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**School Choice Priorities and School Segregation:
Evidence from Madrid**

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Resumen No Técnico

En las últimas décadas, la segregación escolar ha recibido una atención sustancial en el debate público educativo global. La segregación se puede definir como el grado en el que dos o más grupos de la población están separados el uno del otro (ej., inmigrantes en comparación con nativos). Existe una amplia literatura económica que muestra cómo la segregación escolar afecta a la igualdad de oportunidades de los estudiantes. La investigación académica destaca dos mecanismos principales que determinan la segregación escolar. En primer lugar, la segregación residencial de las familias, que se debe a la interacción de la elección de la residencia principal por estas y el resultado de diferentes políticas de vivienda. En segundo lugar, los mecanismos y reglas que establece el Estado para asignar colegios a los estudiantes, como el mecanismo de asignación, las fronteras de los distritos escolares, o los puntos de prioridad que recibe cada estudiante (otorgados p. ej. por proximidad al colegio o diferentes variables socioeconómicas). A pesar de la abundante investigación sobre segregación escolar, todavía no se ha averiguado el alcance y la magnitud del impacto de los puntos de prioridad residencial en la segregación escolar: esto es, no existe una relación clara causal entre el grado de elección de las familias y la segregación escolar.

En este trabajo se investigan dos elementos de la reforma aplicada en la Comunidad de Madrid entre 2012 y 2013, conocida como “reforma del distrito único”. Se analiza cómo el cambio de los puntos de prioridad impacta en las decisiones de elección de colegio de las familias, y sucesivamente en la segregación escolar (definida mediante dos variables: la educación de los padres y la nacionalidad del estudiante). Se analizan dos decisiones más relevantes de la reforma ligadas al proceso de admisión, ambas asociadas a cambios en los puntos de prioridad por parte de las familias. En 2012/2013, se redujo el nivel de prioridad otorgado a estudiantes con familias de bajos ingresos (al reducir la proporción de alumnos dentro del baremo), y se añadieron puntos adicionales a estudiantes con un familiar antiguo alumno del colegio. En 2013/2014, los puntos de prioridad por residencia pasaron a ser mucho menos relevantes. En la ciudad de Madrid (objeto central del estudio) los 21 distritos escolares de la ciudad de Madrid se unieron para crear un distrito único educativo de facto. Para llevar a cabo el análisis se usan datos administrativos de todas las familias solicitantes al sistema público de educación (colegios públicos y concertados) en la Comunidad de Madrid desde 2010/2011 hasta 2016/2017. Se consideran distintas técnicas econométricas para aislar el impacto de la reforma de otros factores relevantes (como las características de las familias, densidad de población de distrito, oferta educativa del distrito y sobre todo, patrones de segregación residencial de las familias).

Los resultados de esta investigación muestran que el distrito único educativo ha incrementado la asignación de las familias a centros en distritos educativos distintos a los de su residencia habitual, y ha aumentado la distancia de viaje del hogar a la escuela. El distrito único incrementó en un 30% el número de familias que solicitan (y son admitidas) en un colegio de un distrito escolar distinto al que residen habitualmente. En términos absolutos, las familias de mayor nivel educativo reaccionaron más a la reforma, pero en términos relativos, las diferencias de incrementos se mantienen constantes entre distintos niveles educativos. Por su parte, las familias con hijos de nacionalidad española reaccionaron más fuertemente a la reforma en el año de implementación, mientras que las familias con niños extranjeros no reaccionan en absoluto durante los dos primeros años de la reforma (aunque tres años después de la reforma en términos reaccionan en la misma proporción que lo hacían antes de la reforma). Estos resultados sugieren un proceso de aprendizaje a lo largo del tiempo por las familias con niños extranjeros.

Los efectos de ambas reformas en la segregación escolar presentan resultados distintos para cada una de las dos decisiones. En primer lugar, la reforma de 2012/2013 (asociada a los puntos de alumnos de rentas bajas e hijos de antiguos alumnos) incrementó la segregación escolar por nivel de educativo y estatus de inmigrante (en un 3 y 13 por cien, respectivamente). En segundo lugar, el cambio de baremo de distrito (el distrito único) apenas muestra impacto alguno en la segregación escolar, siendo, por tanto, neutro (después de controlar por la segregación residencial).

Los resultados de este estudio indican que los mecanismos y reglas de asignación de estudiantes a los colegios, y en concreto, los puntos de prioridad juegan un papel relevante para explicar los niveles de segregación escolar. Si el objetivo de política pública es el de disminuir los niveles de segregación escolar, los puntos de prioridad otorgados a estudiantes con familias de bajos ingresos deberían considerar una población más amplia y a la vez incrementarse, además de abolir los puntos otorgados a estudiantes con un familiar exalumno del colegio. En el caso de Madrid, el distrito único tiene un efecto neutro en la segregación escolar, y por tanto, no parece ser una política efectiva para reducir la segregación escolar (aunque puede favorecer el bienestar de algunas familias al ser asignadas a un colegio de un distrito diferente). Por tanto, los puntos de prioridad (al igual que otras políticas igualmente clave del proceso de oferta y asignación de centros) deben ser diseñadas con cautela para poder alcanzar los objetivos de diversidad que se establezcan en la política pública.

School Choice Priorities and School Segregation: Evidence from Madrid*

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Abstract

We test how government-determined school choice priorities affect families' choices and pupil sorting across schools in the context of the Boston Mechanism. We use two large-scale school choice reforms in the school choice priority structure undertaken in the region of Madrid (Spain) in 2012 and 2013 as a source of variation. In 2012, low-income priorities to the top-ranked school were reduced, and points to alumni family members of the top-ranked school were granted. In 2013, an inter-district school choice reform widely expanded families' choice set of schools. We combine an event study first difference across cohorts and a Difference-in-Difference design to identify the impact of the reforms, using unique administrative data on parents' applications to schools. We show that reducing low-income priorities to the top-ranked school and granting points to alumni family members of the top-ranked school increases school segregation by parental education and immigrant status on 3 and 13 percent, respectively. Families reacted to the 2013's inter-district reform exerting higher inter-district choice and applying to schools located further away from home than before the reform. We find heterogeneous effects, showing potential information gaps and dynamic learning process across immigrant status groups throughout time. Moreover, the inter-district school choice reform marginally reduced school segregation by parental education and largely increased school segregation by immigrant status, but both effects fade out when controlling for residential stratification. Results suggest that priority structures need to be carefully designed to achieve diversity objectives and that abolishing school choice proximity points does not seem an effective public policy for reducing school segregation under the Boston Mechanism.

JEL Codes: I24, I28

Keywords: Education and Inequality, Education Policy, School Choice, School Segregation.

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1 Introduction

School segregation has received substantial attention in the education debate in the last decades. Excessive school segregation is becoming a growing public concern, and international organizations are starting to warn education authorities about the risks of leading to student disadvantage through school segregation (OECD, 2019; Musset, 2012). A relatively large literature analyzes the effects of school segregation, with recent empirical evidence showing that school segregation may contribute to create unequal opportunities for pupils of different schools (Hoxby, 2000; Card and Rothstein, 2007; Hanushek, Kain and Rivkin, 2009). However, there is still limited evidence on understanding the mechanisms that give rise to school segregation. Böhlmark, Holmlund and Lindahl (2016) highlight two key mechanisms that may explain school segregation. First, residential segregation across neighborhoods, which levels may be a result of residential sorting, the so-called Tiebout choice (Tiebout, 1956), or housing policies. Second, the mechanisms and rules for assigning pupils to schools, such as the assignment mechanism, student priorities for schools, school planning, or boundaries of catchment areas, which are the critical components of school choice. There is a fast-growing literature on the market design questions to school choice, mainly devoted to analyzing the relative performance and strategic implications of alternative matching allocation mechanisms, taking the inputs of school choice -preferences, priorities, and capacities- as exogenous (Abdulkadiroglu and Sönmez, 2003). Nevertheless, the extent and magnitude through which school choice priorities impact school segregation remains unclear.

In this paper, we broaden the scope of the market design questions to school choice by investigating how government-determined school choice priorities affect households' choices and pupil sorting across schools. We use two large-scale school choice reforms in the school choice priority structure as a source of variation. First, the low-income priorities' to the top-ranked school were reduced, while students with alumni family members at the school of interest were granted an additional point in the school year 2012/2013. Second, the resident-based priorities to assign pupils to schools were almost completely abolished in 2013/2014. The city of Madrid counts 21 school districts that were almost merged *de facto* into a unique single district.¹ Using unique administrative data on the universe of applicants to the public school system from 2010 to 2016 in the Region of Madrid, along with detailed data on school supply, household socioeconomic characteristics, and standardized test scores, we explore the relationship between changes in school choice admission priorities and families' out of district assignment and school segregation. We combine two different empirical strategies to identify the impact of the reforms. First, we use an event study first-difference approach, comparing families entering the educational system for the first time (preschool, aged 3) before and after the policy changes. Second, we use a Difference-in-Difference Analysis (DID). A limitation of the institutional context is that both reforms were implemented at the same time for every school district of the city of Madrid. Thus, the institutional setting does not provide an alternative control group, since all families are "treated" by the reforms. However, we exploit an analysis based on the spirit of treatment intensity by focusing on parents that are closer to the school district boundaries ("treatment

¹In the Region of Madrid, the Regional Government, enlarged the choice zone to the municipal level, granting a broader set of options to all households. The reform moved from around 2,000 within-municipality catchment areas to 179 single municipal zones. We focus on the city of Madrid for our primary analysis.

group”) and comparing them with those whose primary residence is located at the geometric center (centroid) of each the school district boundaries (“control group”).

The context of this study is unique due to the school choice allocation mechanism and the levels of school segregation before the reform. First, we exploit changes in student priorities in a system where the student assignment mechanism to assign pupils to school is the so-called Boston Mechanism (BM). This allocation mechanism has limitations to capture truthful families’ preferences ([Abdulkadiroglu and Sönmez, 2003](#)), and fosters socioeconomic (strategic) segregation across schools in the public system even with open school choice ([Calsamiglia et al., 2017](#)). In the BM, families’ incentives to top-rank the school in which they have the highest number of points is remarkably strong, hence choices do not necessarily reflect preferences. In other words, under this mechanism, families choose what they can access but not necessarily what they truly want. The change in the inter-district school choice policy reform promoted a *de facto* increase in the families’ choice set. Before the reform, their choice set was mainly restricted to those schools located within their school district, and after the reform, it is every school in the city of Madrid. In this context, the BM setting allows identifying the effect of the reform (this massive increase in the choice set), since we can make this comparison due to the strategic character of the BM. Otherwise, if the allocation mechanism would be strategy-proof (e.g., Deferred Acceptance instead of BM), the preference-revelation should not depend on priorities. Second, the pre-reform levels of school segregation by socioeconomic characteristics in the Region of Madrid were relatively high, while school segregation by immigrant status was rather low.² Then, we can explore the effects on two layers of school segregation widely studied in the empirical evidence (i.e., parental education and immigrant status) that count with highly different pre-determined levels of school segregation. Therefore, our institutional context allows us to investigate the impact of changing the government-determined priorities that increase households’ school choice set on family choices and school segregation, under an allocation system that promotes socioeconomic segregation ([Calsamiglia et al., 2017](#)).

We contribute to the currently existing literature in three main dimensions. First, we can compute the contemporaneous effect of increasing choice on school segregation at the earliest schooling stage (preschool for 3 years old students). Most of the literature focuses on secondary education, an approach that entails two different aspects: (i) Segregation may be the result of a combination of factors that are shaped in earlier educational stages; (ii) Priority bonus in secondary education are typically based on student grades, while those of primary education are usually centered on socio-demographic indicators which may potentially have a more direct impact on school segregation. Second, this paper can closely relate changes in school choice priorities with the immediate impact on school segregation. Most of the related literature has focused either on broader contexts or on the impacts of early-stage policy reforms (e.g., primary education) of later phases of the educational career (e.g., secondary education) -which results may be potentially biased by time-variant confounding factors-. Third, this paper explores variables that some of the previous literature does not consider, such as families’ choices or the precise geo-location of the household’s primary residence and schools. This allows us to control for variables that are determinants of school segregation, such as residential segregation.³

²See [Murillo, Garrido and Belavi \(2017\)](#) and [Murillo and Garrido \(2018\)](#).

³[Oosterbeek, Sóvágó and Klaauw \(2019\)](#) decompose school segregation in five main additive components, such

The relationship between school choice reforms and student segregation has generated significant policy interest. During the last three decades, there has been a clear pattern of educational authorities have increased the degree of school choice in their educational systems (Musset, 2012). In the US, many school choice reforms were complemented by busing programs (e.g., Seattle in 1999 or North Carolina in 2002). In particular, school choice reforms involve, among others, zoning and de-zoning policies, changes in admission criteria, and changes in the system of assignment of students to schools. The potential effects of those policies on school segregation are not straightforward. From a theoretical point of view, Jenkins, Micklewright and Schnepf (2008) points out three main mechanisms that give rise to school segregation: residential segregation, parental choice, and school’ selection of pupils. Residential segregation may be influenced by Tiebout Choice (Tiebout, 1956) or the residence-based priorities to access schools. We expect a strong correlation between the level of residential and school segregation when residence-based priorities bonus is high. Hence, relaxing proximity-based priorities may affect school segregation in different directions.

On the one hand, parents with higher levels of information and preferences for accessing a better performing school may exert higher degrees of choice. If the lack of information and preferences to choose the closest school are correlated with lower household socioeconomic background and immigrant status, we may expect that the reform increases the levels of school segregation.⁴ On the other hand, under a system with strong residence-based priorities and high levels of school segregation, relaxing residence-based priorities may help families who live in deprived neighborhoods to opt-out of the assigned school, contributing to reduce the levels of school segregation.

Most of the previous studies have limited scope to disentangle between segregation that is due to school stratification of residential sorting. An advantage of our paper is that thanks to the richness of the administrative data, we can identify both school and residential segregation (neighborhood stratification). Moreover, most of the empirical evidence devoted to analyzing the impact of increasing the level of choice in school segregation finds a positive relationship between choice and segregation. Epple, Romano and Urquiola (2017) review the theoretical, computa-

as residential segregation, preference heterogeneity, or capacity constraints, in the context of secondary-school with a Deferred Acceptance allocation mechanism.

⁴The literature describes that parents tend to value peer composition of the school mostly and, only to a lesser extent, the effectiveness of the school in the learning progress of students given their socioeconomic characteristics (Rothstein, 2006; Mizala and Urquiola, 2013). Preferences for schools are different depending on families’ socioeconomic backgrounds since preferences for different dimensions of education vary across types (Anderson, A. Palma and Thisse, 1992; Burgess et al., 2015). Hastings, Kane and Staiger (2009) find that while high-income families care mainly about test scores, more impoverished and minority families must trade-off preferences for high-performing schools against preferences for a predominantly minority nearby schools. The authors argue that the difference in choice responses leads to a more stratified school system, as the impact of school choice policies is determined eventually by parents’ preferences on education. The provision of information also matters. Hastings and Weinstein (2008) show, using a natural field experiment, that low-socioeconomic parents receiving information about the school performance increase their likelihood of choosing a high-scoring school.

Additionally, beyond income factors, the sociology and psychology literature has identified several mechanisms through which school choice is shaped by own aspirations, behaviors, social capital, and networks. For example, Teske and Schneider (2001) discuss parental involvement and motivation as drivers of differences in school choice.

tional, and empirical literature on student vouchers: they argue that large-scale voucher systems are associated with more student sorting by ability or parental income, while the introduction of those programs leads public schools to improve. [Böhlmark, Holmlund and Lindahl \(2016\)](#) investigate the effects of a Swedish universal voucher reform in 1992 on school segregation in upper secondary education, which introduced new independent schools and increased the level of parental choice. Exploiting variation in school choice across municipalities, they find that in those regions where school choice became more prevalent, school segregation by immigrant status and parental education increased the most. However, the increase in school segregation that is attributed to the reform in the long term is of moderate size.⁵ [Söderström and Uusitalo \(2010\)](#) focus on an admission reform undertaken in 2000 that changed admission criteria to those solely based on grades for access to upper secondary schools in Sweden. They find that segregation by ability increased, and although the increase in segregation by socioeconomic background is explained by ability sorting, the increase in immigrant segregation may be attributed to the reform.⁶ Other strands of the literature analyze the characteristics of those families who decide to opt-out of their assigned school ([Levin, 1998](#); [Hastings, Kane and Staiger, 2005](#)), the “typing points” for schools ([Card, Mas and Rothstein, 2008](#)),⁷ the impact of choosing private schools on school segregation ([Hsieh and Urquiola, 2006](#); [Figlio and Stone, 2001](#)).⁸, peer effects ([Duflo, Dupas and Kremer, 2011](#)), or the impact of segregation on social cohesion ([Billings, Deming and Rockoff, 2014](#)).

