and respond by switching to private schools. Such switches will be more prevalent in municipalities with a higher fraction of private schools. Here, we present results supporting this hypothesis in two parts. First, we illustrate that municipalities with a higher representation of voucher or public schools experienced a decline in segregation, and municipalities with more private schools experienced an increase in school segregation. Second, we argue that, in fact, the reason driving these results were the switches made by high SES students from public and voucher to private schools.

We report the results of equation (3) in Table 8. Column (1) reports the results on market concentration (HHI index), suggesting that municipalities with higher existing levels of market

[22]For the central part of our analysis, we use the data on access to hospitals. However, we also observe comparable results for access to police stations within a municipality. These results are reported in Table A4 in Web Appendix.

concentration experienced an increase in Duncan index due to the policy. Column (2) explores potential underlying factors driving this result. We interact the fraction of students attending each type of school within a municipality in 2015 with the policy dummy which is our variable of interest. The reference category is the fraction attending private schools. We report a negative and significant interaction coefficient (γ_{1p} and γ_{1v} in equation (3)) indicating that municipalities that had a higher fraction of public/voucher schools than private schools experienced a decrease in segregation due to the policy. We replicate the analysis in column (3) but with the fraction of each school type rather than the fraction of students attending different school types within a municipality. We reach the conclusion that municipalities with a higher fraction of private schools in 2015 became more segregated due to the new policy.

Additionally, the findings in Table 8 show that the pre-existing schooling structure also impacts the levels of school segregation without the new policy (baseline). The main effects for a higher fraction of public and voucher schools are consistently positive and significant across all specifications. The factors driving these heterogeneous effects requires us to explore the response of high versus low SES families to the new policy.

5.2 Exploring mechanisms

School choice literature has shown that parents care about the SES make-up of the school when choosing schools. For instance, Hastings et al. (2009) exhibit that parents value the school's racial composition when reporting their top three school choices. An analysis of parental preferences under centralized allocation in Paris also reveals parental inclination to send their children to schools that had a higher representation of students belonging to the same SES (Fack et al., 2019). Such parental affinity often results in students transitioning between different types of schools post-expansion in school choice due to the centralized system, and this transition could be systematically related to student's background characteristics. Baum-Snow and Lutz (2011) highlight the importance of investigating heterogeneous responses across racial groups for exposing some of the unintended consequences of the desegregation laws in the 1960s and 1970s in the United States (out-migration of minority students cannot invalidate the hypothesis that whites used private schools to avoid desegregation in the south). In the same vein, we investigate whether differential responses by household characteristics can explain why SAS pushed segregation upwards in regions with a high market concentration of private schools.

To this end, we first construct the fraction of students switching from public/voucher to private schools between eighth and ninth grade for consecutive cohorts from 2015 to 2019. We anticipate that municipalities which had a higher fraction of private will make this transition easier. Additionally, we intend to understand what kind of families are more likely to make this transition. The outcome variable for this regression is the proportion of families that switched from public/voucher to private schools. We capture if these switches were more accessible for high-income parents in districts with a higher representation of private schools using a triple interaction between SAS dummy, the fraction of high SES families, and the presence of private schools in 2015. A positive coefficient on this triple interaction indicates that high SES students responded to the policy by moving to private schools from public/voucher schools.

Table 9 presents this result. The coefficient on the triple interaction on SAS dummy, private school dummy in 2015, and fraction of high SES mothers within a municipality is positive and statistically significant. This finding indicates that higher SES families responded to the new policy by switching to private schools. Consequently, we observe an increase in segregation in municipalities with a higher fraction of private schools in 2015.

This examination helps us unmask a critical underlying mechanism that is driving the mixed effects of the new policy on school segregation in Chile. High SES parents seem to have anticipated an increase in the representation of low SES students due to the policy. Consequently, they responded by switching to expensive private schools. Hence, we depict that these pre-existing variations on the supply and price of different types of schools matter across municipalities.

5.3 Threats to identification

In what follows, we perform a series of tests to alleviate concerns regarding common pre-trends assumption. Additionally, we examine the plausibility of any agent responses in anticipation of the policy. Such responses are likely to make it difficult to disentangle the change in segregation due to SAS.

The first identification assumption for the parameter of interest is that we expect to observe parallel trends in baseline outcomes denoted by $Y_{crt}^{baseline}$ across all groups. In other words, it implies that all groups should have followed a parallel trend in school segregation in the absence of treatment. The year and region-specific effects could explain these constant gaps in segregation across groups.

Since SAS's adoption was staggered over time, standard parallel trends visualization will not suffice as regions are switching their treatment status over time. We tackle this issue by providing formal tests to support the parallel trend assumption for our context with multiple regions and treatment time variation. First, we check for differences in pre-trends using the leads and lags test. Any evidence of significant coefficients for the lead treatment indicators is a threat to the parallel trend assumption.

Here we include the treatment indicator for m periods before the actual implementation of policy at $t = 0$ and q years after the implementation of policy for the lags and leads test. Figure

10 summarizes the result of this analysis. The coefficient for the lead term is not statistically different from zero. In other words, any policy change in the future does not affect the prevailing school segregation.

Next, we follow the region-specific trend test from Angrist and Pischke (2008) to provide further evidence to aid our assumption on pre-trends. We estimate equation (4) which includes region-specific trend variables:

$$y_{crt} = \gamma_r + \lambda_t + \sum_{j=-m}^{q} \delta_j \times D_{rt+j} + e_{crt} \tag{4}$$

Table 10 presents these results. The comparison of its columns (1) and (2) in Panel (A) reveals that the inclusion of these additional variables does not alter the coefficient on the treatment dummy.

Third, we present a placebo test for the pre-trends assumption. We use fake treatment groups for this test. We have indicated that SAS was introduced in Antofagasta, Atacama, Valparaiso, Maule, Biobio, Araucania, Aysen, Los Rios, and Arica y Parinacota in 2018 and it was effective in 2019. We use these nine regions to generate the fake treatment group for 2018. In other words, we assume that they were treated in 2018 and accordingly generate the treatment dummy. Moreover, we restrict the analysis to the years before 2019. If we are to believe in the same pre-trends assumption, ex-ante, we expect the policy parameter to be zero for this case. Panel (B) in Table 10 confirms this result. The policy parameter is zero and insignificant for the fake treatment group.

Lastly, given the sequential implementation of the policy, we can visualize a modified version of the parallel trend assumption. We can split the regions into groups based on their year of treatment and then compare the early, late intervention and non-treated groups. The critical thing to note is that early and late treatment groups change their treatment status at different points between 2016 and 2019. This is the crucial point of divergence from a standard Differences-in-Difference set-up where all entities in the treatment group are treated at the same time. In our context, Metropolitana region is not treated till the end of 2018, and consequently, it serves as a control for all other treated regions in every period. Figure 9 depicts the parallel trend assumption using regions treated in 2018 and 2019 and the untreated group. This conclusion, combined with the other results, alleviates any concerns on the violation of equal pre-trends assumption.

In Section 4, we pointed out that identification of δ_0 requires the policy adoption date to be random, and rules out any strategic responses by the parents in anticipation of the policy. The algorithm takes into account residential proximity to school if it fails to allocate a student to any of the listed preferences. We want to provide evidence against any plausibility of parents relocating to different neighborhoods for a better school outcome before the policy implementation.

We take advantage of the student addresses for the complete universe of ninth graders for this analysis. We compare student addresses between 2017 and 2018 for nine regions. SAS was in place in these nine regions in 2018. Consequently, a high fraction of internal migration within these regions will be a threat to the identification strategy. We calculated the fraction of eighth-grade students who did not change their residence between 2017 and 2018. We compared these fractions with the average for the prior years to identify any threats to the identification strategy.