We find that the inter-district school choice reform undertaken in the city of Madrid is associated with an increase in the fraction of outer school district applications and an increase in the distance to the final assigned school of 3 percentage points and 259 meters respectively (30% and 22% with respect to the baseline mean). This result implies that families change their choices when their choice set is amplified. Results are robust to different specifications using both the event study first difference approach and DiD. Even though families of higher quintiles of parental education reacted more to the reform in absolute terms, relative effects were somewhat similar across parental education quintiles (about 30%). Hence the overall inter-district assignment patterns remain constant. Different results emerge when comparing the effects by immigrant status: families with Spanish-born children entirely drive the increase in the outer district assignment and distance to first assigned school since parents of immigrant children

⁵[Böhlmark and Lindahl \(2007\)](#) find evidence of students being sorted by immigrant origin and parental background shortly after the reform was implemented.

⁶[Yang Hansen and Gustafsson \(2016\)](#) find the same results using multilevel models. [Burgess, Propper and Wilson \(2007\)](#) explore the relationship between school segregation and the number of schools available in three cities of the UK, finding an increase in the levels of school segregation by immigrant status, parental income and student ability.

⁷There is evidence of the so-called “white flight” effects, which happens when white students decide to leave certain schools in which the fraction of a minority group is above certain threshold.

⁸In addition, the New Zealand reforms that were implemented in the 90s have been shown to have increased social and immigrant segregation of schools ([Ladd and Fiske, 2001](#)). However, other factors interacting with choice settings may be playing a hidden role in the real effects, such as how schools can implement explicit or implicit forms of discrimination. For example, [Burgess and Briggs \(2010\)](#) investigate the effect of school choice on social mobility in secondary education in England. They find that children from low-income families are less likely to get places in good schools, and that probability is unaffected by the degree of school choice. This suggests that there must be other additional features belonging (or related) to the educational system that affect student mobility beyond the degree of school choice.

do not seem to have reacted at all in the first two years of the reform. Interestingly, results support the idea of potential information gaps across immigrant status groups, since immigrant started to react to the reform (by the same magnitude as Spanish families) three years after the implementation of the reform. The dynamics seem to point out for a learning process over time of families with non-Spanish children, catching up on the absolute effect of the reform in the last observed two years (2015 and 2016).

We measure school segregation using the Mutual Information Index, which satisfies several desirable properties (Frankel and Volij, 2011). We find a decreasing trend in school segregation by parental education over time (mostly driven by the decrease in within school district segregation), but an increasing trend in school segregation by immigrant status. We find that reducing low-income priorities to the top-ranked school and granting points to alumni family members of the top-ranked school is associated to an increase in school segregation by parental education and immigrant status on 3 and 13 percent, respectively. Results are robust to controlling for residential segregation, school district fixed effects, and time-variant district characteristics. Furthermore, we find that the inter-district school choice reform is associated with a relatively marginal reduction in school segregation by parental education, but with a substantial increase in school segregation by immigrant status. However, both effects fade out when controlling for pure residence-based segregation.

There is an institutional characteristic that directly relates to the interpretation of the results, which we do not directly observe. In the list of priority points in case of over-demand of schools, a specific point is decentralized to the school principals' decision to break ties. School principals may have stronger preferences for students of higher ability (a characteristic that is correlated with higher socioeconomic background and non-immigrant status). In this case, this point does not change after the reform. However, the school principals may use it with higher intensity after the reforms to counterbalance the potential increase of pupils from lower socioeconomic background and non-immigrant status to self-select their preferred students. Hence, we are potentially estimating an upper bound of the effects on school segregation (with respect to the counterfactual of an absence of this particular point) when observing an increase, and a lower bound when noticing a decrease.

The inter-district reform was implemented in several municipalities (usually those of medium size) in 2012/2013 (as well as the low-income and alumni pupil bonus criteria), whereas for the larger ones (including Madrid), it took place in 2013/2014. We exploit the gradual implementation of the policy in different municipalities conditional on the population size to estimate changes in school segregation associated with the reform. We show that results on the willingness to commute of households and the increase in school segregation by immigrant status are robust and consistent. Although large-size and middle-size municipalities present similar levels of school segregation by immigrant status, school segregation seems to have increased more on large-size municipalities in the reform years. This pattern is driven by the within municipality school segregation, which increasingly seems to be more salient in large-size municipalities. Interestingly, the between municipality school segregation seems to be almost negligible for large-size and middle-sized municipalities, but it is almost equally important as the within municipality segregation in small-size municipalities. Overall, results on 2012's reform suggest that priority structures need to be carefully designed to achieve diversity objectives and that abolishing school

choice proximity points does not seem an effective public policy to reducing school segregation under the Boston Mechanism.

Organization of the Paper. The remainder of the paper is organized as follows. Section 2 describes and contextualizes the school choice reform undertaken in Madrid. Data are detailed in Section 3. The empirical strategy and potential identification challenges are discussed in Section 4. Results are shown in Section 5. Section 6 addresses several robustness checks. Finally, Section 7 concludes.

2 Institutional Background

The Spanish Education System. The Spanish education system consists of 10 years of compulsory education, which starts at age 6 and includes six years of primary school (up to age 12) and four years of lower secondary education (up to age 16). Even though compulsory primary education starts at the age of 6, students are offered free universal access to the public education system from the age of 3 onwards. Since most of publicly-funded schools offer preschool and primary education together, age of 3 is typically the time when families enroll their children to primary school.⁹

Regarding the access to schools, the 1978 Spanish constitution grants the right to education and the freedom to educate children, an equilibrium of rights stemming from a political pact between progressive and conservative forces.¹⁰ In the following years, this was accompanied by a decentralization process through which educational policies started to be jointly determined at the national, regional and municipal level.¹¹ Since then, the central government is responsible for establishing the organic laws (*Organic Laws*) and the royal decrees that the regional governments are allowed to further develop as long as they do not contradict the organic laws. Concerning the Spanish school choice policies in the years around the reform, the national organic law in place at the time of the reform (LOE) established the general regulatory principles to be followed by the regional governments to determine the priority criteria of students in over-demanded schools.¹²

In Spain, the vast majority of schools are publicly funded. The publicly funded school network includes public and semi-public schools.¹³ The government fully funds public schools, which are managed by civil servants and local school boards. Semi-public schools (*centros concertados*) are privately run but mostly financed through public funds. Although tuition fees are not allowed in semi-public schools, in practice, parents pay small quasi-compulsory symbolic donations for essential educational services that can act as a barrier to entry for disadvantaged families. Concerning admissions, all the schools in the public system (public and semi-public) are expected to

⁹Preschool Education is entirely publicly funded from ages 3 to 6. This right is recognized in the [Organic Law 1/1990 \(LOGSE\)](#).

¹⁰In terms of education policy, the second principle was translated into the 1985 education act (LODE), which explicitly regulated the degree of freedom of families to choose their children's school. See [Organic Law 8/1985 \(LODE\)](#).

¹¹See the [Organic Law 9/1992: Ley Orgánica de transferencia de competencias a Comunidades Autónomas que accedieron a la autonomía por la vía del artículo 143 de la Constitución](#).

¹²[Organic Law 2/2006 \(LOE\)](#).

¹³We follow [Calsamiglia and Güell \(n.d.\)](#) that refer to the network of privately managed schools as semi-public schools.

unconditionally accept all students assigned by the centralized school choice mechanism, provided demand does not exceed supply.

School Choice in Madrid. In the Region of Madrid, the majority of schools (about 85%) are part of the publicly-funded network of schools. This system includes publicly managed schools (which enroll approximately around 50% of all students) and semi-public schools (which cover around 35% of all students). Semi-public schools tend to be located in urban areas which are larger and serve more upper-middle-income and non-immigrant households.¹⁴

The school choice system is based on a centralized assignment mechanism that is used to allocate students to schools in the publicly-funded system (both public and semi-public) for preschool (starting at the age of 3), primary (age 6), lower secondary (age 12) and special education. More than 96 percent of the students in the Region of Madrid attend preschool, and the school choices decisions are taken when they are three years old (Anghel, Cabrales and Carro, 2016). Students who are enrolled in preschool in a given school have full priority over every student applying to primary education (age 6). If all vacancies are filled at the age of 3 years old, and no student leaves the school, there would be no available slots for those who are not previously enrolled in that level at that cohort. As a result, changes in school after the age of 3 are not frequent, and the vast majority of families make their schooling decisions at this moment in children’s life.

Families are requested to submit a rank-order list of schools up to a total number of choices, and their children are allocated by the centralized and algorithm-based automatic allocation procedure, the so-called Boston Mechanism (Abdulkadiroglu and Sönmez, 2003).¹⁵ The application timing works as follows. Before the school year starts in September (between the end of April and early May), every participating family is requested to submit the rank-order list of schools to their first-choice school. Applicants are assigned to a school using the Boston Mechanism (BM hereafter), a centralized school choice system that works as follows. First, students are allocated to their first-choice school. For schools where there is an over-demand of students, students are granted priority points (according to several criteria which depend on student characteristics and location of the household or parental job), which provide them with a rank number that assigns places to students until all available places are filled. Ties are broken conditional on priority bonus points obtained¹⁶. In the second step, students who are rejected from their first-choice are proposed to their second submitted school in the rank-ordered list if there are available seats after the first step. If there are more applicants than available places, students are allocated in the same way as in the first step with the priority points granted in the first-choice school. In the third step, those students who are rejected from their second choice are proposed to their third choice, and the mechanism continues until all students are assigned a seat or are rejected from all schools in their rank-order list. The final assignment is made public in June, and enrollment must take place at the end of June (for pre-primary and primary education) or July to September (for lower secondary education). A special feature of the system is that students’ priority points

¹⁴Some authors have argued that preferences for education in Spain are strongly mediated by the existence of the semi-public network (Arellano and Zamarro, 2007; Mancebón et al., 2012).

¹⁵It has been further updated and regulated after the 2006 LOE education act was passed.

¹⁶See Table A 1 in the Appendix for further details.

that are used for tie-breaking at all stages are based on the ones obtained for the first-choice.¹⁷

Until recently, the BM has been very influential in practice (beyond Spanish regions, US school districts, which used this mechanism including Boston, Cambridge, Denver, Minneapolis, and Seattle, among others, as well as other cities such as Beijing, Amsterdam or Frankfurt). One of the special features of this assignment system is that the choice of the top-ranked school is highly important since the assignment in each round is final. The probability of a student being admitted in the second round relative to the first is dramatically reduced, and the chances decrease even more in further rounds.¹⁸ Recent empirical evidence supports the theory. In the case of Barcelona, [Calsamiglia and Güell \(n.d.\)](#) highlight the fact that more than 85 percent of the assignments are resolved in the first round in Barcelona, and this is persistent across different cities worldwide.¹⁹ In Madrid, about 86 percent of children were assigned to the school they ranked first (see Section 3).

Another essential feature of the BM is that this mechanism tends to promote segregation across schools. [Calsamiglia et al. \(2017\)](#) shows that the BM fosters socioeconomic (strategic) segregation across public schools, even with open school choice. The Region of Madrid is the most socially segregated (socially defined as social, economic, and cultural characteristics of the family) among all autonomous communities in Spain and neighboring countries in secondary education ([Murillo and Garrido, 2018](#)). In terms of immigrant-origin segregation, the levels are rather low in comparison to other Spanish regions ([Murillo, Garrido and Belavi, 2017](#)). However, as mention in the Section 1, this paper studies segregation levels right at the beginning of the schooling age (families applying for preschool with children of 3 years old), which may be different from those studied in secondary education.²⁰

Reform of the priority criteria to school access in the city of Madrid. In the case of over-demand at a specific school, students are assigned to schools based on a government-determined priority criterion, which grants points to students according to their characteristics and their home residence or parental job location. For school choice, the Region of Madrid counts 179 municipalities, with the medium and large-size municipalities being subsequently divided into school choice catchment areas.²¹ In particular, the city of Madrid (the largest municipality and our central unit of analysis) is divided into 21 school districts, which coincide with such choice

¹⁷[Calsamiglia \(2014\)](#) states that the main reason why the government uses this procedure is that it is computationally easier. Alternative assignment mechanisms require computational power that, currently, the education administration cannot deal with. Section H provides further details on the theoretical properties of the BM assignment mechanism.

¹⁸[Abdulkadiroglu and Sönmez \(2003\)](#) highlight that one of the major difficulties of the BM is the fact that it is not strategy-proof. A student may have a very high priority to enter school s , but if she does not list it as her top-ranked school, she loses her seat in favor of students who have listed s as their top choice. BM provides incentives to families to misreport their preferences by ranking first those schools in which they have higher priorities to be admitted.

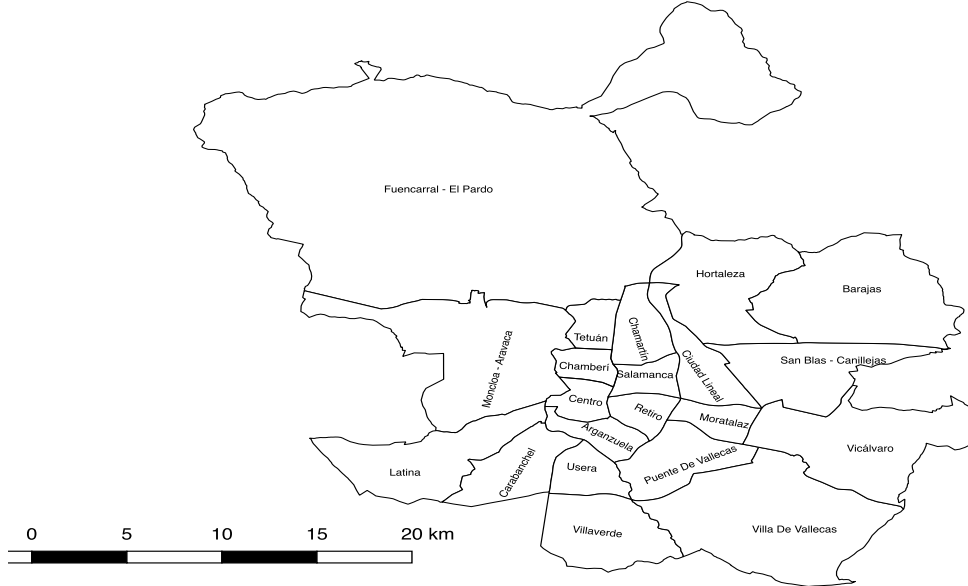
¹⁹See also [Abdulkadiroglu et al. \(2006\)](#) for Boston; [Hastings, Kane and Staiger \(2009\)](#) for Charlotte; [Lavy \(2010\)](#) for Tel Aviv; and [De Haan et al. \(2015\)](#) for Amsterdam.

²⁰Another relevant factor that may have contributed to the increasing levels of segregation is the expansion of semi-public schools between 2000 and 2010 and the implementation of the bilingual program in the Region of Madrid starting in 2006. [Anghel, Cabrales and Carro \(2016\)](#) find that observable characteristics of families changed against students with immigrant status (and those with lower socioeconomic background) in schools, which became bilingual when the policy was implemented in the first place.

²¹Called as *zonas de influencia*.

catchment areas. Figure 1 shows a map of the distribution of the 21 school districts in the city of Madrid.

Figure 1: School Districts in the city of Madrid.



Note: Own computation using shapefiles data from the 21 school districts of the city of Madrid.

Table 1 shows the score scale used in the city of Madrid before and after the reform.²² Before the school year 2012/2013, children living in the (within the boundary of) district of the top-ranked school received 4 points (2 points).²³ Regarding individual student characteristics, students were awarded 2 points if their per capita household income was under the IPREM Index (7,236.60 euros), and got 1 point if their per capita household income was between 100% and 200% of this Index (between 7,236.60 and 14,473.20 euros).²⁴ Families which ranked a school where there was a sibling enrolled got 4 points for the first sibling, plus an additional 3 points for every one of them enrolled at this school. Students received extra points if they had a family member with a disability (1.5 points), and if they belonged to a large family (1.5 if general - 3 children -, and 2.5 if special- 4 or more children-). Besides, a specific point (1 point) was decentralized to the school principals' decision, which must be decided according to objective criteria that are made public.

In March 2012, the Regional Government announced a reform that aimed at strengthening the principle of school choice by households with children entering pre-primary, primary and lower secondary schools.²⁵ The Regional Government founded its arguments on the constitu-

²²Table 1 also applies to the rest of the municipalities regarding the individual characteristics.

²³Families receive the same scale of points if any of the parent/guardians are working in the district of the top-ranked school.

²⁴IPREM is the acronym in Spanish for Multiple Effects Income Public Index and represents a minimum annual threshold for social programs and subsidy eligibility. The Index remained constant between 2010 and 2015.

²⁵Order 2939/2012 of March 9 of the Regional Government of Madrid.

Table 1: Priority Points in case of over-demand of schools in the city of Madrid.

BONUS	CRITERIA	NUMBER OF POINTS		
		Before 2012/2013	2012/2013	2013/2014
Proximity -Madrid city-	Family house or parents' work in:			
	School district	4	4	
	Boundary school district	2	2	
	Family house or parents' work in:			
	Same municipality			4
	School district			0.5
	Region of Madrid			2
Low-income	Income \leq IPREM	2		
	IPREM $<$ Income \leq 2IPREM	1		
	Minimum Insertion Subsidy		2	2
Siblings	First one 4pts, and additional 3pts	4		
	One or more		8	10
Disability	Parents, students or siblings	1.5	1.5	1.5
Large Family	General	1.5	1.5	1.5
	Special	2.5	2.5	2.5
Alumni family member	Family member is alumni student		1.5	1.5
School discretionary		1	1	1

Notes: The changes beyond the proximity criteria were applied together across all medium and large municipalities. IPREM is the acronym in Spanish for the Multiple Effects Income Public Index, which was €7,455.14 in the period of study. The Minimum Insertion Subsidy (*Renta Mínima de Inserción*) is a special provision granted for people with lower income than IPREM. School discretionary is a point that the schools have freedom to assign based on “public and objective” criteria.

tional right that parents have to educate their children based on their convictions. The goals of the government policy were to increase families participation to improve the availability of information on schools (through the results on the standardized test scores, schools' educational program, school resources, and services), to simplify the admission process, to promote school competition, and to enhance free school choice. In particular, the reform modified the computation of pupils' priority points in each school (see Table 1). The changes in priority points and school districts were implemented in two consecutive years:

1. In 2012/2013:

- The criteria to obtain bonus points granted to low-income families was reduced and changed.
- A new priority bonus was granted when a pupil's family member was an alumni

student of the top-ranked school.²⁶

2. In 2013/2014: The proximity to the school criterion was relaxed. The Regional Government of Madrid updated the regulatory framework with a regional decree which regulated the single school choice for all the municipalities of the region.²⁷ This change implied moving from 21 school districts (with around 25 schools per district) as choice catchment areas to a virtually single municipal school choice district with more than 500 schools in the city of Madrid.²⁸

In 2012/2013, a sharp decline in the bonus for low-income families was introduced. Children were awarded 2 points if the family received the Minimum Income for Insertion Subsidy (*Renta Mínima de Inserción*), a social program which is granted to a small proportion of low-income households with no earnings (0.9% of the total population in the Region of Madrid). The number of recipients of this subsidy is much smaller (around 30,000 households in a region of more than 6 million population) than the number of families with a per capita household income under the 100% of the IPREM (around 15% of the population)²⁹. Finally, an additional 1.5 points were awarded to students in a school where any family member had been an alumni student, a feature that may potentially limit equality of opportunity of students to access certain schools, given the weight given to the socioeconomic background of parents.³⁰

In 2013/2014, families' incentives to apply for a school inside their residence school district were shifted with the implementation of the inter-district school choice (the 2013/2014 reform is referred to as the inter-district school choice reform henceforth). A pupil living (or with parents working) and applying to a school in the same school district was awarded an additional 0.5 points, plus 4 points (2 points) if the school was located in the same municipality (other municipality in the region) of the household or the parental workplace.³¹ Overall, the inter-district school choice reform implied a substantial drop in the importance of the proximity criteria for over-demanded schools.

Implementation of the reform in other municipalities. In the Region of Madrid, the number of school catchment areas (which correspond to school districts in the city of Madrid) was a function of the size of the municipality. The region has 179 municipalities. The smallest 142 municipalities - with a population of less than 10,000/15,000 inhabitants - have always had a unique school catchment area, whereas larger municipalities had more than one. Due to capacity constraints, the expansion of the inter-district school choice in medium and large-size

²⁶Additionally, more points were granted to families with siblings enrolled in the school. Following Calsamiglia and Güell (n.d.), we consider this change as irrelevant for the analysis, given that families' choice is previously conditioned by their older children's choice, and we do not include pupils with older siblings in our main analysis.

²⁷Decree 29/2013 (*Decreto del Consejo de Gobierno, de libertad de elección de centro escolar en la Comunidad de Madrid*).

²⁸Relative to 2012/2013, 2 extra points were awarded to families with siblings enrolled at the school. We do not consider this change relevant for our analysis.

²⁹The share of households at risk of poverty or social exclusion in Madrid in 2014 was 19.2%. The poverty line in 2014 was established at 7,961 euros, slightly higher than the IPREM index, 6,390 euros.

³⁰Tie-break criteria were also slightly modified, as can be seen in Table A 1 of Appendix.

³¹The weight of going to a school within the same district of household residence/parental job went from 4 points out of 4 to 0.5 points out of 4.5 points after the reform.

municipalities was conducted in two consecutive years: (i) In 2012/2013, 22 municipalities, mostly of medium size (with a population between 15,000 and 100,000 inhabitants approximately), adopted the inter-district school choice policy; (ii) In 2013/2014, the remaining 15 municipalities (mostly the larger ones, including the city of Madrid) adopted the inter-district school choice policy.³² We use this gradual implementation across municipalities to perform robustness checks.

3 Data and Summary Statistics

3.1 Data

We use a combination of four administrative datasets that provide rich and unique information on the universe of preschool and primary school applications of each household in the Region of Madrid, the characteristics of the publicly funded schools in the region of Madrid, the education level of households at the census block level in the city of Madrid, and the standardized test scores at the school level. Data on student applications, schools, and school test scores are provided by the Education Ministry (*Consejería de Educación*) of the Regional Government of Madrid, and data on parental education was obtained from the Madrid Census. Information is available for every year from 2010/11 (2010 hereafter) to 2016/2017 (2016 hereafter).

Applications for preschool and primary education. Our primary source of analysis is a unique administrative database containing information on the universe of students who applied to a primary school in the Region of Madrid. For each applicant, the dataset contains the top-ranked school from the rank-order list, the primary student information regarding family characteristics, home address, total priority points obtained based on such characteristics, and the assigned school. Regarding family information, the data contain the precise geo-location of each pupil’s home residence, which we link (with the help of a geo-location software) to different geographical areas (districts, neighborhoods, and census blocks). Besides, the application contains information about the pupil’s country of birth, which we use to construct a proxy for immigrant background status.

School database. We use the universe of schools in the region of Madrid provided by the Regional Government. This database includes the precise geographic coordinates of each school, the school type (public, semi-public or private), whether the school offers bilingual education (schools with English and Spanish instruction), and the levels of education offered.

Household socioeconomic characteristics. We use information from the Census Office of the city of Madrid, which provides the distribution of education levels of the population by census block of the city on January 1 2012, 2013, and 2014. The data is accessible for the three geographical levels of disaggregation: districts, neighborhoods, and census blocks. The most disaggregated units are the census blocks (*Sección Censal*), which are constructed for local, regional and national election purposes (assigning each census block to one voting center), and usually contain no more than 2,500 individuals.³³ We have access to information on the proportion of population in each level of education by age groups at the census block level. We

³²Table A 2 in the Appendix provides a summary of the municipalities that joined the single-zone school choice system across years.

³³Figure B.1 in the Appendix includes an example of a block of the Central district of Madrid.

use this to translate the corresponding level of education to an equivalent number of years of schooling, which allows us to compute the average number of years of schooling in each census block.³⁴ We assign to each family the corresponding value of the census block where the family resides. This proxy for parental education is, therefore, affected by measurement error. Potential limitations and unobserved heterogeneity issues are discussed in Section 4.³⁵

School Standardized Test Scores. To proxy school quality, we use a standardized exam administered for all 6th Grade students in the region of Madrid between the 2004/2005 and 2014/2015 school years. The exam, known as the Essential Knowledge and Skills test (*CDI-Conocimientos y Destrezas Indispensables*), was designed for education policy measures and did not have any specific academic consequences for students. The goal of this test was to provide information for policymakers, schools, and families about the school’s average performance. The test focused mostly on curriculum content knowledge in the areas of reading and mathematics. The results were publicized every year to facilitate school choice for families with new students entering the system.

The population of interest for our main analysis is formed of households who live in the city of Madrid and apply to schools in Madrid. We use families who apply for preschool at the age of 3 years old, which is the age at which the vast majority make their schooling decisions. We restrict our sample to families that have no siblings in the top-ranked school ([Calsamiglia and Güell, n.d.](#)).³⁶ Families with older siblings enrolled at the school have different incentives and behavior compared to the rest of applicants, since their past choice conditions their present choice. The number of bonus points that families obtain when applying to a school where a sibling is already enrolled is the highest. As a result, admission to those schools is almost automatically guaranteed. These families may, therefore, react differently to policy changes since they have distinct preferences and incentives, which could make their decisions more inelastic to changes in the bonus criteria. Table G 1 presents the restrictions that we use to construct the analysis sample.

3.2 Summary statistics of applicants

Table 2 presents the summary statistics of applicants. First, the majority of applicants (more than 60 percent) are applying to start in preschool education at the age of 3, which is our population of interest. Beyond this, a large fraction of applicants are native students (around 85 percent), whereas the rest represents the foreign-born pupils’ population. This table presents a decreasing trend in the number of families of 3 years-old children applying to preschool over

³⁴The construction of this variable is detailed in Appendix Section C. Ideally, we would use data from the 25-49 age group to obtain a more accurate proxy for parental education, as this is the most relevant level of education for parents with preschool and primary school children. Nevertheless, we do not use this measure in the primary analysis since the database that includes such desegregation corresponds to the year 2017 onward and not to pre-reform years.

³⁵We assign to each family the corresponding value of the census block in the following way: (i) Those applying in 2010, 2011 or 2012 are assigned the values of January 1 in 2012; (ii) Those applying in 2013 are assigned the values of January 1 in 2013; (iii) Those applying in 2014, 2015 and 2016 are assigned the values of January 1 in 2014. Results are robust to changes in the computation of this variable and are available upon request.

³⁶[Calsamiglia and Güell \(n.d.\)](#) also restrict their primary estimation sample to families who apply for preschool at 3 years old.

time, with a sharp reduction in 2013. Table D 1 presents the population census of 3 years-old children over the period under study, showing that the observed drops in the total population at that age are not specific to our estimation sample. In 2013, there was a significant rise in the proportion of applicants with immigrant background, from 13% to 16.7%, although this is also consistent with the city demographics.³⁷ The share of female applicants remains constant over the period. We observe that the gradual decrease in the sample size is not correlated with parental education. Therefore, the changes in sample size over time are driven by city demographics. In our empirical strategy, we account for these demographic changes by tracking residential dynamics of the immigrant population.³⁸

³⁷According to official municipal data from the city of Madrid, there was a sharp decrease in the number of births in 2009 (i.e., individuals aged 3 in 2012) and 2010 (who were 3 in 2013) concerning those born in 2008. In particular, the number of births in the city of Madrid was 36,663 in 2008, 35,147 in 2009, and 33,987 in 2008. Conversely, the number of immigrants increased between 2010 and 2013. Hence, the observed drops in the census are consistent with those observed in Table 2.

³⁸Pupils' awarded places with each of the two new priority bonus created in the 2012 reform only account for a small part: between 3% and 4% for the new low-income bonus and around 6% for alumni student relatives at the school. We do not drop these students from the main sample analysis since we do not have this information for years before the reform. Discarding these observations may lead to a sample selection bias between the period before and after the reform.

Table 2: Summary Statistics: School applicants in the city of Madrid over 2010-2016.

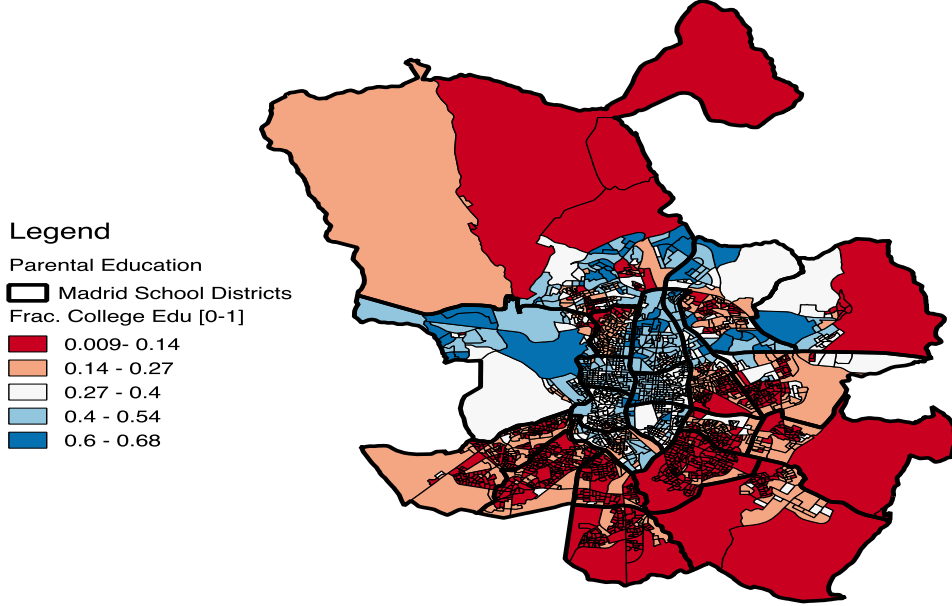
Variable	2010	2011	2012	2013	2014	2015	2016
A. Grades in City of Madrid							
preschool age of 3	18,391	18,289	18,006	16,970	16,323	16,266	15,696
	[0,62]	[0,64]	[0,62]	[0,6]	[0,59]	[0,62]	[0,62]
preschool Age 4	2,738	2,571	2,850	2,746	2,556	2,268	1,418
	[0,09]	[0,09]	[0,1]	[0,1]	[0,09]	[0,09]	[0,09]
preschool Age 5	2,087	1,925	2,156	2,306	2,109	1,769	1,000
	[0,07]	[0,07]	[0,07]	[0,08]	[0,08]	[0,07]	[0,07]
Primary 1th grade	4,254	3,946	3,973	4,121	4,315	3,899	2,688
	[0,14]	[0,14]	[0,14]	[0,14]	[0,16]	[0,15]	[0,15]
Primary 2 to 5th grade	1,602	1,373	1,539	1,618	1,559	1,451	1,123
	[0,05]	[0,05]	[0,05]	[0,06]	[0,06]	[0,06]	[0,06]
Primary 6th grade	664	596	681	717	717	618	542
	[0,02]	[0,02]	[0,02]	[0,03]	[0,03]	[0,02]	[0,02]
B. Students characteristics - preschool age of 3- City of Madrid							
Immigrant	0.116	0.131	0.167	0.158	0.145	0.137	0.132
Female	0.491	0.493	0.484	0.487	0.500	0.489	0.487
Quintile 1	0.206	0.211	0.206	0.203	0.203	0.208	0.203
Quintile 2	0.208	0.200	0.205	0.203	0.199	0.202	0.199
Quintile 3	0.199	0.206	0.208	0.203	0.204	0.201	0.204
Quintile 4	0.199	0.200	0.196	0.197	0.202	0.197	0.202
Quintile 5	0.188	0.181	0.184	0.191	0.187	0.189	0.187
Distance to Closest District Border (meters)	463.7	454.2	627.0	626.5	632.4	633.0	625.3
Distance to Closest School (meters)	177.3	164.3	231.7	230.5	231.7	234.2	239.9
Number of Schools in a Radius of 500 meters	3.696	3.757	3.686	3.678	3.661	3.649	3.623
Observations	18,391	18,289	18,006	16,970	16,323	16,266	15,696
C. Students characteristics - preschool age of 3- Region of Madrid (without Madrid city)							
Immigrant	0.143	0.158	0.166	0.164	0.153	0.140	0.147
Female	0.487	0.486	0.486	0.490	0.485	0.483	0.489
Distance to Closest Municipality Border (meters)	1,454	1,439	1,436	1,431	1,438	1,416	1,431
Distance to Closest School (meters)	323.5	319.1	333.0	330.1	331.2	336.6	342.1
Number of Schools in a Radius of 500 meters	2.792	2.788	2.674	2.654	2.677	2.597	2.578
Observations	26,261	27,175	27,039	26,099	25,299	24,856	23,620

Notes: Each year corresponds to the year of application and the school year starting in September of that year. Data on bonus information for alumni family members and RMI are not available before 2012 given that the reform was implemented that year. Quintiles of parental education are defined at the census block level.