Figure 11 suggests that migration is very limited in these regions. Moreover, we do not observe any pattern of abruptly higher migration between 2017 and 2018. The fractions of families who do not change their residences in 2018 are comparable to the numbers computed for 2017. Most of these averages are well above 95% of the total population of students. Therefore, we conclude that parents are not responding to the policy announcement by changing their addresses.

Finally, there is no reason to believe that policy adoption date is correlated with the existing levels of school segregation in a region. The government implemented the policy in less populated regions first and then moved to more populated areas (see Table A2 in Web Appendix).

5.4 Robustness Checks

Alternative definitions of socioeconomic status. We have used mother's education to define low and high SES students for the central part of our analysis. However, the SIMCE files also report father's education and a family income index. We replicate our main results using these alternative proxies for student SES.

Panel (A) of Table 11 mimics the analysis of Table 6 but using father's education to define the Duncan Index (as before a high school degree separates low and high SES groups). We reach the same conclusion. Overall, SAS does not affect segregation, and this result is not affected by the inclusion of covariates.

We repeat the analysis using the household income index. These results are displayed in panel (B) of Table 11. We categorize all students whose household income is less than 100,000 Chilean pesos as low SES and others with higher income as high SES. Again, we get no overall effect of SAS on segregation across all the specifications. These two exercises confirm the robustnesses of our findings.

Urban vs. rural areas. Urban and rural areas are likely to have different composition of school types. As discussed in Sánchez (2019), public schools have a better reach in terms of geography and affordability than their private counterparts. Consequently, rural areas have a much higher fraction of public schools than urban areas.

To ensure that some of these rural-urban differences do not drive the principal conclusions, we replicate the central results solely for municipalities with urban schools. These results are reported in Table 12. We again get marginally positive estimates of the policy parameter δ_0, where the estimate is statistically insignificant across all specifications.

Provinces as school districts. Table 3 showed that around two-thirds of the students choose a high school in the same municipality as their residence. Since we compute the dissimilarity index at the municipality level, we implicitly assume that students are mostly choosing schools within the same municipality as their residence. This assumption implies that schools are catering to the students in the same municipality as their location. However, this assumption is not valid for one-third of the sample. Consequently, we proceed to confirm that our results are robust to the definition of the relevant market.

Panel (B) in Table 3 shows that 90% of ninth graders attend schools in the same province as their province of residence. Thus, Table 13 presents segregation analysis with the province as the unit of observation (there are a total of 54 provinces, so we get 270 observations for five years of data). This aggregate-level regression suggests qualitatively similar results to what we observed for the municipality level analysis. The policy parameter for the overall sample is marginally negative. However, the policy effect is not statistically significant.

Overall, we find that the differences in the definition of the schooling market, computation of Duncan index based on other socioeconomic indicators, and rural-urban differences do not make any substantial changes to the results. However, one concern that we did not address through the above checks is whether the results are robust to alternative socioeconomic disparity measures. We address this next using the M index of socioeconomic segregation.

Alternative segregation measure. Using the Duncan index as the primary outcome variable makes our analysis easy to interpret for policy recommendations and comparable to existing studies in the literature. However, as discussed above, Duncan index has some shortcomings. In this Section, we introduce and discuss an alternative measure of segregation (M index) as it overcomes some of the Duncan index's limitations and helps us ensure that our key results are robust to a different measure.

The Mutual Information index (M index) was first introduced by Theil and Finizza (1971) and developed in Frankel and Volij (2011). M index is based on the concept of diversity. In our school segregation setting, it compares the representation of students from different socioeconomic backgrounds in schools with the overall levels of diversity in a region.

We first introduce the required notation. Let r denote a specific region (there are fifteen regions in Chile). For sake of simplicity, we assume the existence of S schools in every region. Of course, the empirical analysis relaxes this assumption allowing the number of schools (and municipalities) to differ across regions. Every student belongs to either a low or high SES group. Let N be the number of students residing in region r, and N_1 and N_2 be the number of low SES students and high SES students, respectively ($N = N_1 + N_2$). Thus, the M index for school segregation is defined as in Gradín (2014):

$$M = \frac{N_1}{N}\ln\left(\frac{N}{N_1}\right) + \frac{N_2}{N}\ln\left(\frac{N}{N_2}\right) - \sum_{j=1}^{S}\frac{n_j}{N}\left[\frac{n_j^1}{n_j}\ln\left(\frac{n_j}{n_j^1}\right) + \frac{n_j^2}{n_j}\ln\left(\frac{n_j}{n_j^2}\right)\right],$$

where n_j is the fraction of students in school $j \in \{1, ..., S\}$. n_j^1, n_j^2 denote the number of low and high SES students in school j, respectively.

One interesting feature of this index is that it can be decomposed into between and within components, i.e., $M = I_b + I_w$. The first component I_b measures the extent of segregation across municipalities in a region, while the second component, I_w, measures the within municipality school segregation.

Note that the within component measures the extent of school segregation in a municipality, which is comparable to the Duncan index analyzed so far in the paper. We first replicate our key findings using the within component of the M index. Columns (1) and (2) in Table 14 provide results for equation (2) and (3), respectively. We confirm that the increase in school segregation happened in municipalities with more residential segregation and with a higher fraction of private schools in 2015. This ensures that our results are robust to this other measure of segregation.

In addition, we can use the M index to understand the source of variation helping us identify the policy implications. Panel (A) in Figure 12 shows the decomposition of the M index of school segregation into within and between municipality components for 2019. The graph suggests that the within component is the primary source of school segregation across regions. The M index varied between [0.07,0.14] across regions in 2019, and the extent of variation in the within component was [0.06,0.11]. On the other hand, the magnitude of between component variation was much lower ([0.00,0.04]).

Finally, Figure 12 also illustrates that there is substantial heterogeneity across regions in Chile. For example, in Magallanes, which was the first region that adopted the new policy in 2016, the M index showed a slight drop between 2016 and 2017, but it has sharply risen since then. The rise in within component pushed up the M index and the between component decreased between 2017 and 2019. Another compelling case is Los Rios (panel (C)), which adopted the program in 2018. In this region, the M index declined marginally between 2018 and 2019, and most of this decline came through the within component. Some of this drop was undone by the slight uptick in the between component. Such variation is also seen for other regions such as Valparaiso (Panel

(D)).

6 Conclusion

Chile adopted a centralized student assignment system (SAS) in 2016 and implemented it throughout the country sequentially. There is extensive research on the demand side consequences of these mechanisms (Calsamiglia and Güell, 2018; Lucas and Mbiti, 2014). We contribute to this literature by shedding light on the impact of SAS on school segregation.

Despite the fact the Chilean government aimed this policy at advancing the representation of low SES students across schools, our findings do not suggest an overall improvement in the evenness of the student background distribution. We confirm this using multiple indicators. However, our results do indicate heterogeneous effects by levels of pre-existing residential segregation and local school supply. In particular, we document that school districts that had high (low) residential segregation experienced an increase (decline) in school stratification post the implementation of the new system. Beyond residential segregation, we find regions with a higher fraction of private schools have also seen an uptick in segregation due to SAS. These findings highlight the relevance of spatial distribution of schools across municipalities and regions as schools strategically locate themselves to target specific groups.

Moreover, we provide evidence on a potential mechanism explaining our findings. If high SES parents anticipated a more integrated school as a result of SAS, heterogeneous preferences for school socioeconomic composition could have led to strategic responses, with some families switching to private schools. We present evidence supporting these transitions. Indeed, higher SES families responded to the new policy by out-migrating from public and voucher schools. SAS's unintended consequence explains why school districts that had a lower pre-SAS proportion of public or voucher schools witnessed more of this transition to private schools.

We conclude that the ultimate impact of centralized school admission systems depends on how the parents choose schools, which in turn depends on their location and the market structure and characteristics of their neighborhoods. Any policy prescription that aims to improve the extent of diversity within schools requires taking into account the school district's features for desired results.

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Tables and Figures

Table 1: Student and school participation in SAS, national average

Year	All Students	All Schools	Ninth-grade students (%)
	(1)	(2)	(3)
2016	3436	63	46.2
2017	76821	2172	51.2
2018	274990	6421	52.4

Notes: Column (1) and (2) in panel A provide total number of students and schools that participated in SAS across all grades. Column (3) corresponds to the percentage of ninth-grade students participating in SAS. SAS implementation was sequential, therefore, every subsequent year, new regions were added.

Table 2: Quality of match between enrollment and SIMCE files

Variables	N	Mean	Std. dev.	Min.	Max.
Enrollment 2015	265093	–	–	–	–
Matched with SIMCE eight 2014	242574	–	–	–	–
% with valid background info	84.84	–	–	–	–
Mother's education	175208	11.66	3.64	0	22
Father's education	170831	11.67	3.79	0	22
Family income index	176958	4.96	3.50	1	15
Enrollment 2016	259037	–	–	–	–
Matched with SIMCE eight 2015	235884	–	–	–	–
% with valid background info	84.41	–	–	–	–
Mother's education	173888	11.74	3.68	0	22
Father's education	165191	11.67	3.88	0	22
Family income index	173737	5.14	3.52	1	15
Enrollment 2017	255400	–	–	–	–
Matched with SIMCE sixth 2014	239341	–	–	–	–
% with valid background info	80.04	–	–	–	–
Mother's education	168422	12.66	3.67	1	22
Father's education	161247	12.74	3.91	1	22
Family income index	169738	4.94	3.55	1	15
Enrollment 2018	246937	–	–	–	–
Matched with SIMCE eight 2017	229371	–	–	–	–
% with valid background info	87.03	–	–	–	–
Mother's education	172283	12.01	3.63	0	22
Father's education	165711	11.92	3.83	0	22
Family income index	172304	5.60	3.61	1	15
Enrollment 2019	246115	–	–	–	–
Matched with SIMCE sixth 2016	232182	–	–	–	–
% with valid background info	81.04	–	–	–	–
Mother's education	165184	12.09	3.58	0	22
Father's education	157139	11.92	3.72	0	22
Family income index	163323	5.40	3.62	1	15

Notes: Table shows the extent of match between the enrollment and the SIMCE files from 2015 to 2019. We use parents' education and family income index as student background variables, so this Table also lists the number of cases for which we obtained non-missing data for these variables. SIMCE reports a household income index that ranges between 1 and 15. The mean income index of ~5 corresponds to an income between \$400,000 - \$500,000 (in Chilean Pesos).

Table 3: Percentage of students choosing schools in their municipality/province of residence, national level

Year	Students attending school in municipality/province of residence (N^*)	Total number of students (N)	% ($\frac{N^*}{N}$)
	(1)	(2)	(3)
	A. Municipality		
All students			
2015	2772746	3548845	78.1
2016	2758348	3550949	77.7
2017	2750364	3558394	77.3
2018	2759966	3582448	77.0
2019	2774174	3611057	76.8
Ninth graders			
2015	182643	265093	68.9
2016	176889	259037	68.3
2017	174451	255400	68.3
2018	167782	246937	67.9
2019	166001	246115	67.4
	B. Province		
All students			
2015	3289121	3548845	92.7
2016	3278951	3550949	92.3
2017	3273885	3558394	92.0
2018	3286719	3582448	91.8
2019	3301120	3611057	91.4
Ninth graders			
2015	242349	265093	91.4
2016	235396	259037	90.9
2017	230838	255400	90.4
2018	222144	246937	90.0
2019	219723	246115	89.3

Note: We match the resident municipality of each student with the municipality of their school using the enrollment files (panel A). Similarly, matching of student residential province and school province is done in panel B. Column (3) displays the percentage of students attending school in their municipality/province of residence.

Table 4: Composition and distribution of high school types, at the national level

Variable	Number of schools	Percentage of schools/students
	A. **Supply of schools, by type**	
Public	915	30.9
Voucher	1614	54.5
Private	433	14.6
Total	2962	100
	B. **Student enrollment, by school type**	
Public	100793	40.8
Voucher	124295	50.3
Private	21849	8.8
Total	246937	100

Note: The sample for this table consists of all schools offering high school education and all ninth-grade students enrolled in high school in 2018.

Table 5: Descriptive Statistics for variables in regression

Variables	N	Mean	Std. dev.	Min.	Max.
School segregration in municipality (Duncan index)	1,646	0.25	0.19	0.00	0.82
SAS dummy (D_{rt})	1,646	0.22	0.42	0.00	1.00
Intensity of SAS (I_{rt})	1,646	0.19	0.36	0.00	0.96
Residential segregation (access to amenities)	1,623	2.29	5.54	0.00	55.25
% of enrollment in public schools in municipality pre-SAS	1,646	0.60	0.26	0.05	1.00
% of enrollment in voucher schools in municipality pre-SAS	1,646	0.37	0.24	0.00	0.95
% of enrollment in private schools in municipality pre-SAS	1,646	0.03	0.10	0.00	0.81
% of public schools in municipality pre-SAS	1,646	0.61	0.26	0.06	1.00
% of voucher schools in municipality pre-SAS	1,646	0.37	0.24	0.00	0.94
% of private schools in municipality pre-SAS	1,646	0.03	0.09	0.00	0.79
Herfindahl Index pre-SAS	1,646	0.15	0.16	0.01	1.00

Notes: The Duncan index measures school segregation at the level of the municipality. SAS dummy takes a value 1 if SAS was implemented in region r in year t and 0 otherwise. Intensity of SAS $\in [0, 1]$ depends on the fraction of schools in region r that participated in SAS in year t. Pre-SAS corresponds to the year 2015. Percentage (%) of enrollment in public (voucher) pre-SAS corresponds to the fraction of students attending a public (voucher) school in each municipality in 2015. Percentage (%) supply of public (voucher) pre-SAS corresponds to the proportion of public (voucher) schools in each municipality in 2015.

Table 6: Difference-in-Difference: Estimation for School Segregation

	Duncan index			
VARIABLES	(1)	(2)	(3)	(4)
SAS dummy (D_{rt})	-0.001	-0.000		
	[0.006]	[0.006]		
% enrollment in public pre-SAS		-1.051***		-1.051***
		[0.073]		[0.073]
% enrollment in voucher pre-SAS		-0.564***		-0.564***
		[0.079]		[0.079]
Intensity of SAS (I_{rt})			-0.001	-0.000
			[0.007]	[0.007]
Constant	0.109*	1.033***	0.109*	1.033***
	[0.064]	[0.082]	[0.064]	[0.082]
Observations	1,646	1,646	1,646	1,646
R-squared	0.141	0.603	0.141	0.603
Region FE	y	y	y	y
Year FE	y	y	y	y
Additional covariates	n	y	n	y

Notes: ***p<0.01, ** p<0.05,* p<0.1. Standard errors clustered at municipality in square brackets. Column (1) and (2) use SAS dummy as the treatment variable, while column (3) and (4) use intensity as treatment variable.