Figure 2 illustrates the distribution of parental education (measured as the fraction of parents with a college education by census block) across school districts and census blocks of the city of Madrid in 2013. Higher quintiles of parental education are concentrated around the center and north of the city, while lower quintiles are over-represented in the south. This suggests a high level of spatial residential segregation in the city of Madrid by parental education.

We find two limitations in the data. First, we do not have the information concerning the location of the parents' workplace. Given that the reform reduces the importance of the district of both the household and workplace location, we need to assume that parental distance to

Figure 2: Parental Education by census block in 2013.



Note: Own computation using shapefiles data from the 21 school districts of the city and Census Office data of Madrid.

the workplace is constant during the years of the reform. Otherwise, changes in out-of-district assignments could be driven by changes in parents' workplaces during these years. We believe that this is not a reliable assumption since changes in the location of the workplace are limited and challenging to exert by families, particularly over the years when the world economic crisis was particularly strong in Spain. Moreover, households typically choose where to locate their primary residence to take advantage of the supply of public local good (Tiebout, 1956).

The second data limitation relates to the measure of parental education. This variable may potentially suffer from unobserved heterogeneity caused by the measurement error of parental education. While we can measure student immigrant status with a full degree of accuracy (at the student level), the data from the parental background is more limited since we use average values across census blocks, which each cover a population of about 2,000 inhabitants. This measure may incur in measurement error, which potentially reverses to the mean tails in each block. For example, in low and middle-income census blocks, highly educated parents are identified with much lower education levels (and not identified through education quintiles, as their observed educational level is averaged with those living in their same census block). A similar phenomenon occurs for low-educated households living in highly educated blocks. If the reaction to the reform is higher in relative terms for highly educated parents, our measure of parental education may incur in measurement error that is correlated with the effect of the inter-district school choice reform. If that is the case, our estimates of changes in out-of-district assignment by parental education may suffer from negative bias, so that the "true" effects may be even larger after the reform for relatively highly educated families.³⁹ Besides, our measure of school segregation

³⁹It is unlikely that the sign of the bias would go in the opposite direction since on average, highly educated families living in districts with high-quality schools do not prefer low-educated areas with low performing schools.

(through parental education) may be under-estimated, especially in low-educated blocks. This leads to an under-estimation of the gaps in inter-district assignment and an over-estimation of the change in school segregation by parental education after the reform.

4 Empirical Strategy

In this paper, we first attempt to estimate the effect of changes in pupil priorities on families' school choices and final school assignment, and second, whether the reform had an impact on the levels of segregation across schools (measured by parental education and immigrant status). Hence, we investigate whether the inter-district school choice reform had a direct impact on families' willingness to commute to schools located in different school districts and whether this affected pupils' sorting across schools. An advantage of the context under study is that we can closely relate changes in school choice priorities with contemporaneous school segregation changes at the start of the schooling decisions. There was no other modification of the school system apart from the sizeable inter-district reform in the city of Madrid, which we use as the primary source of variation.

4.1 Out of School District Choice and Assignment

4.1.1 Event Study: First Difference Approach

The two policy reforms undertaken in the city of Madrid modified the set of feasible schools where families had a high priority of admission. We identify the effect of these changes on families' choices by comparing school choices immediately before and after these modifications. First, we investigate whether parents aimed to get admission or were finally assigned to a school located in a different school district from the household's primary residence. Second, we use two different measures for computing the commuting distance between the household across two margins: (i) Parents' top-ranked school; (ii) Their assigned school. We use the Open Source Routing Machine (OSRM) routine, which returns the travel distance using the latitude and longitude coordinates of the household and the school.⁴⁰ Both variables provide different information. While outer district applications may be seen as a simple "extensive" margin measure of commuting distance to school, the average distance to first-choice (and assigned) school may represent a combination of the "intensive" and "extensive" margins of commuting distance, as the distance traveled is composed of both within and between school district.

To estimate the effect of the changes in priorities on families' out-of-district choices we estimate the following reduced-form specification:

$$D_{ibsd t} = \alpha + \delta_t + X'_{isdt}\beta + B'_{bt}\gamma + \nu_b + \epsilon_{ibsd t} \quad (1)$$

where $D_{ibsd t}$ is either a dummy that takes value 1 if pupil i living in census block b applies for a school s located in a different school district d where she resides in year t , and 0 otherwise,

⁴⁰The command computes this distance based on a map: we use OpenStreetMap as it allows us to work offline with an unlimited request of distances to be computed and replicated (Huber and Rust, 2016). The database contains the UTM coordinates in ED50 base. The OSRM command needs GPS coordinates and ETRS89 base so we use a Geographical Information System (GIS) to convert them into suitable coordinates.

or the travel distance from the residence of the pupil i in census block b and school district d to the school s that was top-ranked in year t in her application form; δ_t are year fixed effects; ν_b are census blocks fixed effects; X'_{isdt} is a vector of households characteristics, which includes the number of schools in a radius of 500 meters (i.e., a proxy for school supply), the Euclidean distances (in meters) to the closest school district border and to the nearest school; B'_{bt} is a vector of time-variant census block characteristics, such as population density and average income; and ϵ_{ist} is the error term. The coefficients of interests are the year fixed effects. The fixed effect of the year prior to the reform is excluded, such that δ_t are interpreted as the change in the dependent variable in year t with respect to the baseline year 2011. Therefore, α captures the mean outcome variable in the year prior to the reform (academic year 2011/2012) for the excluded census block. We cluster the standard errors at the census block level to account for the fact that willingness to commute may exhibit spatial and serial correlation within a given census block. We may expect that families' responses to the reform may be different depending on the distance to the boundary of catchment areas, the supply of schools surrounding their primary residence, or the census block in which they reside. Note that our data are constructed as a repeated cross-section of families with 3 years old children who apply for preschool, which implies that the sample of families is different every year. We also perform different specifications that include neighborhoods or school district fixed effects, as well as observable characteristics at these two geographical units, finding that our results are robust and point estimates are barely sensitive to these specifications.⁴¹

Using parents who are already in the system and who apply to a school change would potentially bias the results. First, after the first year of entry in the system (at the age of 3), pupils have priority to remain at the same school (if they plan to continue in the first grade of primary education). Pupils who enter the system after the age of 3 do not face the same set of feasible schools as pupils who enter the system at the age of 3, as they are only left with the available slots due to current students leaving the school, or under-demanded schools. Second, these families may have different preferences for schools. Third, these households may act even more strategically since they potentially know better how the system works since they have previously applied. Hence, pupils who enter the system for the first time (at the age of 3) may have different preferences, priorities and behavior than pupils who aim to change the school later on the system, making those groups difficult to compare.⁴² Therefore, to avoid bias and take advantage of the cleared school choice market in the first preschool year, we use families with 3 years old children as our estimation sample.

4.1.2 Difference-in-Difference Analysis

We implement a Difference-in-Difference (DID) estimation strategy. The DID strategy is a mean comparison design that consists of creating a counterfactual outcome for the treatment group using the outcome of the control group. The limitation of this institutional context is that both reforms were implemented at the same time for every school district of the city of Madrid. Thus,

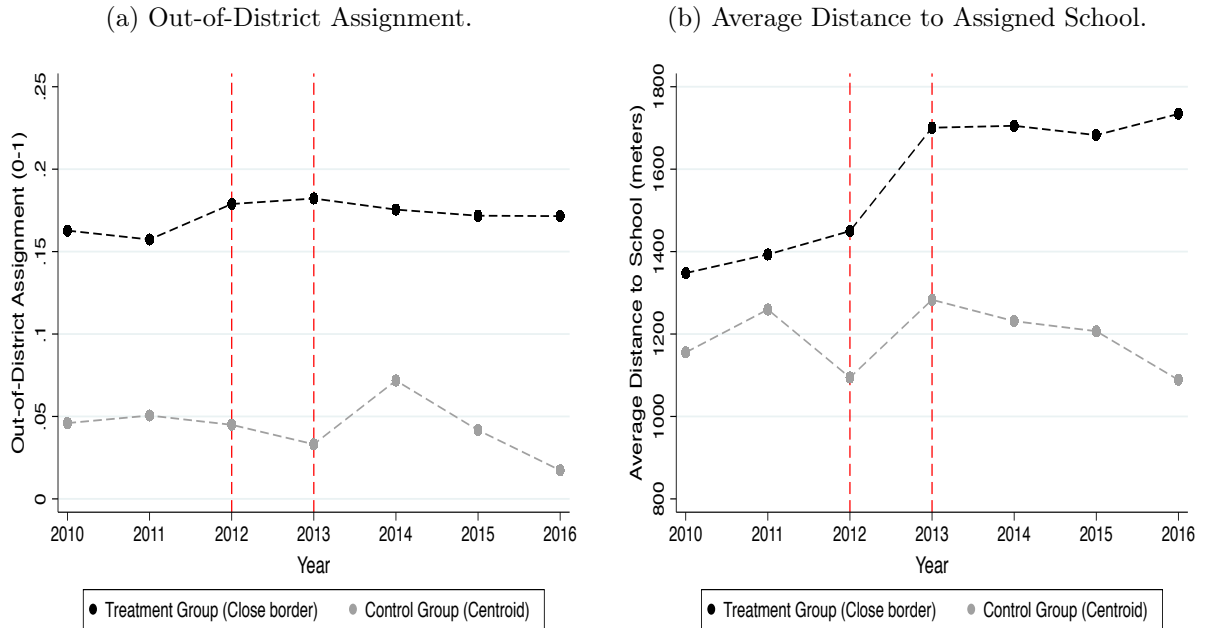
⁴¹Results are available upon request.

⁴²In our empirical framework, we need to assume that the distribution of parents' preferences remains constant over time. This seems to be highly plausible at least for the specific years of the reform.

the institutional setting does not provide an alternative control group that is not affected by the reforms, since all families are “treated”. However, the school choice literature finds that distance to school enters as a harmful component of parents’ preferences. We can, therefore, exploit an analysis in the spirit of treatment intensity by focusing on parents that are closer to the school district boundaries, and comparing them with those who are further away. Parents whose primary residence locates within 300 meters close to the school district boundaries are defined as “treatment group”. Families whose primary residence locates within 150 meters close to the geometric center of the school district boundaries (centroid) are defined as “control group”.

Figure 3 shows the trends in out-of-district assignment and average distance to assigned school of defined both groups of families. It seems that the treatment group presents higher levels of out-of-district assignment and average distance to assigned school than families whose primary residence is at the school district centroid. The trends for the treated and the control group are both slightly constant and almost parallel (especially for the out-of-district assignment), which makes the common trend assumption reasonably plausible.

Figure 3: Out-of-District Assignment and Average Distance to Assigned School by group of treatment.



Note: Black and grey dots represent averages. The red stripes reflect the two consecutive changes in the choice priority system in 2012 and 2013.

Even if the pre-trends may look fairly similar, the two groups may still systematically differ due to the discretionary nature of the selection rule applied. We compare whether household characteristics are balanced between treatment and control groups in the pre-reform years. Finding that some groups of families are more likely to sort on each of the groups would indicate

endogenous sample selection. Linear regressions are performed using each of the households' observable characteristics (i.e., immigrant status, gender, distance to closest schools, number of schools in a radius of 500 meters) as the dependent variable. Table I 1 shows the treatment-control balance in fixed households characteristics in pre-reform years. Two out of eight contrasts are significant at the 10% level. The fraction of families whose primary residence is located within a census block that is labeled on the highest quintile of education and the euclidean distance to the closest school are higher in families located close to the school choice district boundaries. We also test for the joint significance of the observable characteristics for treatment and control groups. We cannot reject the null hypothesis that the F-statistic is equal to zero.

To estimate the effect of the changes in priorities on families' out-of-district assignment we estimate the following reduced-form specification:

$$D_{ibsd t} = \alpha + \delta T_i + \lambda Y2012_t + \zeta \text{Post}2013_t + \kappa T_i * Y2012_t + \pi T_i * \text{Post}2013_t + X'_{isdt} \beta + B'_{bt} \gamma + \theta_d + \epsilon_{ibsd t} \quad (2)$$

where $D_{ibsd t}$ is either a dummy that takes value 1 if pupil i living in census block b applies for a school s located in a different school district d where she resides in year t , and 0 otherwise, or the travel distance from the residence of the pupil i in census block b and school district d to the school s that was top-ranked in year t in her application form; T_i is a dummy variable equal to 1 when the households belong to the treatment group, and zero otherwise; $Y2012_t$ is a dummy variable equal to 1 when the year is 2012, and zero otherwise; $\text{Post}2013_t$ is a dummy variable equal to 1 when the year is 2013 or later, and zero otherwise; θ_d are school district fixed effects; X'_{isdt} is a vector of households characteristics, which includes the number of schools in a radius of 500 meters (i.e., a proxy for school supply), the euclidean distances (in meters) to the nearest school; B'_{bt} is a vector of time-variant census block characteristics, such as population density and average income; and ϵ_{ist} is the error term. We cluster the standard errors at the census block level to account for the fact that willingness to commute may exhibit spatial and serial correlation within a given census block. The coefficients of interests are κ and π , that provide the effect of the 2012's reform and the 2013's inter-district school choice reform, respectively.

4.2 School Segregation

The first goal of this study is to analyze whether the school choice reform had an impact on the outer district top-ranked and assigned school. The second goal of this study is to investigate whether changes in the outer district assigned school were translated into different school segregation levels among new pupils entering the school system. We test whether changes in the levels of segregation across schools by parental education and by immigrant status are associated with the policy reform. As explained in Section 3, we proxy parental education by the average years of schooling at the census block level, and we divide families by quintiles of parental education. We measure immigrant status through a dummy variable that takes value one when the children are non-Spanish and zero otherwise.⁴³

We use the Mutual Information Index (M hereafter) as our main measure of segregation across schools. We complement this measure using other global segregation indices widely used in the

⁴³Note that we observe parental education at the census block level and immigrant status at the student level.

literature, such as Dissimilarity Index (Duncan and Duncan, 1955), the Adjusted R-squared, and the Normalized Exposure Index. Results are robust to the use of these global segregation indices.⁴⁴ We define M as:

$$M = 1 - [(\sum_{\text{School } s} \left(\frac{\# \text{ Pupils in school } s}{\# \text{ Total pupils}} \right) * E_s) / E_g] \quad (3)$$

where s is the school, E_s and E_g are the Entropy Diversity Index distribution of each school and group g (defined as parental education quintiles or non-immigrant/immigrant status).⁴⁵

We use the M index since it has several desirable properties. This index satisfies Scale Invariance, Independence, the School Division Property, Symmetry, the Group Division Property, and a technical continuity property (Frankel and Volij, 2011).⁴⁶ However, there are two limitations of this index. First, it is not Composition Invariant, which is a specific drawback of this index. Second, we can not directly interpret the values of this index, which corresponds to the general trade-off between intuitiveness and performance in choosing an index. Therefore, the values do not provide an intuitive meaning, but we can directly interpret changes in segregation associated with the policy reform.

A graphical analysis of the evolution of the levels of school segregation over years would provide evidence of the association between the school choice reform and school segregation. However, trends in school segregation may be correlated with other important factors, such as residential trends or demographic pressure. In order to investigate whether the reform is statistically significantly associated with changes in school segregation, we use the following model:

$$Seg_{dt}^s = \alpha + \delta_t + \nu_d + \gamma Seg_{dt}^{nm} + D'_{dt} \beta + \epsilon_{dt} \quad (4)$$

where Seg_{dt}^s is the school segregation index (either by parental education or by immigrant status) of school district d in year t ; δ_t are year fixed effects; ν_d are school districts fixed effects; Seg_{dt}^{nm} is the school segregation index (either by parental education or immigrant status) of district d in year t under pure residence-based assignment (i.e., if it were entirely due to residential segregation); D'_{dt} is a vector of time-variant school district characteristics, such as population density and average income; and ϵ_{ist} is the error term. We use robust standard errors. The variable Seg_{dt}^{nm} can be seen as a counterfactual measure of an extreme situation in which every student attends to the assigned school based on their primary residence (i.e., out-of-district assignment). This variable control for trends in residential segregation over time by groups, and improves the precision of our estimates. We abstract from causal interpretations of the year fixed effects in Equation 1 and Equation 4, and view these parameters as providing conditional associations.