Table 7: Difference-in-Difference: Heterogeneous effect by Residential Segregation

	Duncan index	
VARIABLES	(1)	(2)
SAS dummy (D_{rt})	-0.012	-0.013
	[0.008]	[0.008]
Residential Segregation	0.002*	0.002***
	[0.001]	[0.001]
SAS dummy (D_{rt}) $\times$ Residential Segregation	0.008*	0.008*
	[0.004]	[0.004]
Constant	1.039***	1.046***
	[0.083]	[0.080]
Observations	1,623	1,623
R-squared	0.598	0.612
Region FE	y	y
Year FE	y	y
Covariates	y	y

Notes: ***p<0.01, ** p<0.05,* p<0.1. Standard errors clustered at municipality in square brackets. In specification (1) we also control for the pre-SAS percentage of students enrolled in public and voucher schools. In specification (2) we add pre-SAS fraction of students in rural schools.

Table 8: Difference-in-Difference: Heterogeneous effects by market concentration and type of schools

	Duncan index		
VARIABLES	(1)	(2)	(3)
SAS dummy (D_{rt})	-0.015	0.372***	0.610**
	[0.010]	[0.137]	[0.255]
% of enrollment in public pre-SAS		-1.053***	
		[0.072]	
SAS dummy (D_{rt})× % of enrollment in public pre-SAS		-0.373***	
		[0.136]	
% of enrollment in voucher pre-SAS		-0.557***	
		[0.077]	
SAS dummy (D_{rt})× % of enrollment in voucher pre-SAS		-0.389***	
		[0.148]	
Herfindahl index	-0.744***		
	[0.066]		
SAS dummy (D_{rt}) ×Herfindahl index	0.080*		
	[0.042]		
% of public schools pre-SAS			-1.029***
			[0.087]
SAS dummy (D_{rt})×% of public schools pre-SAS			-0.601**
			[0.253]
% of voucher schools pre-SAS			-0.569***
			[0.092]
SAS dummy (D_{rt}) × % of voucher schools pre-SAS			-0.656**
			[0.274]
Constant	0.367***	1.082***	1.077***
	[0.012]	[0.071]	[0.086]
Observations	1,623	1,623	1,623
R-squared	0.403	0.599	0.501
Region FE	y	y	y
Year FE	y	y	y

Notes: ***p<0.01, ** p<0.05,* p<0.1. Standard errors clustered at municipality in square brackets. In all specifications residential segregation is also included as an additional covariate. Column (2): Percentage (%) of enrollment in public (voucher) pre-SAS corresponds to the fraction of students attending a public (voucher) school in each municipality in 2015. Column (3): Percentage (%) supply of public (voucher) pre-SAS corresponds to the proportion of public (voucher) schools in each municipality in 2015.

Table 9: Difference-in-Difference: Heterogeneous effects by family background (mother's education)

VARIABLES	Transition (1)
SAS dummy (D_{rt})	0.004**
	[0.002]
Educ mother >= 12	0.010***
	[0.003]
SAS dummy (D_{rt})× [Educ mother >= 12]	-0.004
	[0.004]
Private dummy (pre-SAS)	-0.009**
	[0.004]
Private dummy (pre-SAS) ×[Mother educ. >= 12]	0.015**
	[0.006]
SAS dummy (D_{rt}) ×Private dummy (pre-SAS)	-0.041*
	[0.025]
SAS dummy (D_{rt}) ×Private dummy (pre-SAS)× [Educ mother >= 12]	0.068*
	[0.038]
Constant	-0.004**
	[0.002]
Observations	1,712
R-squared	0.179
Region FE	y
Year FE	y

Notes: ***p<0.01, ** p<0.05,* p<0.1. Standard errors clustered at municipality in square brackets. The outcome variable used here (transition) is the fraction of students that switched from public/voucher to private school in a municipality. Private dummy pre-SAS takes a value 1 for municipalities which had at least one private school previous to the reform, and 0 otherwise. Educ mother dummy takes a value 1 if student's mother has a high school degree, and 0 otherwise.

Table 10: Test for pre-trends with region specific trend variables and fake treatment groups (Duncan index)

	Duncan index	
VARIABLES	(1)	(2)
A. **State specific trends**		
SAS dummy (D_{rt})	-0.001	-0.001
	[0.006]	[0.007]
Constant	1.020***	1.011***
	[0.095]	[0.096]
Observations	1,646	1,646
R-squared	0.535	0.536
Region FE	y	y
Year FE	y	y
Set of covariates	y	y
State specific trend	n	y
B. **Fake treatment group**		
SAS Dummy (D_{rt})	-0.003	-0.002
	[0.008]	[0.008]
Constant	0.108*	1.015***
	[0.065]	[0.097]
Observations	1,315	1,315
R-squared	0.138	0.500
Region FE	y	y
Year FE	y	y
Additional covariates	n	y

Notes: ***p<0.01, ** p<0.05,* p<0.1. Standard errors clustered at municipality in square brackets. In panel (A) we perform the formal test for parallel trends using state specific trend variable. In panel (B) we conduct a placebo test using fake treatment groups. Both specifications also include additional covariates such as the pre-SAS fraction of public, voucher and private schools in a municipality.

Table 11: Difference-in-Difference: Estimation for school segregation with father's education and income index

	Duncan index			
VARIABLES	(1)	(2)	(3)	(4)
		A: Father's education		
SAS dummy (D_{rt})	0.000		0.001	
	[0.006]		[0.006]	
Intensity of SAS (I_{rt})		0.001		0.002
		[0.007]		[0.007]
Constant	0.096	0.096	1.072***	1.072***
	[0.060]	[0.060]	[0.085]	[0.085]
Observations	1,646	1,646	1,646	1,646
R-squared	0.133	0.133	0.609	0.609
Region FE	y	y	y	y
Year FE	y	y	y	y
Additional covariates	n	n	y	y
		B: Household Income Index		
SAS dummy (D_{rt})	-0.004		-0.004	
	[0.011]		[0.010]	
Intensity of SAS (I_{rt})		-0.004		-0.003
		[0.012]		[0.012]
Constant	0.115***	0.115***	0.930***	0.930***
	[0.005]	[0.005]	[0.064]	[0.064]
Observations	1,646	1,646	1,646	1,646
R-squared	0.182	0.182	0.561	0.561
Region FE	y	y	y	y
Year FE	y	y	y	y
Additional covariates	n	n	y	y

Notes: ***p<0.01, ** p<0.05,* p<0.1. Standard errors clustered at municipality in square brackets. In panel (A) we use father's education to construct the Duncan index, while in panel (B) it is computed using household income. In columns (1) and (3) we employ SAS dummy as the treatment variable, and in columns (2) and (4) we use intensity of SAS. Columns (3) and (4) also include additional covariates such as the pre-SAS fraction of public, voucher and private schools in a municipality.

Table 12: Difference-in-Difference: Estimation for school segregation using municipalities with urban schools only

	Duncan index			
VARIABLES	(1)	(2)	(3)	(4)
SAS dummy (D_{rt})	0.003		0.004	
	[0.010]		[0.012]	
Intensity of SAS (I_{rt})		0.006		0.006
		[0.014]		[0.014]
Constant	0.407***	0.407***	1.167***	1.167***
	[0.005]	[0.046]	[0.087]	[0.087]
Observations	224	224	224	224
R-squared	0.304	0.304	0.778	0.778
Region FE	y	y	y	y
Year FE	y	y	y	y
Additional covariates	n	n	y	y

Notes: ***p<0.01, ** p<0.05,* p<0.1. Standard errors clustered at municipality in square brackets. In columns (1) and (3) we employ SAS dummy as the treatment variable, and in columns (2) and (4) we use intensity of SAS. Columns (3) and (4) also include additional covariates such as the pre-SAS fraction of public, voucher and private schools in a municipality.