⁴⁴Results are available upon request.

⁴⁵The entropy of s is defined as $\sum_{k=1}^K q_s \log \frac{1}{q_s}$ where q_s is the proportion of the students in school s within the city of Madrid. The entropy of g is defined as $\sum_{k=1}^K q_g \log \frac{1}{q_g}$ where q_g is the proportion of the students in group g within the city of Madrid.

⁴⁶For a summary of the properties satisfied by the different indices see Table 1 of Frankel and Volij (2011).

4.3 Identification Threats

In this subsection, we identify several potential identification challenges for our main specification and discuss their implications for our results.

First of all, we cannot capture parents’ full response since we only observe the top-ranked school in the submitted list. The school choice assignment mechanism plays a vital role. A unique characteristic of the BM is the fact that first-ranked school is crucial for final allocation. [Abdulkadiroğlu, Che and Yasuda \(2011\)](#) highlight that one of the features of the BM is that it better takes the parents’ cardinal preferences into account, compared to other algorithms with more desirable ordinal properties (e.g., Gale Shapley or Top Trading Cycles). Moreover, a specific feature of the school choice in Madrid (and Barcelona) is the fact that pupils’ priority points are always measured for the top-ranked school, which provides an additional incentive to families to think carefully about their first-choice and potentially to apply to the school where they have high chances of being admitted. Table 3 shows the percentage of pupils who were assigned to their top-ranked school, those who went to a school they did not rank first, and those not assigned to any of their listed schools. It shows that about 86 percent of the students were assigned to the school they ranked first, and around 3 percent were not assigned to any of the schools that families listed. Hence, despite not being able to capture the full extent of families’ behavioral responses, the top-ranked school is crucial under the BM to understand the essential choice and provides a sizeable amount of information.

Table 3: School Assignment in the city of Madrid between 2010/2011 and 2016/2017.

Variable	2010	2011	2012	2013	2014	2015	2016
Assigned to first-choice of school	15,640 [0.85]	15,286 [0.84]	15,703 [0.87]	14,845 [0.87]	14,253 [0.87]	1,4049 [0.87]	13,669 [0.87]
Assigned to other school	2,226 [0.12]	2,203 [0.12]	1,961 [0.11]	1,693 [0.1]	1,604 [0.1]	1,539 [0.09]	1,486 [0.09]
Not assigned to any ranked school	525 [0.03]	800 [0.04]	342 [0.02]	432 [0.02]	466 [0.03]	678 [0.04]	623 [0.04]
Total Students	18,391	18,289	18,006	16,970	16,323	16,266	15,696

Notes: Each year corresponds to the year of application and the school year starting in September of that year. Fraction of students are shown in square brackets.

Another important threat to our identification is the residential sorting of families as a consequence of an anticipation to the reform, that may confound the out of school district application effect. The announcement of the reforms plays a key role in exploring this identification challenge. The inter-district school choice reform was a proposal in the electoral program of the political party that won the elections in the region of Madrid in May 2011.⁴⁷ The information on the 2012 (and 2013) priority changes was disclosed to the press in February 2012 and announced formally through an administrative order in March 2012. Applications are handled between April and

⁴⁷In the program, the winning party in the 2011 election (the conservative party *Partido Popular*) included the following statement: *to establish full freedom of school choice, implementing a single zone for parents to bring their children to whichever school they want.*

May of the academic year, implying that families did not have much time from March to May of 2012 to change their decisions. However, they had about one year between the formal announcement of the reform and the 2013 round of applications, which could raise concerns about anticipation. Such effects would create a problem for identification if families reacted before the implementation of the reform (e.g., changing their primary household residence). [Hastings, Kane and Staiger \(2009\)](#) find that the preferences for high ranked schools increase with proximity and that parents with higher income are more willing to commute farther away for such schools. This increases the demand for school districts with higher average public school performance, leading to a rise in the housing prices of those districts.⁴⁸ A relaxation of the proximity priority criteria may reduce those incentives, and potentially provide incentives for families to change their primary residence to districts with lower housing prices (typically positively correlated with lower school performance) since living in the school district of the desired school is not as decisive as previously in terms of admission probabilities. In this case, a potential positive significant effect on out of district application (and distance to school) may be correlated with this dispersion effect, leading to an upward bias in our estimates that would reflect an upper bound of the “true” effect. Table E 1 is aimed to test this potential response. We observe that housing prices are positively correlated with school district average performance. However, we find no evidence of differential changes in housing prices associated with the policy reform, which seems to rule out housing anticipation effects.

5 Results

5.1 Out of District Choice and Assignment

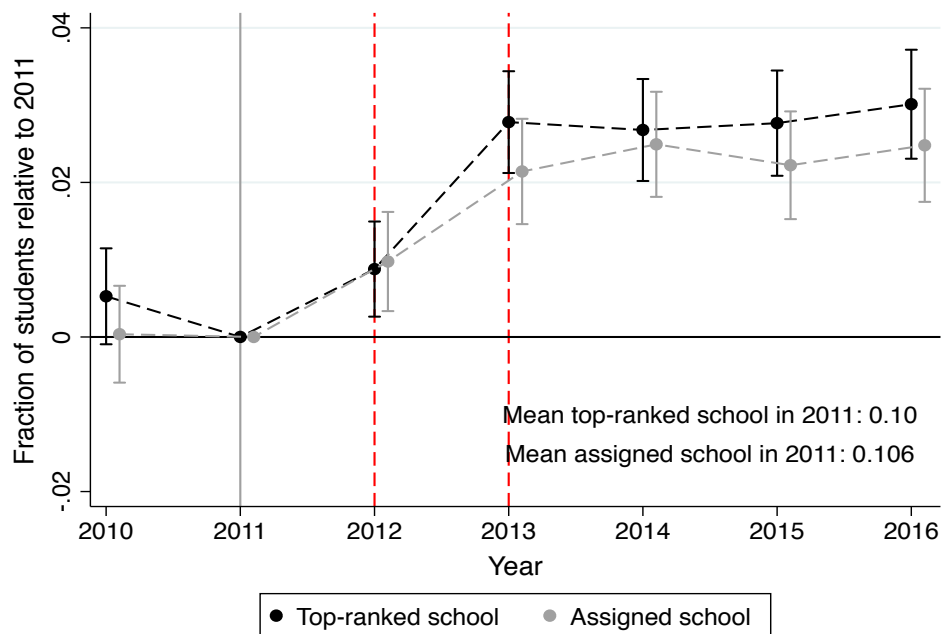
5.1.1 Event Study: First Difference Approach

Average Effects. Figure 4 and Figure 5 plot the point estimates and confidence intervals of year fixed effects in Equation 1 for out of district applications and assignment, and average travel distance to the top-ranked and assigned school respectively. The inter-district school choice reform, and (to a lesser extent) the 2012 reform seem to be associated with a sharp increase in these two variables. These changes seem to be reasonably stable over time. The fraction of out of district applications before the reform was 0.10. This relatively low pre-reform level may be explained by the fact that BM induces high residential sorting, though most of the families exert school choices through the primary household residence choice. The 2012’s reform is associated with an increase in out of district school applications of 1.1 percentage point, which is equivalent to an increase of 11% with respect to the baseline mean of 2011. The 2013’s inter-district reform is associated with a further increase in the fraction of out of district applications of 3 percentage points (30% with respect to the baseline mean). The figure shows that the effects on the probability of top-ranking out of district school almost equals the impact on the probability of being assigned to an out of district school. This strong association may be explained mechanically by the fact that the vast majority of families get their first-choice under the BM. The baseline average travel distance to the top-ranked school was 1,2 kilometers in 2011. The 2012 reform is associated with an increase in this distance of 33 meters (3% with

⁴⁸See, for instance [Fack and Grenet \(2010\)](#).

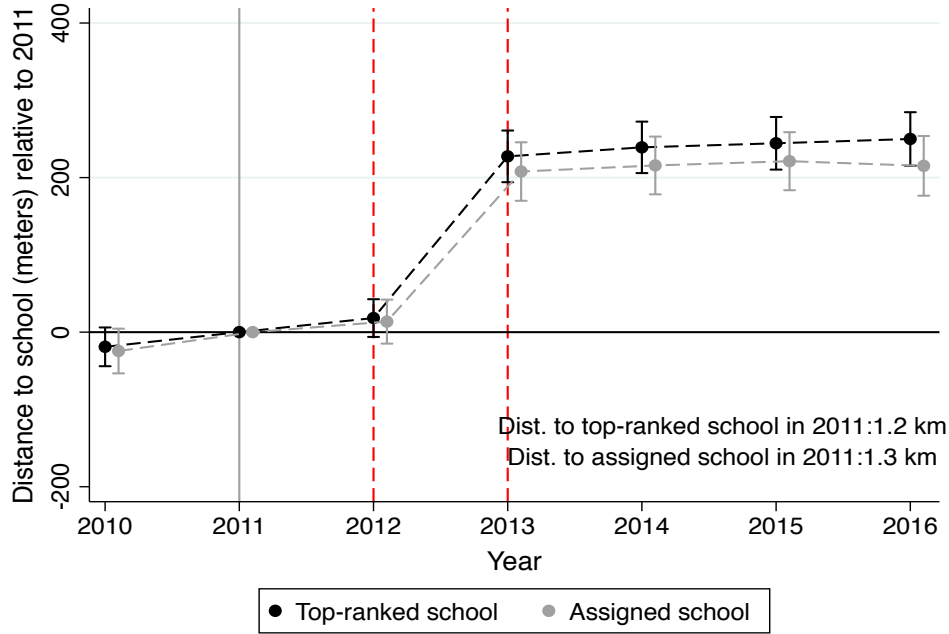
respect to the baseline mean), and the inter-district school choice reform further increased it by 259 meters on average (22% with respect to the baseline mean).

Figure 4: Outer School District Applications: Top-Ranked School vs. Assigned School.



Note: Black and grey dots represent point estimates. Horizontal lines depict confidence intervals at the 95% level of confidence. The red stripes reflect the two consecutive changes in the choice priority system in 2012 and 2013. The coefficients are normalized to zero in 2011.

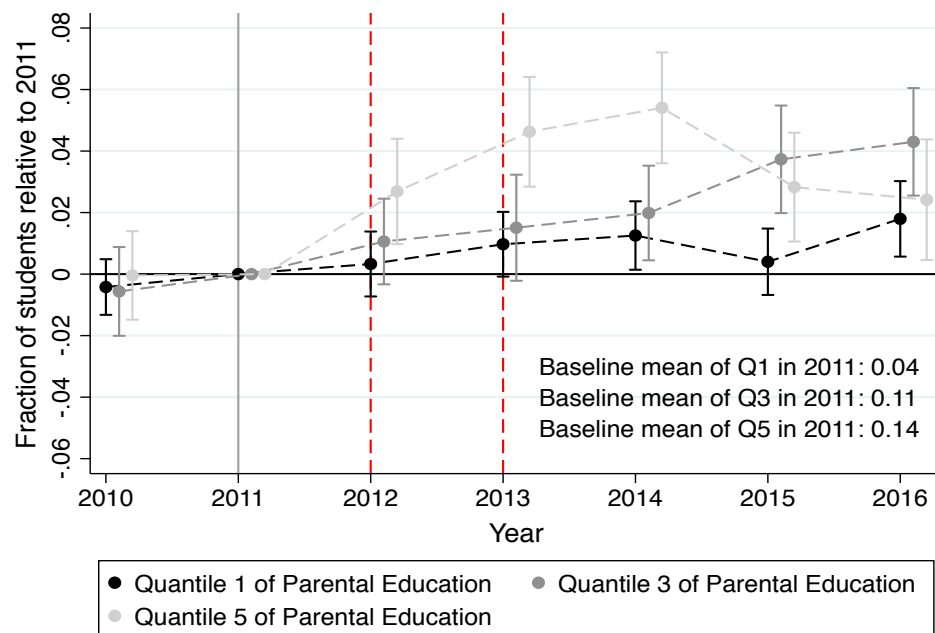
Figure 5: Average Distance to Top-Ranked School vs. Assigned School.



Note: Black and grey dots represent point estimates. Horizontal lines depict confidence intervals at the 95% level of confidence. The red stripes reflect the two consecutive changes in the choice priority system in 2012 and 2013. The coefficients are normalized to zero in 2011.

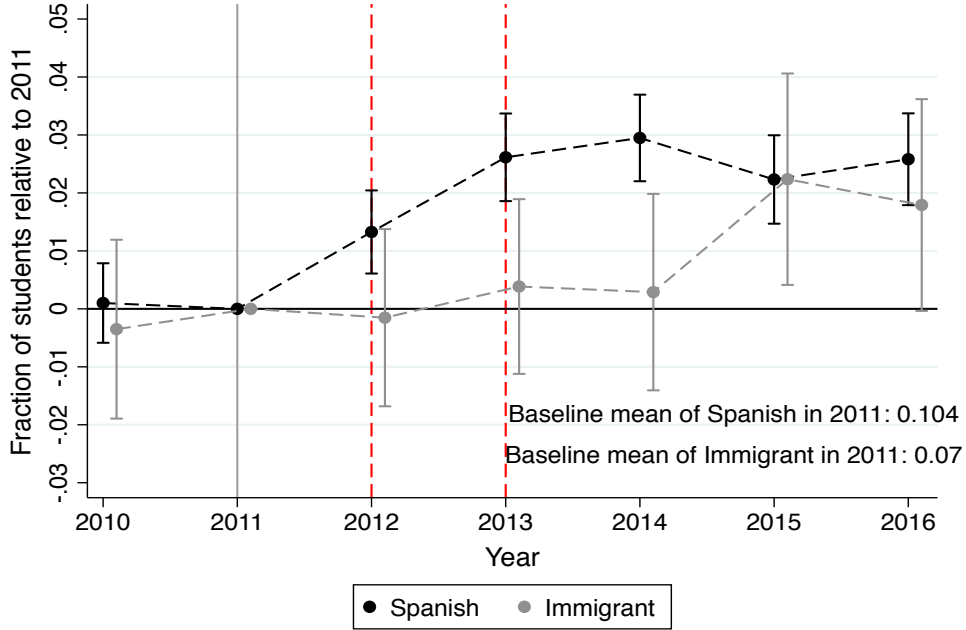
Heterogeneous Effects by Parental Education and Immigrant Status. Figure 6 shows the effect of the reform on out-of-district assignment by parental education quintiles. The inter-district school choice reform seems to be associated with a heterogeneous increase in the out of district assignment by parental education. Interestingly, even though families with higher levels of education reacted more to the reform in absolute terms, the effects were somewhat similar across parental education quintiles in relative terms. The baseline probabilities of being assigned to an out of district school in 2011 were substantially different: 0.04, 0.11, and 0.14 for parental education quintile one, three, and fifth, respectively. The inter-district school choice reform was associated with an increase in the out-of-district assignments of 1, 3, and 5 percentage points, but the effect size of these increases was 26, 31, and 31 percent respectively, hence suggesting no overall change in the pattern of school composition due to student socioeconomic status. A different situation occurs when considering heterogeneous effects by immigrant status (see Figure 7). Families with Spanish children entirely drive the increase in the out of district assignment since parents of immigrant children do not seem to have reacted at all in the first years of the reform. However, the figure shows an increase in the out-of-district assignment in 2015 and 2016 for immigrants, which may suggest information gaps between immigrants versus native families groups.

Figure 6: Impact of the Reform on Out-Of-District Assignment by Parental Education.



Note: Black and grey dots represent point estimates. Horizontal lines depict confidence intervals at the 95% level of confidence. The red stripes reflect the two consecutive changes in the choice priority system in 2012 and 2013. The coefficients are normalized to zero in 2011.

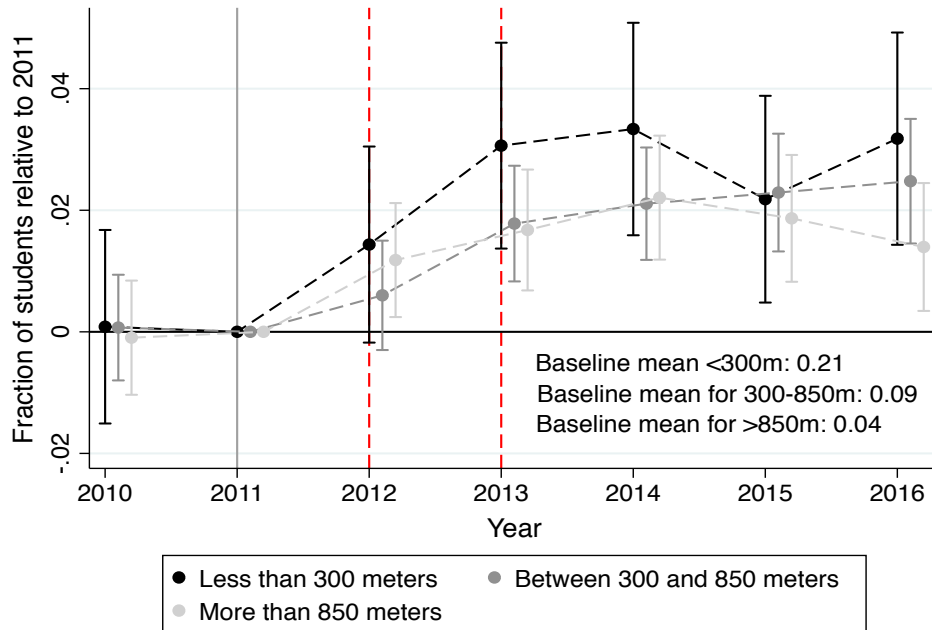
Figure 7: Impact of the Reform on Out-Of-District Assignment by Immigrant Status.



Note: Black and grey dots represent point estimates. Horizontal lines depict confidence intervals at the 95% level of confidence. The red stripes reflect the two consecutive changes in the choice priority system in 2012 and 2013. The coefficients are normalized to zero in 2011.

Heterogeneous Effects by Distance to the Closest Border. Figure 8 presents the effect of the reform on out-of-district assignment by distance to the closest school district border. We find substantial heterogeneity in the probability of being assigned to an out of district school conditional on the distance of the households' primary residence to the closest school district border. While families who live within 850 meters or more get an out-of-district assignment in four percent of the cases, parents whose primary residence is located within 300 meters get 21 percent. The effect of the reform is larger for parents who live closer to the school district boundaries in absolute terms. However, families who lived further away reacted more in relative terms (40% and 14% with respect to the baseline mean for families living within more than 850 and less than 300 meters, respectively). These results imply that the reform expanded the out of district assignment throughout the entire spacial dimension, although with larger relative impacts for those families living further away from school district boundaries.

Figure 8: Impact of the Reform on Out-Of-District Assignment by Distance to the Closest School District Border.



Note: Black and grey dots represent point estimates. Horizontal lines depict confidence intervals at the 95% level of confidence. The red stripes reflect the two consecutive changes in the choice priority system in 2012 and 2013. The coefficients are normalized to zero in 2011.

To which schools are pupils assigned? Families with lower levels of education quintiles managed to get admission in schools with higher average performance (although the size of the effect is quite small), middle parental education quintiles increased their propensity to get access to schools in districts with higher average income levels. Most of the families managed to get access to districts with lower predetermined levels of school segregation (measured by parental education status). There are no substantial differences between immigrants and natives on admission by school average performance and predetermined school segregation (measured by immigrant status), but immigrants tend to get admission in schools in which the average income is lower on average.⁴⁹ The fact that most of the families got access to a slightly higher performing-rank school is potentially correlated with the constant supply of schools, but decreasing demographic trends of pupils of the age of 3, during the period under study in the city of Madrid.

5.1.2 Difference-in-Difference Analysis

Table 4 shows the main results of the DID strategy. It is the result of estimating equation Equation 2. Columns (1) to (3) report three specifications for out-of-district assignment, while columns (4) to (6) provide the same three specifications for distance to assigned school. Column (1) and (3) present the baseline estimates, including school district fixed effects, columns (2) and (4) include census block level demographic controls, and columns (3) and (6) add households

⁴⁹See Section J for details.

observable characteristics. The effect of the inter-district school choice reform is positive and statistically significant in all specifications. The effect size is an increase of 3.6 percentage points for out-of-district assignment 311 meters for distance to the assigned school. Considering that the average fraction of out-of-district assignment (distance to assigned school) in 2011 was 0.05 (1,259 meters) for families whose primary residence locates within 150 meters to the school district centroid, an increase of 3.6 percentage points (311 meters) is equivalent to a 70% increase (25%). Results are robust to the sensitivity choice in the definition of the treatment group, such as parents whose primary residence locates within 200, 250, 300, 350, and 450 meters close to the school district boundaries (see Table I 2).

Table 4: Effect of the reform on Out-of-District Assignment and Distance to Assigned School. Difference-in-Difference Approach.

Dependent Variable	Out-of-District Assignment			Distance to Assigned School		
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment	0.143*** (0.025)	0.117*** (0.027)	0.118*** (0.026)	174.249** (80.861)	16.606 (97.967)	0.281 (91.522)
Year 2012	-0.005 (0.023)	-0.008 (0.024)	-0.004 (0.023)	-63.671 (73.993)	-87.925 (82.657)	-42.383 (78.108)
Post 2013	-0.008 (0.015)	-0.010 (0.016)	-0.007 (0.015)	-1.960 (75.096)	-20.473 (80.212)	16.393 (76.834)
Treatment*Year 2012	0.024 (0.024)	0.025 (0.025)	0.021 (0.025)	134.096* (79.564)	149.392* (87.770)	91.449 (82.325)
Treatment*Post 2013	0.036** (0.016)	0.040** (0.017)	0.036** (0.017)	331.053*** (79.802)	351.699*** (85.263)	311.179*** (81.671)
School District Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Demographic Controls	No	Yes	Yes	No	Yes	Yes
Individual Controls	No	No	Yes	No	No	Yes
Observations	29,518	29,518	29,518	29,518	29,518	29,518

Notes: Each year corresponds to the year of application and the school year starting in September of that year. Standard errors are clustered at the census block level and displayed in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Overall, there are two significant findings. First, on average, the reform implied a positive households' response for the distance traveled and out-of-district school assigned. Second, the effect was not homogeneous across parental education status and between natives and non-natives. In particular, students from the most educated households and native students were the ones that reacted the most to the reform in absolute terms, but in relative terms, the effect size of the reform was relatively similar and hence neutral across socioeconomic groups. These results are consistent with previous evidence from reforms of other countries (e.g., Sweden⁵⁰), showing that less advantaged and immigrant households tend to exert less choice than more socially advantaged and natives families when choosing schools (which may reflect differences in preferences, information). This could have distributional implications that are further analyzed in the next section. Finally, the absolute magnitude of the change in terms of the total student population is modest. It is probably due to the weight of other key contextual factors, such as the 0.5 point that families continue to obtain when they reside in the district of their first-

⁵⁰See Böhlmark and Lindahl (2007).

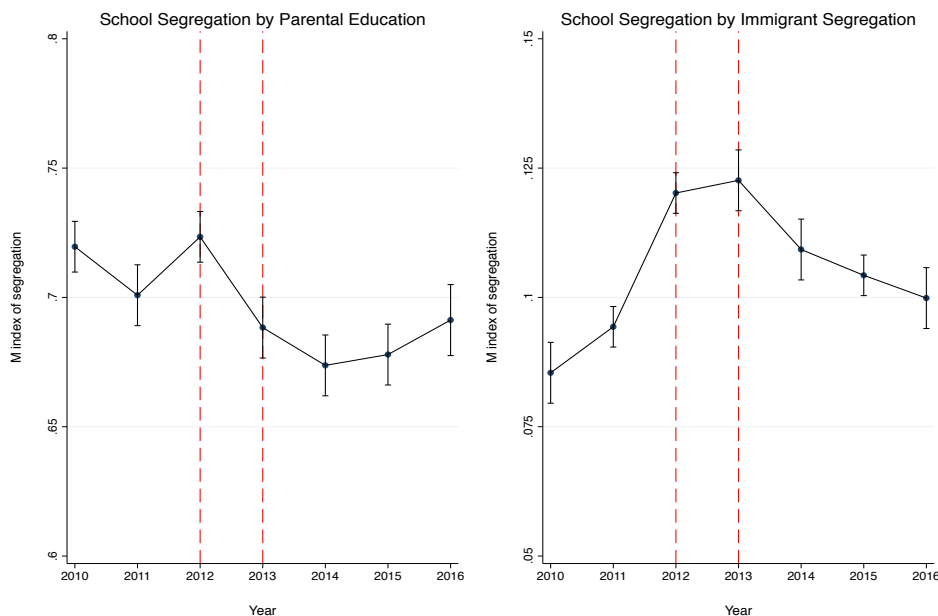
choice application, the incentives generated by the BM assignment model, the disutility from commuting, and the fact that the extent of the effect is expected to be small due to the low-risk behavior in the top-ranked school induced by the BM.

5.2 School Segregation

We have analyzed the impact of the reform on the probability that the top-ranked and assigned school are located in a different school district from where families reside, finding an increase in the out-of-district assignment. This subsection is devoted to investigate whether this reshuffle of pupils had a contemporaneous impact on school segregation by parental education and immigrant status. We explore the trends in school sorting over time, being able to compare the within vs. between district school segregation, and the school vs. residential segregation. We conclude with an econometric analysis to explore conditional associations between the school choice reform and student sorting.

Trends in School Segregation. Figure 9 plots the M Index of school segregation by parental education and immigrant status. Standard errors are computed using the bootstrap resampling method with 100 replications. Despite the small increase in the level of segregation between schools by parental education in 2012, there is a decreasing trend over time following the inter-district school choice reform between 2013 and 2015. School segregation by immigrant status shows the opposite pattern. There is a sharp increase in the level of segregation in 2012 and 2013 with a decrease after that ends at slightly higher levels than in 2010 and 2011.

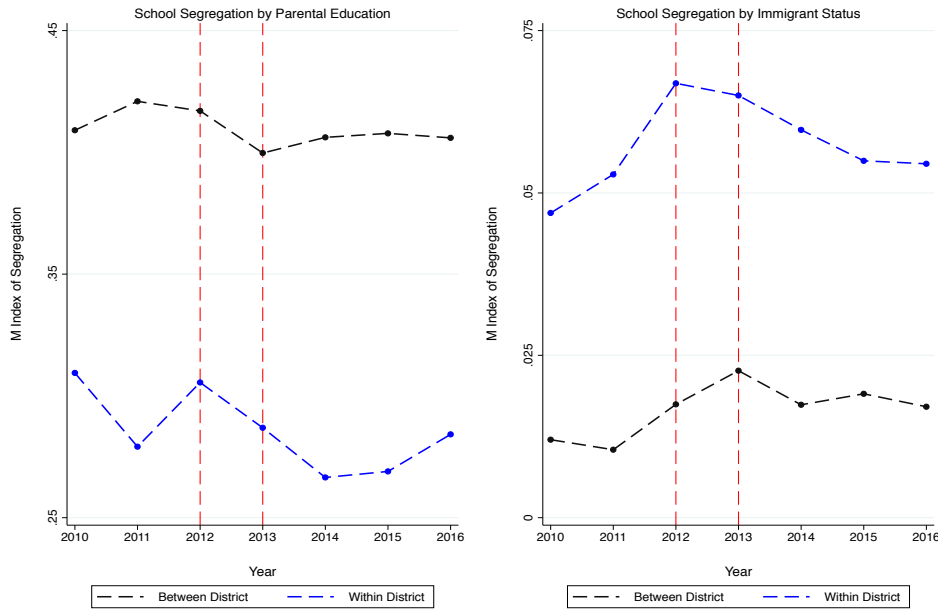
Figure 9: School Segregation (M Index).



Note: The Figure shows the M index of segregation. The left hand side Figure represents the school segregation measured by parental education. The right hand side of the Figure plots the school segregation by immigrant status. Blue dots are the estimates of school segregation using the Mutual Information Index of Segregation. Horizontal lines depict confidence intervals at the 95% level of confidence using bootstrap with 100 replications. The red stripes reflect the two consecutive changes in the choice priority system in 2012 and 2013.

Within vs. Between School District Segregation. One of the advantages of the M Index of segregation is that it is additively decomposable. This property allows to divide the value of the index into two components: (i) The share of segregation that comes from the school segregation between different groups (e.g., between school districts), which we refer as between district school segregation; (ii) A component that measures the part of segregation that comes from within groups school segregation (e.g., within school districts). The addition of between and within district school segregation adds up to the total school segregation. Most of the indices that are widely used in the literature, such as the Dissimilarity Index, do not have this property. Figure 10 investigates the extent through which the dynamics of the total school segregation are driven by within and between school district segregation. Interestingly, whereas the level of between district segregation is higher than the within district segregation by parental education, the opposite pattern is right when we consider segregation by immigrant status. It seems that the decreasing trend in school segregation by parental education is driven mostly by the decrease in within district segregation, while between district segregation remains flat after the inter-district school choice reform. Both between and within district segregation by the immigrant status display a similar trend, but within district, segregation shows a more significant increase.

Figure 10: Within vs. Between School District Segregation.



Note: The Figure shows the M index of segregation. The left hand side Figure represents the school segregation measured by parental education. The right hand side of the Figure plots the school segregation by immigrant status. Blue dots are the estimates of within school segregation using the Mutual Information Index of Segregation. Black dots are the estimates of between school segregation using the Mutual Information Index of Segregation. The red stripes reflect the two consecutive changes in the choice priority system in 2012 and 2013.

School vs. Residential Segregation. An important confounding factor when addressing the effects of the reform on school segregation is the trends in residential segregation. Changes in segregation between schools may be correlated with changes in the social composition of

neighborhoods, especially when analyzing a cross-cohort comparison. An advantage of this study is that we count with the precise geo-location of families' home address, allowing to compute an accurate measure of residential sorting. Residential segregation is measured as the M index of families' primary residence segregation by parental education and immigrant status between neighborhoods (hence using neighborhoods, not schools, as units of analysis). Figure 11 plots the trends in school and residential segregation. Although residential segregation is higher than school segregation by parental education, the opposite occurs when we consider segregation by immigrant status. Two different reasons may explain this stylized fact. First, a potential reason may be the measurement error of parental education, and the reverse mean effect it implies, generating less variation across families within neighborhoods and hence observing more residential segregation under the M Index. Second, it may be explained by the findings of Figure 7, in which we see that immigrants are less likely to top-rank a school located in a different district than natives: this may create a situation in which the levels of school segregation by immigrant status are higher than the residential ones. This is not as clear for segregation by parental education: since every quintile of parental education move to some extent, and the relative effect is similar, the equilibrium outcome is more uncertain.

Figure 11: School vs. Residential Segregation.



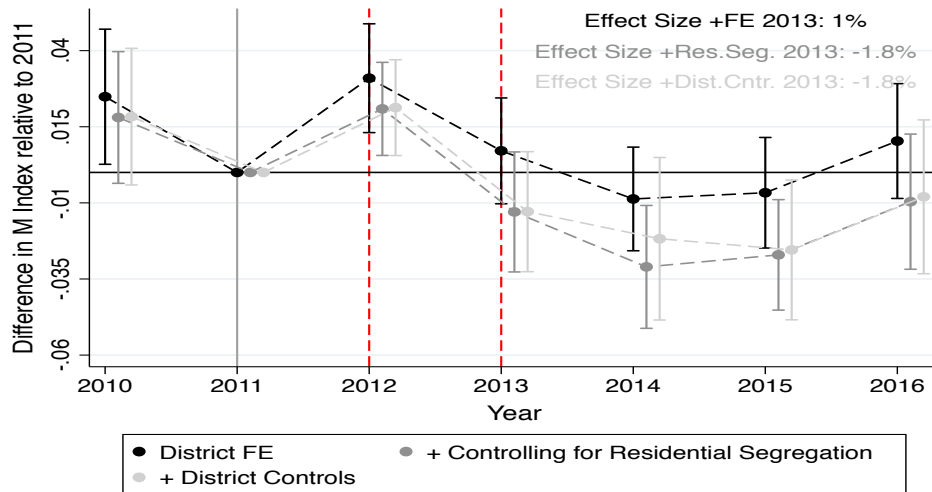
Note: The Figure shows the M index of segregation. School segregation is measured as the M index of pupils segregation by parental education and immigrant status between schools. Residential segregation is measured as the M index of families' primary residence segregation by parental education and immigrant status between neighbourhoods. The left hand side Figure represents the school segregation measured by parental education. The right hand side of the Figure plots the school segregation by immigrant status. Black dots are the estimates of school segregation using the Mutual Information Index of Segregation. Red dots are the estimates of residential segregation using the Mutual Information Index of Segregation. The red stripes reflect the two consecutive changes in the choice priority system in 2012 and 2013.