Table 13: Robustness check for the definition of the market

	Duncan index	
VARIABLES	(1)	(2)
SAS dummy (D_{rt})	-0.006	
	[0.006]	
SAS treatment intensity (I_{rt})		-0.007
		[0.006]
Constant	0.288***	0.288***
	[0.108]	[0.108]
Observations	269	269
R-squared	0.348	0.348
Region FE	y	y
Year FE	y	y
Additional covariates	n	n

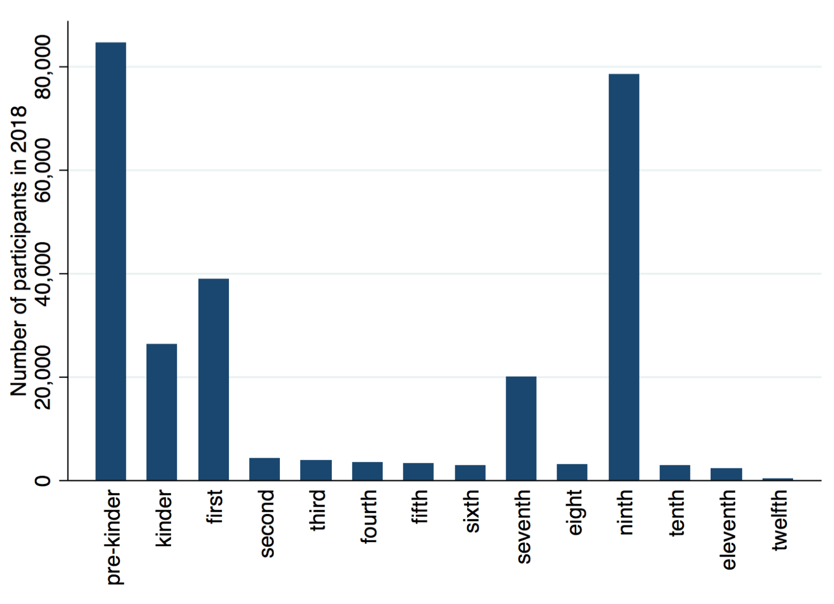
Notes: ***p<0.01, ** p<0.05,* p<0.1. Standard errors in square brackets. As the Duncan index for this robustness check is constructed at the province level instead of municipality, standard errors are clustered at province. In column (1) we employ SAS dummy as the treatment variable, and in column (2) we use intensity of SAS.

Table 14: Factors driving the within component heterogeneity in M index

	M index (within component)	
VARIABLES	(1)	(2)
SAS dummy (D_{rt})	-0.007*	0.251***
	[0.004]	[0.068]
% of enrollment in public pre-SAS		-0.206***
		[0.054]
SAS dummy (D_{rt})×% of enrollment in public pre-SAS		-0.248***
		[0.068]
% of enrollment in voucher pre-SAS		-0.078
		[0.059]
SAS dummy (D_{rt})×% of enrollment in voucher pre-SAS		-0.261***
		[0.072]
Residential segregation	-0.001	
	[0.001]	
SAS dummy (D_{rt})×Residential segregation	0.002***	
	[0.001]	
Constant	0.030**	0.210***
	[0.015]	[0.055]
Observations	1,623	1,646
R-squared	0.094	0.433
Region FE	y	y
Year FE	y	y
Covariates	n	n

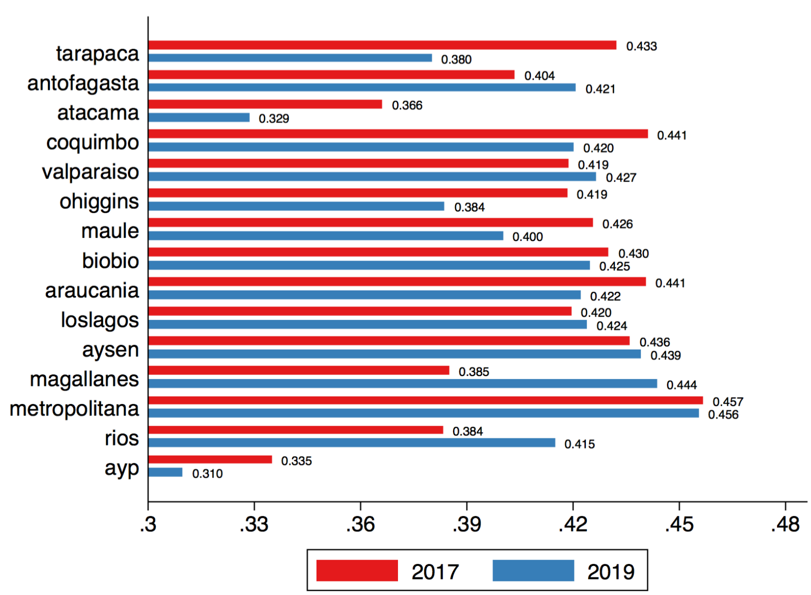
Notes: ***p<0.01, ** p<0.05,* p<0.1. Standard errors clustered at municipality in square brackets. In column (1) we perform the heterogeneous effect using residential segregation. In column (2) we do the same using the local pre-SAS school structure.

Figure 1: Participants across grades in SAS in 2018



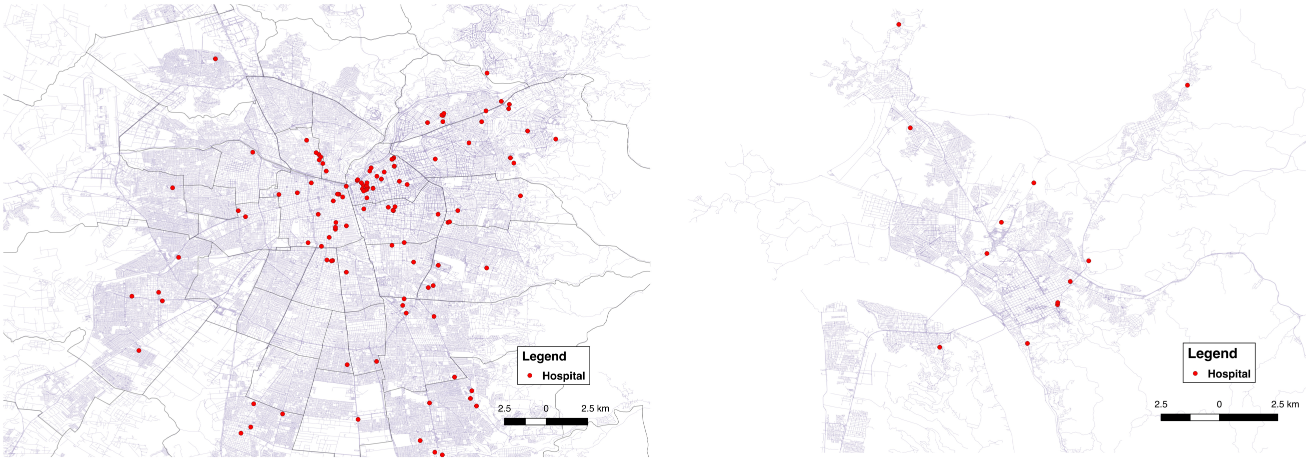
Notes: By 2018, all regions in Chile except Metropolitana had the new policy for school admission process. We observe that most participants apply to pre-k and ninth grade admissions.

Figure 2: Comparison of Duncan index between 2017 and 2019, by region



Notes: The only region that had the new policy implemented in 2017 was Magallanes. The new system was implemented in all other regions by 2018, except Metropolitana.