Interestingly, we find that the decrease in school segregation after the inter-district school choice reform is not associated with a change in residential sorting since the latter remains flat

after 2013. However, the increasing pattern in school segregation by immigrant status seems to be highly correlated with changes in residential segregation, which may act as a confounding factor when identifying the effect of the reform. This confirms the importance of controlling for this variable when analyzing associations between the inter-district school choice reform and school segregation would improve the precision of our estimates, especially when considering school segregation by immigrant status.

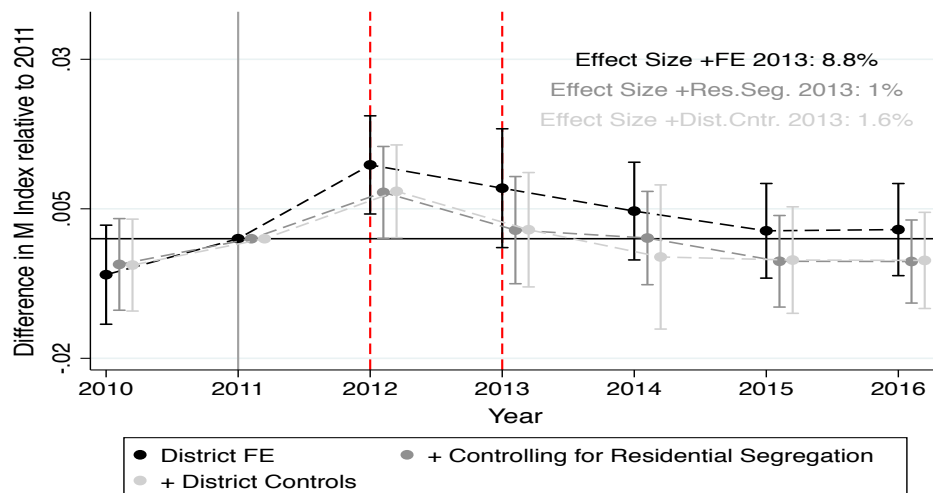
The Effect of the School Choice Reform on School Segregation. To perform a more formal test of the impact of the reform on the levels of school segregation, we estimate the model described by Equation 4, which controls for school districts' fixed effects, segregation under pure residence-based assignment, and time-variant school district characteristics. Table 5 shows the regression results. The 2012 reform is associated with a mild increase in school segregation by parental education of 3%, and a sizeable increase in segregation by immigrant status by 13% (see Figure 12 and Figure 13). Both impacts are statistically significant at the 1 and 5 percent confidence levels, respectively. By contrast, the inter-district school choice reform of 2013 is associated with a reduction of 2% in the level of segregation by parental education, but the effect is non-statistically significant. Nevertheless, the estimates further decrease 3.1% and 3.5% in 2014 and 2015, respectively, becoming statistically significant only in some specifications. On the contrary, the inter-district school choice reform is associated with an increase in the level of segregation by the immigrant status of 1.6%, which statistical significance does not hold when controlling for residential segregation. In the subsequent years, point estimates converge to the baseline mean, and the effects get close to zero. Hence, it seems that residential segregation explains a large part of the variation in school segregation by immigrant status (as suggested by Figure 11).

Figure 12: The Effect of the School Choice Reform on School Segregation by Parental Education.



Note: Black and grey dots represent point estimates. Horizontal lines depict confidence intervals at the 95% level of confidence. The red stripes reflect the two consecutive changes in the choice priority system in 2012 and 2013. The coefficients are normalized to zero in 2011.

Figure 13: The Effect of the School Choice Reform on School Segregation by Immigrant Status.



Note: Black and grey dots represent point estimates. Horizontal lines depict confidence intervals at the 95% level of confidence. The red stripes reflect the two consecutive changes in the choice priority system in 2012 and 2013. The coefficients are normalized to zero in 2011.

Table 5: The Effect of the School Choice Reform on School Segregation by Parental Education and Immigrant Status.

	Dependent Variable: Segregation by					
	Parental Education			Immigrant Status		
	(1)	(2)	(3)	(4)	(5)	(6)
Constant	0.251*** (0.010)	0.105*** (0.036)	0.065 (0.115)	0.076*** (0.009)	0.042*** (0.010)	0.053 (0.042)
Year 2010	0.025** (0.011)	0.018 (0.011)	0.018 (0.011)	-0.006 (0.004)	-0.004 (0.004)	-0.004 (0.004)
Year 2012	0.031*** (0.009)	0.021*** (0.008)	0.021*** (0.008)	0.012*** (0.004)	0.008** (0.004)	0.008** (0.004)
Year 2013	0.007 (0.009)	-0.013 (0.010)	-0.013 (0.010)	0.008* (0.005)	0.001 (0.005)	0.001 (0.005)
Year 2014	-0.009 (0.009)	-0.031*** (0.010)	-0.022 (0.013)	0.005 (0.004)	0.000 (0.004)	-0.003 (0.006)
Year 2015	-0.007 (0.009)	-0.027*** (0.009)	-0.025** (0.012)	0.001 (0.004)	-0.004 (0.004)	-0.004 (0.004)
Year 2016	0.010 (0.010)	-0.010 (0.011)	-0.008 (0.013)	0.002 (0.004)	-0.004 (0.004)	-0.004 (0.004)
Residential Segregation		0.344*** (0.080)	0.331*** (0.082)		0.644*** (0.118)	0.637*** (0.122)
School district FE	Yes	Yes	Yes	Yes	Yes	Yes
Time-Variant District Characteristics	No	No	Yes	No	No	Yes
Segregation level in 2011	0.7	0.7	0.8	0.06	0.06	0.06
R-squared	0.911	0.927	0.927	0.598	0.673	0.676
Observations	147	147	148	147	147	147

Notes: Each year corresponds to the year of application and the school year starting in September of that year. Robust standard errors in parentheses. *, ** and *** indicate significance at 10-, 5- and 1-percent level, respectively.

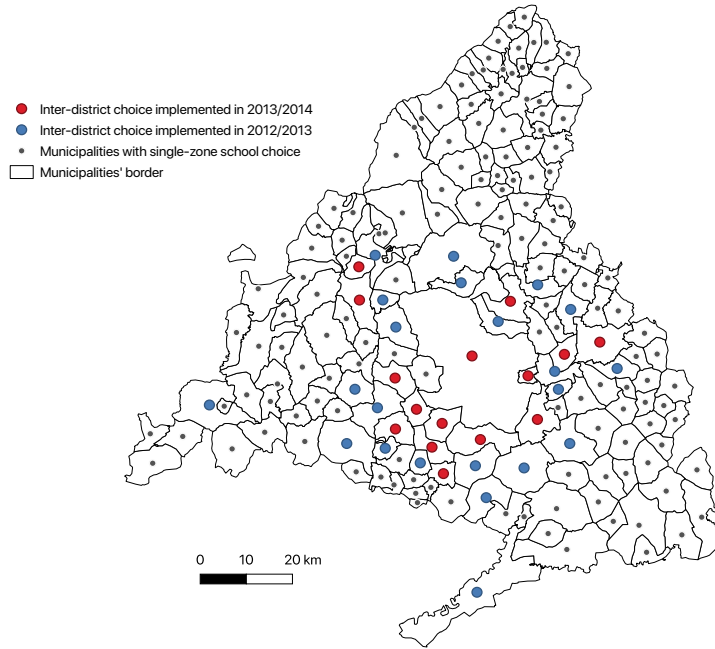
To sum up, it seems that the 2012 reform, in which priorities for low-income pupils were reduced and new priority was granted for alumni school family members, is associated with a contemporaneous increase in the levels of school segregation by both parental education and immigrant status of 3 and 13 percent, respectively. However, the inter-district school choice reform marginally reduced school segregation by parental education and largely increased school segregation by immigrant status. However, these effects are not robust to different specifications controlling for residential segregation and time-variant district characteristics. Hence, we find that the inter-district school choice reform has limited impact on school segregation by parental education and immigrant status.

6 Robustness Check: Phasing-in of the Reform in other Municipalities

As we described in Section 2, the school choice reform was gradually implemented in other municipalities beyond the city of Madrid. The inter-district reform was implemented in several municipalities (mostly those of medium size) in 2012 (as well as the low-income and alumni pupil bonus criteria), whereas, for mostly the larger ones (including Madrid), it took place in 2013.

Figure 14 shows a map of the phase-in of the reform in the entire set of municipalities in the region of Madrid.⁵¹ We exploit this phasing-in of the inter-district school choice to analyze the effects on the other municipalities as a robustness check. In particular, we compare the results between three groups of municipalities that we label as small-size (no reform change), medium-size municipalities (the reform took place in 2012/2013) and large-size municipalities (the reform took place in 2013/2014).⁵²

Figure 14: Phasing-in of the Reform in the Municipalities of the Region of Madrid.



Note: Own computation using shapefiles data from the 179 municipalities of the region of Madrid.

6.1 Out-of-Municipality Assignment and Distance to Assigned School

In terms of the out of district assignment, we measure the distance to the assigned school given that we do not have access to geographical data on the catchment areas in other municipalities than Madrid city before the reform.⁵³ Besides, we compute the out-of-municipality assignment as a proxy of an extensive margin measure. This variable is defined as a dummy variable that

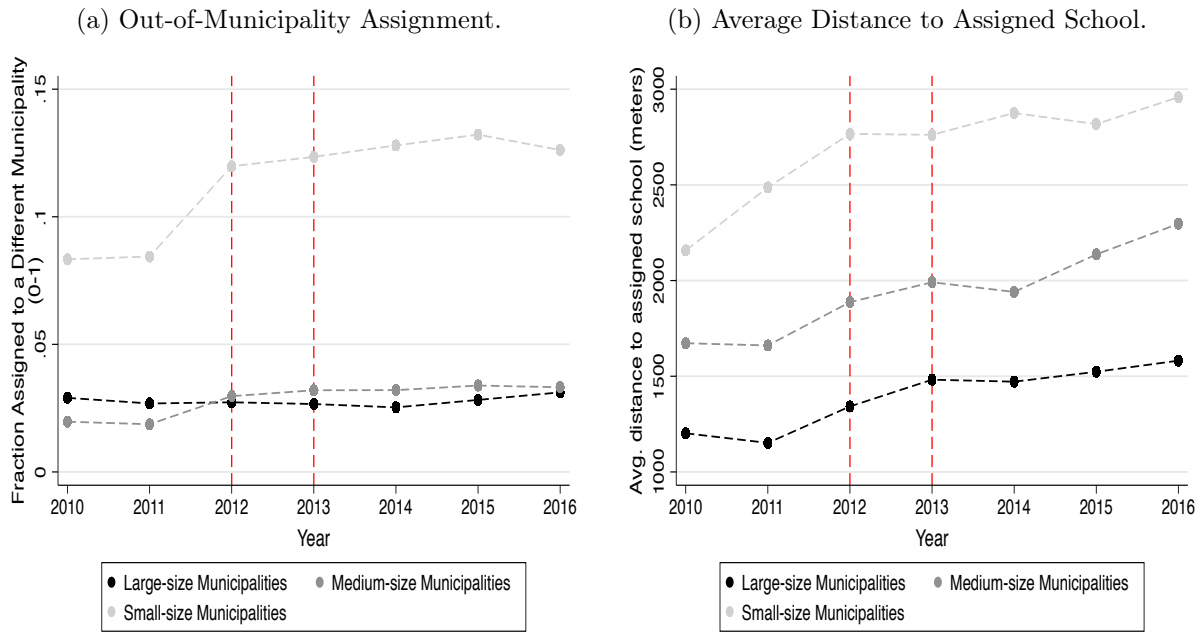
⁵¹Table A 2 in the Appendix describes which municipalities joined the inter-district criterion in 2012 and 2013.

⁵²The relationship between the labels of medium and large size municipalities is not a perfect 1:1 mapping to population size. For instance, in 2012/2013, Alcobendas and Las Rozas (with about 120k and 100k inhabitants respectively) incorporated the inter-district reform and are labeled as medium-sized municipalities. Whereas in 2013/2014, municipalities such as Rivas-Vaciamadrid, Collado-Villalba, Boadilla del Monte, or Galapagar (with about 80k, 60k, 50k, 30k inhabitants respectively) implemented the inter-district reform and are labeled as large-size municipalities.

⁵³In Madrid, the choice catchment areas coincide with the city district. However, in other municipalities, the catchment areas were defined using other criteria. We do not count on data on catchment areas in other municipalities than Madrid, which implies that we cannot compute the out of school district assignment. However, we can compute the average commuting distance in other municipalities.

takes value 1 if the pupil is assigned to a school located in a different municipality, and zero otherwise. Figure 15 shows the average out-of-municipality assignment and the distance to assigned school by municipality size. Medium-size municipalities seem to increase both their out-of-municipality assignment and their distance to the assigned school in 2012 when both reforms were implemented. Interestingly, households living in large-size municipalities do not seem to change their out-of-municipality assignment but react to increasing their distance to the assigned school. Families living in small-size municipalities present the highest values of out-of-municipality assignment and distance to the assigned school. These households seem to be also changing their pattern, increasing both margins with the 2012's reform. The change in these trends for small-size municipalities can be explained by the fact that school choice reform relaxed the proximity bonus for intra-municipality school choice (obtaining 4 points for a top-ranked school located within the same municipality), but also the inter-municipality school choice (granting 2 points for a top-ranked school located in other municipality of the region).⁵⁴ As the educational markets at the municipal level are not independent, the relaxation of the inter-municipality bonus points may generate interactions between several municipalities.

Figure 15: Average Out-of-Municipality Assignment and Average Distance to Assigned School by municipality size.



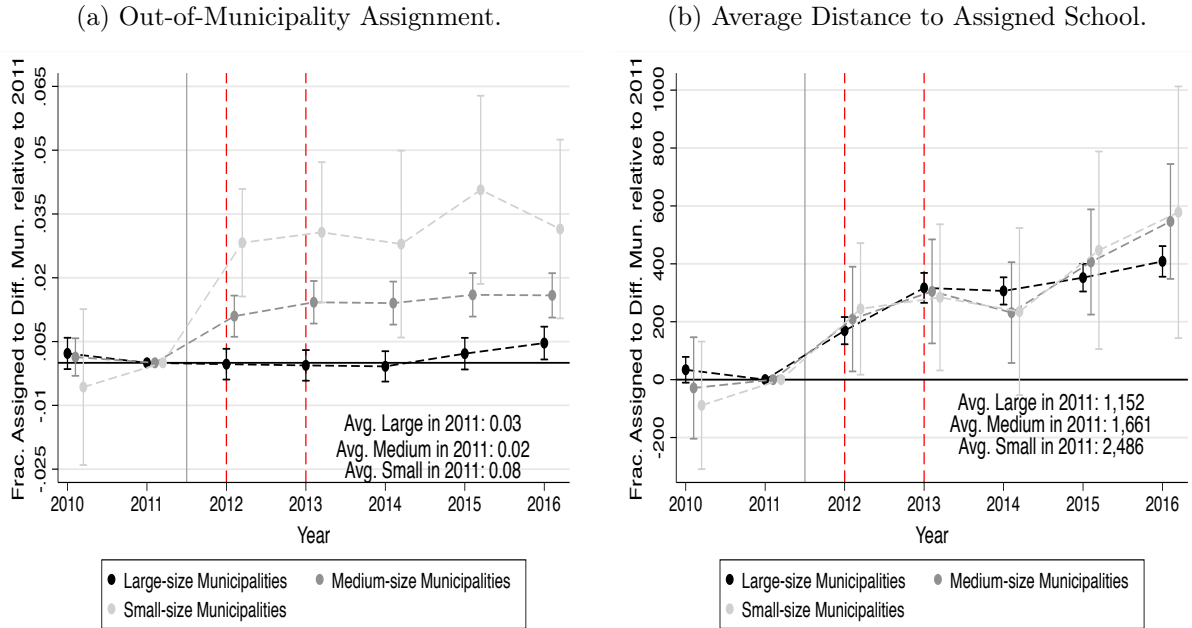
Note: Black and grey dots represent averages. The red stripes reflect the two consecutive changes in the choice priority system in 2012 and 2013. The coefficients are normalized to zero in 2011.