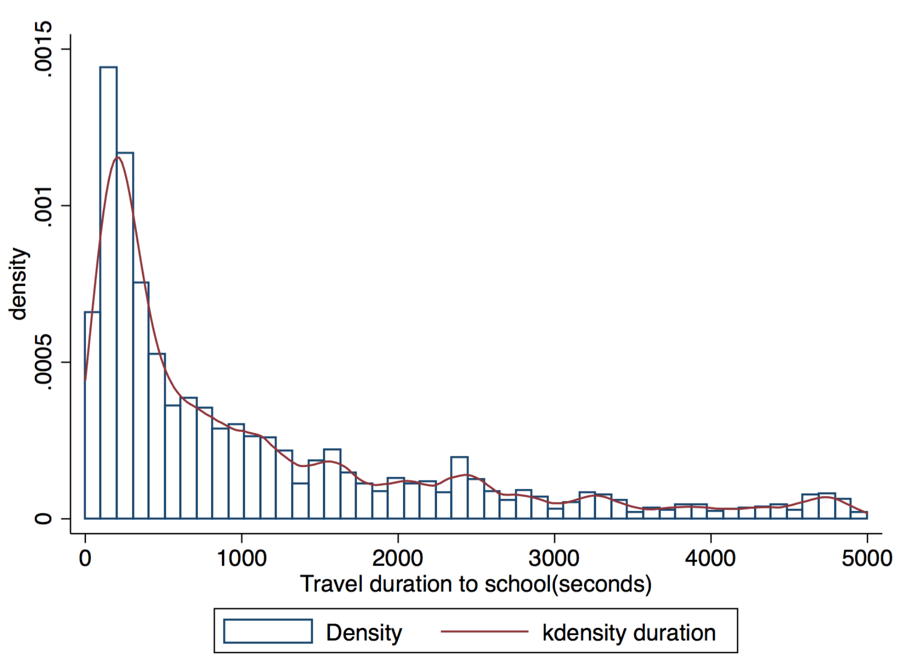
Figure 3: Residential segregation: Spatial distribution of hospitals in two large provinces



A. Santiago B. Concepcion

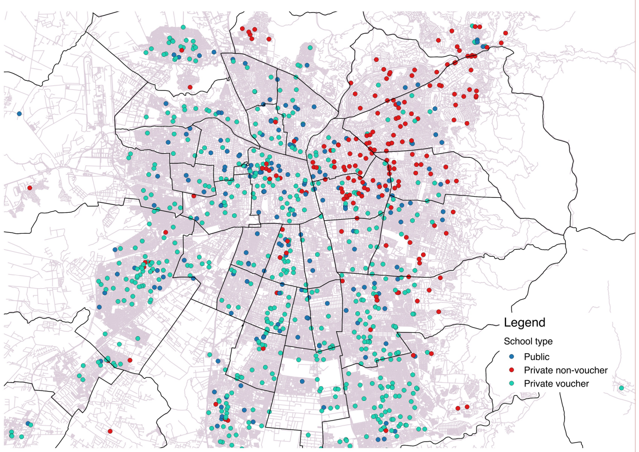
Notes: Panel (A) displays the spatial distribution of hospitals in Santiago province (Metropolitana region). Panel (B) does it for Concepcion province (Biobio region).

Figure 4: Travel time to school for ninth graders in 2018

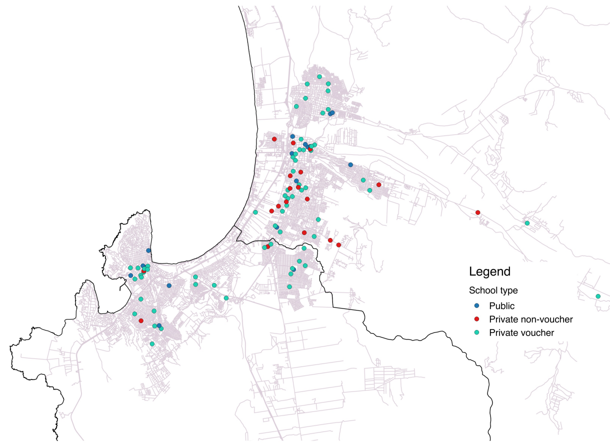


Notes: We display the travel time by car for ninth-grade students in 2018. This travel time computation was done using OSRM API.

Figure 5: Spatial distribution of different types of schools in the Metropolitana and Coquimbo regions



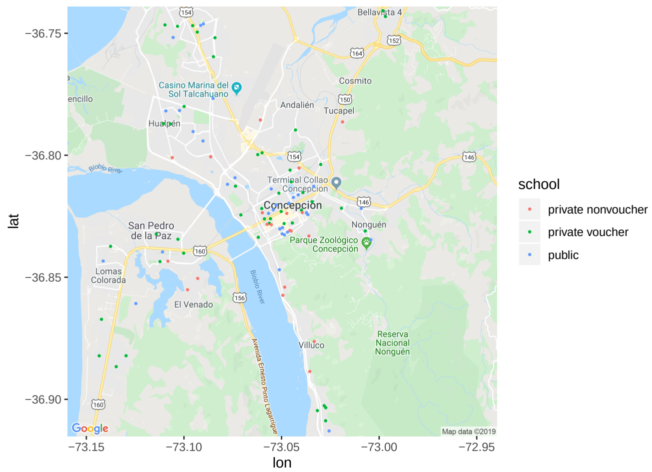
A. Metropolitana



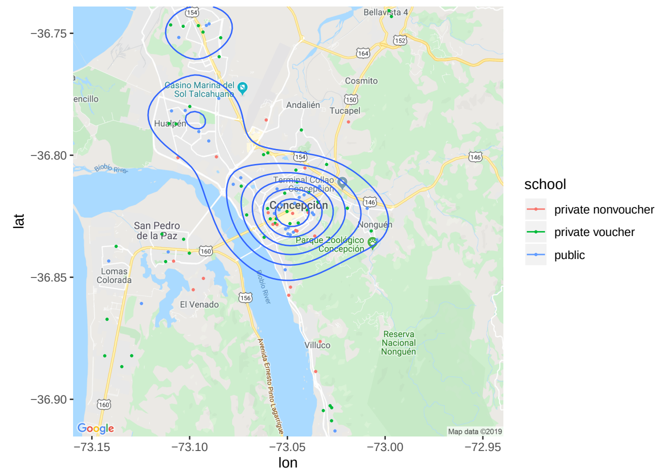
B. Coquimbo

Notes: The graph shows the spatial distribution of public, voucher and private schools for different municipalities in Metropolitana and Coquimbo regions.

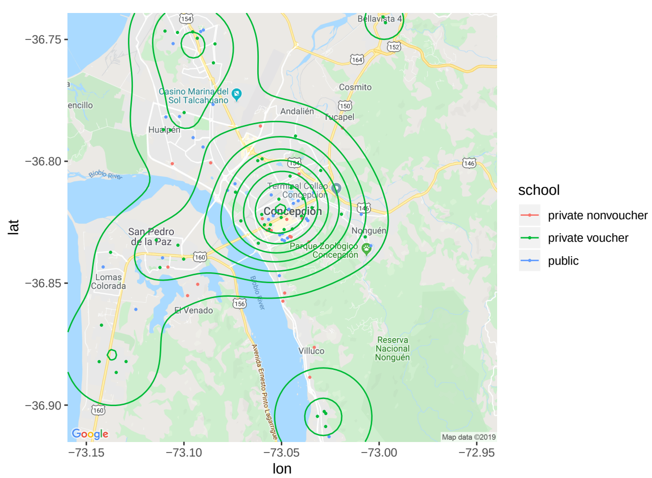
Figure 6: Spatial density plots of school distribution in Biobio Region



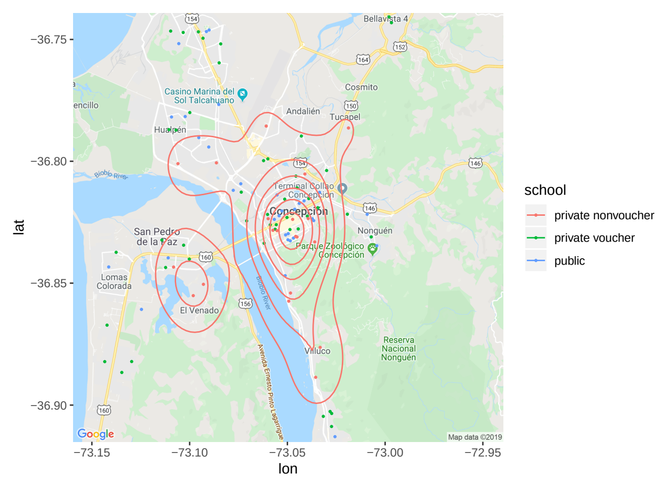
A. All schools



B. Public schools



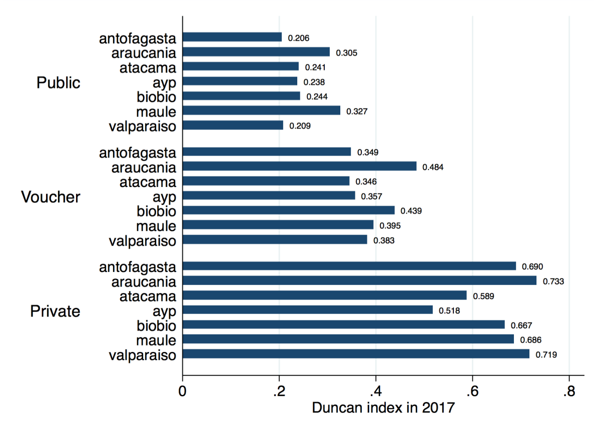
C. Voucher schools



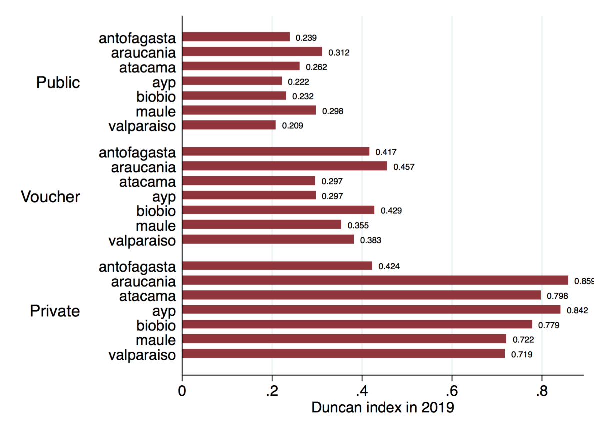
D. Private schools

Notes: Figure displays contour plots for spatial density of different school types. We observe that voucher schools are more evenly spread as compared to public and private schools in Biobio region.

Figure 7: Differences in segregation by school type



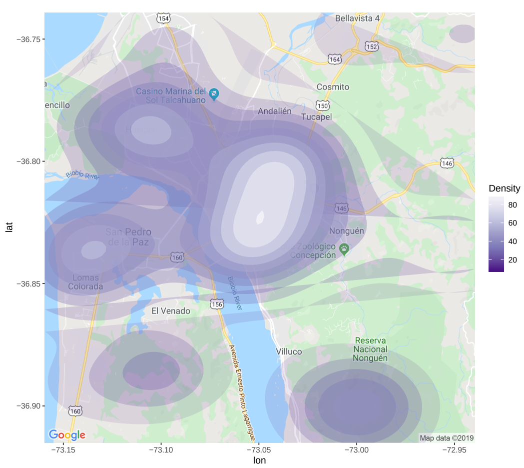
A. 2017

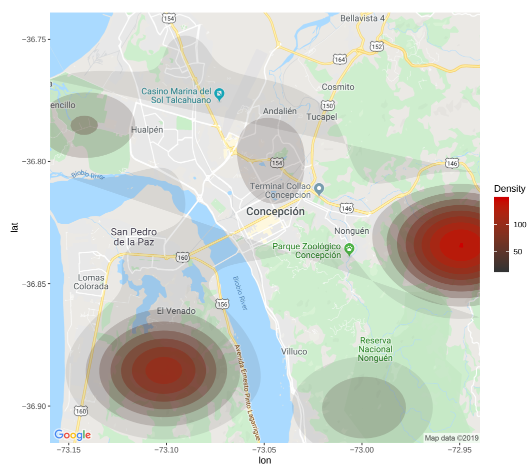


B. 2019

Notes: We consider differences in the Duncan index by three types of school-public, voucher, and private. Segregation is more pronounced in the private schools than in the public/voucher schools.

Figure 8: Spatial density plots of low and high SES students in Biobio region

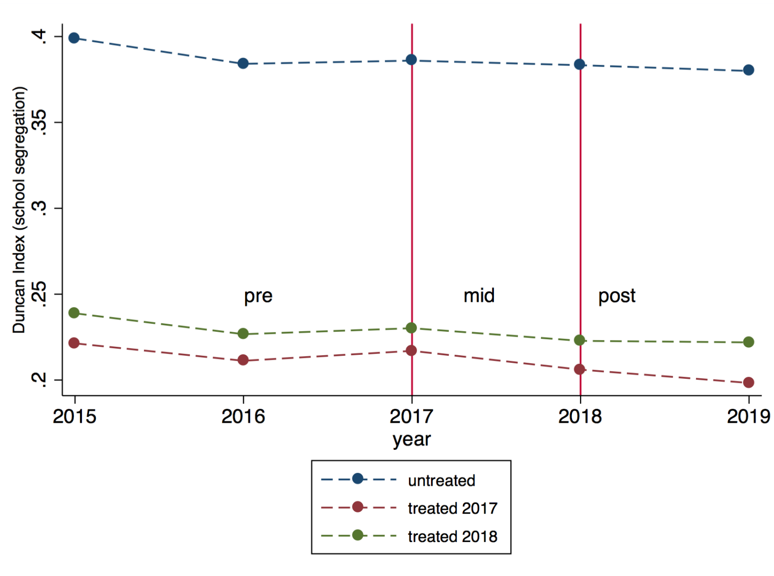




A. Students in lowest income category B. Students in highest income category

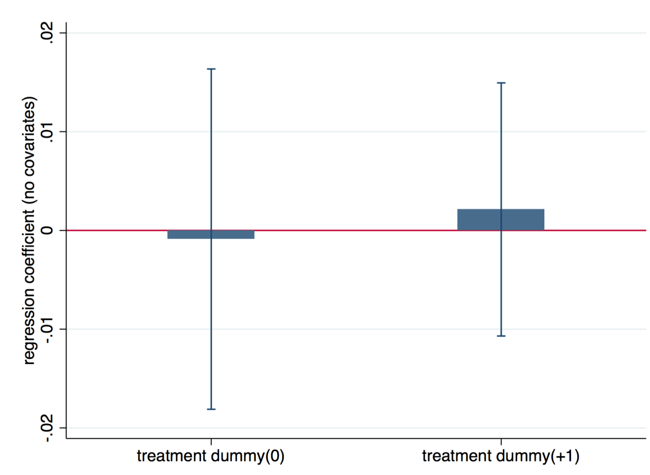
Notes: We plot the contour densities for low and high income students in Biobio region. This illustrates that high income students and low income students are located in non-overlapping pockets.

Figure 9: Parallel trends with treatment time variation

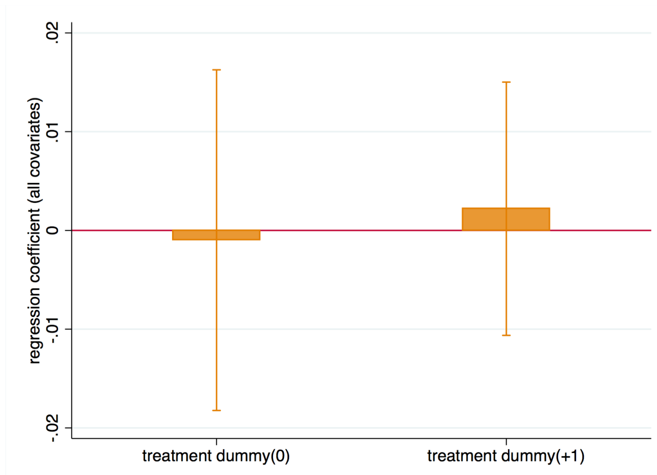


Notes: This is the visualization of the modified parallel trends assumption due to sequential implementation of SAS. For the purpose of this exercise the regions were divided into early (2017), late (2018) and control groups.

Figure 10: Leads and lags analysis for parallel trends



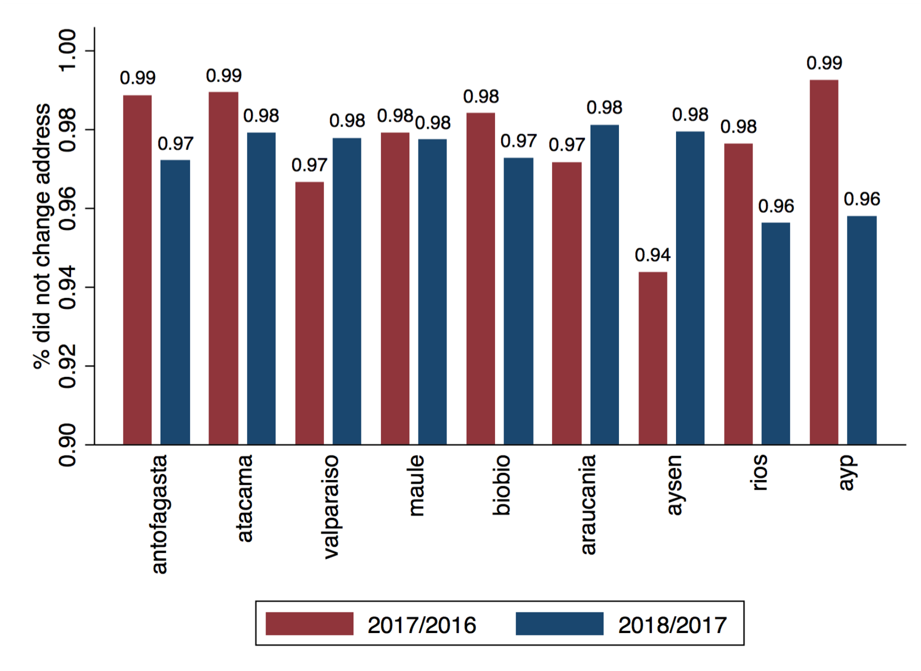
A. Model 1: No covariates



B. Model 2: With covariates

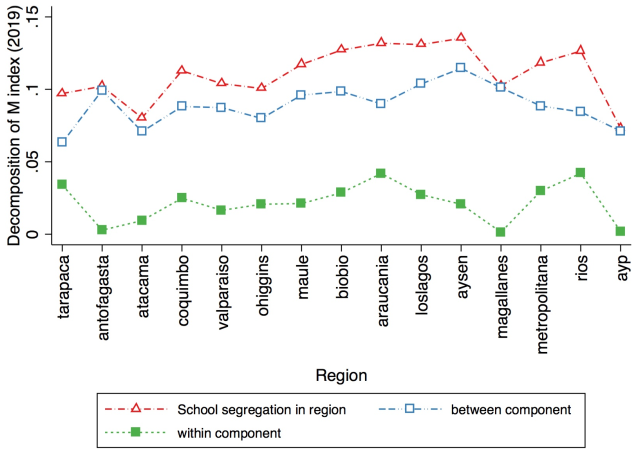
Notes: Figure displays the leads and lags test for parallel trends assumption. The list of control variables for the second specification in panel (B) includes the pre-SAS fraction of public, voucher, private schools and rural schools.

Figure 11: Change in residential addresses in response to introduction of SAS, by region

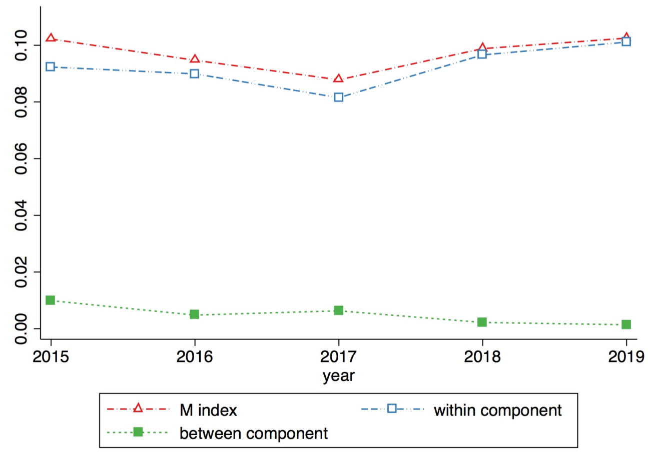


Notes: We explore whether there was a systematic increase in residential changes in response to the policy. We perform this analysis for regions in which SAS was implemented in 2017 and was effective in 2018.

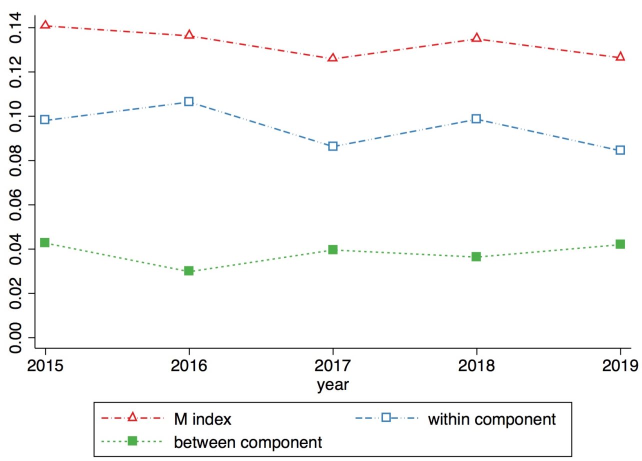
Figure 12: Decomposition of M information index into within and between components



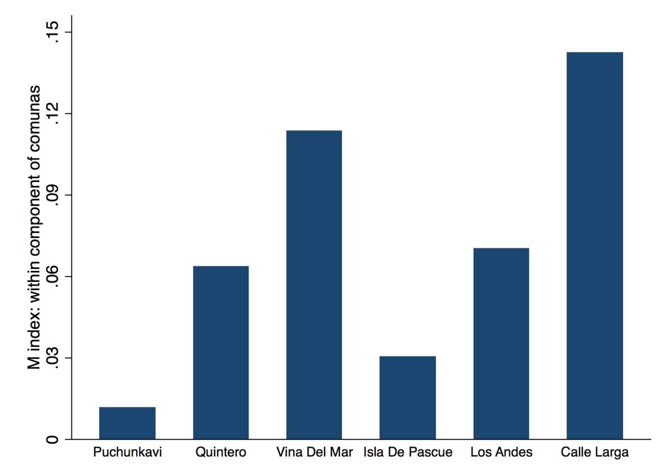
A. 2019 by Region



B. 2015-19: Magallanes



C. 2015-19: Los Rios



D. Within component: Valparaiso

Notes: Figure displays the decomposition of the M index into within and between components. For this exercise we use SIMCE and enrollment data for 2015, 2016, 2017, 2018 and 2019 for this analysis.