Figure 16 shows the effect of the school choice reforms on these variables, confirming the detailed results found in Figure 15. Panel A shows that the low-income and alumni reform

⁵⁴See Table 1.

and the inter-district school choice reform increased the out-of-municipality assignment (average distance traveled to the top-ranked school) in 50% (12%) with respect to the baseline mean for medium-size municipalities where the inter-district choice was implemented in 2012. The school choice reforms increased the out-of-municipality assignment (average distance traveled to the top-ranked school) in 37% (8%) with respect to the baseline mean for those small-size municipalities (with a single school choice zone). We observe no effect of the low-income and alumni bonus points reform in the out-of-municipality assignment, and a slight increase in the average distance traveled to the top-ranked school (13%) for large-size municipalities, that is consistent with the results from in Figure 4 and Figure 5. In 2013, the reform led to a 30% increase (with respect to the baseline mean) in the commuting distance to the top-ranked school in large-size municipalities, which caught up with the absolute effect of those of medium-size municipalities, remaining constant over the following years.

Figure 16: Effect of the School Choice Reform on Out-of-Municipality Assignment and Average Distance to Assigned School by municipality size.



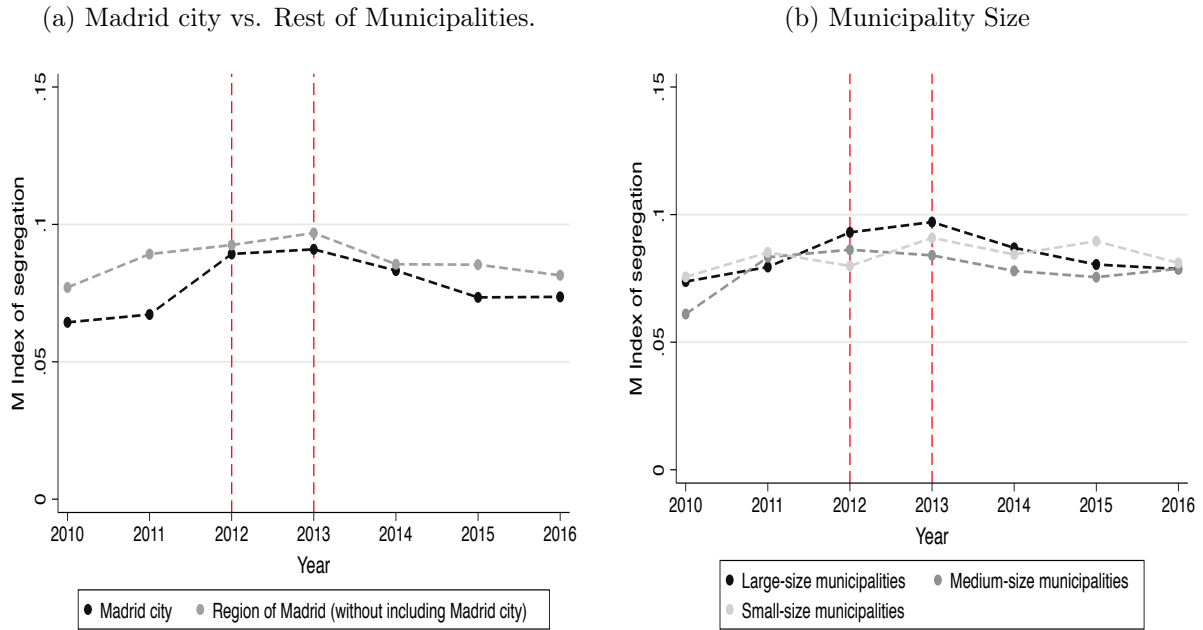
Note: Black and grey dots represent point estimates. Horizontal lines depict confidence intervals at the 95% level of confidence. The red stripes reflect the two consecutive changes in the choice priority system in 2012 and 2013. The coefficients are normalized to zero in 2011.

6.2 School Segregation by Immigrant Status

We can also exploit the gradual implementation of the policy to estimate changes in school segregation associated with the reform. It seems that even though large-size and middle-size municipalities present similar levels of school segregation by immigrant status, school segregation seems to have increased more on large-size municipalities in the reform years (see Figure 17). Figure 18 shows that this raise in school segregation is driven by the within-municipality school

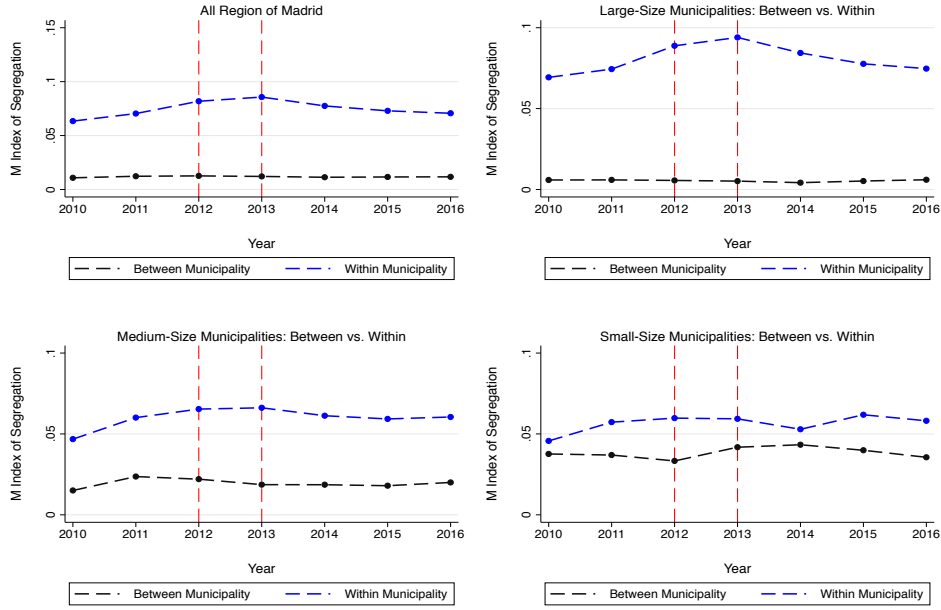
segregation, which increasingly seems to be more salient in large-size municipalities. Interestingly, the between municipality school segregation seems to be almost negligible for large-size and middle-sized municipalities, but it is almost equally important as the within municipality segregation in small-size municipalities.

Figure 17: School Segregation by Immigrant Status by Municipality Size.



Note: The Figure shows the M index of segregation. The dots represents the school segregation measured by immigrant status. The left hand side Figure represents the school segregation in Madrid city and in the rest of the Region of Madrid. The right hand side of the Figure plots the school segregation by municipality size. The red stripes reflect the two consecutive changes in the choice priority system in 2012 and 2013.

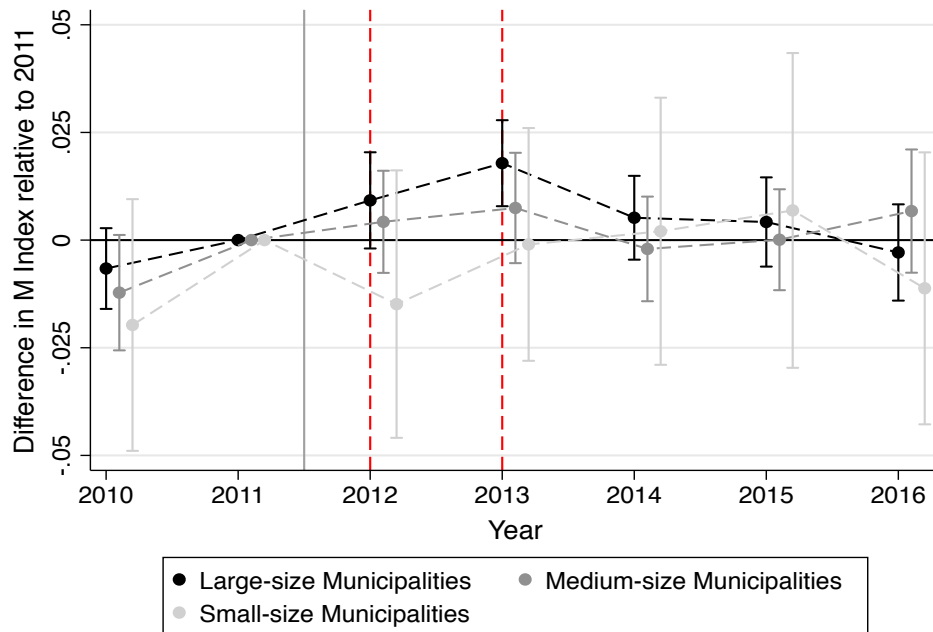
Figure 18: School Segregation by Immigrant Status: Within vs. Between Municipality.



Note: The Figure shows the M index of segregation. Blue dots are the estimates of within school segregation using the Mutual Information Index of Segregation. Black dots are the estimates of between school segregation using the Mutual Information Index of Segregation. The red stripes reflect the two consecutive changes in the choice priority system in 2012 and 2013.

To determine whether the inter-district school choice reform had a differential impact on school segregation by immigrant status, we regress school segregation by immigrant status at the municipal level on year and municipality fixed effect. Results are summarized in Figure 19. The implementation of the inter-district school choice reform seems to be associated with a small increase in school segregation by immigrant status, but results are clearer and more precise in municipalities of larger size. We cannot reject the null hypothesis of no change in school segregation in small-size municipalities. Results are robust to those found in the previous section for the city of Madrid.

Figure 19: The Effect of The School Choice Reform on School Segregation by Immigrant Status and Municipality Size.



Note: Black and grey dots represent point estimates. Horizontal lines depict confidence intervals at the 95% level of confidence. The red stripes reflect the two consecutive changes in the choice priority system in 2012 and 2013. The coefficients are normalized to zero in 2011.

7 Conclusion

In this paper, we use novel administrative data of the region of Madrid to analyze the impact of two large-scale school choice reforms on school choice and school segregation. We study the reduction in low-income pupils' priorities plus the creation of additional points to alumni family members of the top-ranked school in 2012, and a large-scale inter-district school choice reform undertaken in 2013. We find that the inter-district school choice reform increased the probability of applying and of being assigned to an out-of-district school of parents, with a larger response for families with higher levels of education and non-immigrant children. We show potential information gaps and dynamic learning process across immigrant status groups throughout time. We find that reducing low-income priorities to the top-ranked school and granting points to alumni family members of the top-ranked school increases school segregation by parental education and immigrant status on 3 and 13 percent, respectively. Besides, we find that the inter-district school choice reform marginally reduced school segregation by parental education and largely increased school segregation by immigrant status. However, these effects are not robust to different specifications controlling for residential segregation and time-variant district characteristics. Hence, we find that the inter-district school choice reform has a limited impact on school segregation by parental education and immigrant status.

We find evidence showing that relaxing residence-based priorities may be an effective policy

to increase pupils' inter-district school assignment, but the heterogeneous behavioral responses, especially for immigrant parents, needs to be taken into account. Immigrants may lack the networks and information that are necessary to make an informed choice, or they may prefer to choose the nearest school for cultural reasons, but such informational gaps seem to be narrowed 3 years after the reform. However, we cannot precisely claim that a raise in the inter-district school assignment translates into an increase in families' welfare through a better fit with their preferences since we can only identify choices but not preferences under the BM.

In terms of school segregation, this paper shows that even under a context that induces low levels of inter-district choice and non-risky behavior, in which low elasticity of response to changes in school priorities are expected, school segregation may be affected. Results suggest that school choice priorities do play a role in determining the levels of school segregation under the Boston Mechanism. Relaxing low-income priorities and promoting priorities related to alumni family members contribute to increasing school segregation. Moreover, abolishing school choice proximity points does not seem an effective public policy for reducing school segregation. Hence, priority structures need to be carefully designed to achieve diversity objectives.

Further research needs to be undertaken to understand under which conditions, such as the predetermined levels of school (and residential) segregation, subgroups of the population considered, school choice allocation mechanism, or parents' preferences, school priorities may contribute to reduce indeed or to increase school segregation.

References

- Abdulkadiroglu, Atila, and Tayfun Sönmez.** 2003. "School choice: A mechanism design approach." *The American Economic Review*, 93(3): 729–747.
- Abdulkadiroglu, Atila, Parag Pathak, Alvin E Roth, and Tayfun Sonmez.** 2006. "Changing the Boston school choice mechanism." National Bureau of Economic Research.
- Abdulkadiroğlu, Atila, Yeon-Koo Che, and Yosuke Yasuda.** 2011. "Resolving conflicting preferences in school choice: The " boston mechanism" reconsidered." *American Economic Review*, 101(1): 399–410.
- Anderson, S, A. Palma, and J Thisse.** 1992. *Discrete Choice Theory of Product Differentiation*. The MIT Press.
- Anghel, Brindusa, Antonio Cabrales, and Jesus M. Carro.** 2016. "Evaluating a bilingual education program in Spain: The impact beyond foreign language learning." *Economic Inquiry*, 54(2): 1202–1223.
- Arellano, Manuel, and Gemma Zamarro.** 2007. "The choice between public and private schools with or without subsidies in Spain." *Unpublished*.
- Billings, Stephen B., David J. Deming, and Jonah Rockoff.** 2014. "School segregation, educational attainment, and crime: Evidence from the end of busing in Charlotte-Mecklenburg." *Quarterly Journal of Economics*, 129(1): 435–476.
- Böhlmark, A., and M. Lindahl.** 2007. "The impact of school choice on pupil achievement, segregation and costs: Swedish evidence." *IZA Discussion Paper Series*, , (2786): 65.
- Böhlmark, Anders, Helena Holmlund, and Mikael Lindahl.** 2016. "Parental choice, neighbourhood segregation or cream skinning? An analysis of school segregation after a generalized choice reform." *Journal of Population Economics*, 29(4): 1155–1190.
- Burgess, Simon, and Adam Briggs.** 2010. "School Assignment, School Choice and Social Mobility." *Economics of Education Review*, 29: 639–649.
- Burgess, Simon, Carol Propper, and Deborah Wilson.** 2007. "the Impact of School Choice in England." *Policy Studies*, 28(2): 129–143.
- Burgess, Simon, Ellen Greaves, Anna Vignoles, and Deborah Wilson.** 2015. "What Parents Want: School Preferences and School Choice." *The Economic Journal*, 125(587): 1262–1289.
- Calsamiglia, Caterina.** 2014. "Matching Practices for Elementary and Secondary Schools – Spain." MiP Country Profile 17.
- Calsamiglia, Caterina, and Maia Güell.** n.d.. "Priorities in School Choice: The case of the Boston mechanism in Barcelona." *Journal of Public Economics, Forthcoming*.

- Calsamiglia, Caterina, Francisco Martínez-Mora, Antonio Miralles, et al.** 2017. "Sorting in public school districts under the Boston Mechanism." *Unpublished working paper*.
- Card, David, Alexandre Mas, and Jesse Rothstein.** 2008. "Tipping and the Dynamics of Segregation." *The Quarterly Journal of Economics*, 123(1): 177–218.
- Card, David, and Jesse Rothstein.** 2007. "Racial segregation and the black–white test score gap." *Journal of Public Economics*, 91(11–12): 2158–2184.
- De Haan, Monique, Pieter A Gautier, Hessel Oosterbeek, and Bas Van der Klaauw.** 2015. "The performance of school assignment mechanisms in practice."
- Duflo, Esther, Pascaline Dupas, and Michael Kremer.** 2011. "Peer effects, teacher incentives, and the impact of tracking: Evidence from a randomized evaluation in Kenya." *American Economic Review*, 101(5): 1739–1774.
- Duncan, Otis Dudley, and Beverly Duncan.** 1955. "A Methodological Analysis of Segregation Indexes." *American Sociological Review*, 20(2): 210.
- Epplé, Dennis, Richard E Romano, and Miguel Urquiola.** 2017. "School vouchers: A survey of the economics literature." *Journal of Economic Literature*, 55(2): 441–92.
- Fack, Gabrielle, and Julien Grenet.** 2010. "When do better schools raise housing prices? Evidence from Paris public and private schools." *Journal of public Economics*, 94(1–2): 59–77.
- Figlio, David N, and Joe A Stone.** 2001. "Can public policy affect private school cream skimming?" *Journal of Urban Economics*, 49(2): 240–266.
- Frankel, David M, and Oscar Volij.** 2011. "Measuring school segregation." *Journal of Economic Theory*, 146(1): 1–38.
- Hanushek, Eric A, John F Kain, and Steven G Rivkin.** 2009. "New evidence about Brown v. Board of Education: The complex effects of school racial composition on achievement." *Journal of labor economics*, 27(3): 349–383.
- Hastings, Justine, and Jeffrey Weinstein.** 2008. "Formation, School Choice, and Academic Achievement: Evidence from Two Experiments." *The Quarterly Journal of Economics*, 123: 1373–1414.
- Hastings, Justine S, Thomas J Kane, and Douglas O Staiger.** 2005. "Parental preferences and school competition: Evidence from a public school choice program." National Bureau of Economic Research.
- Hastings, Justine, Thomas Kane, and Douglas Staiger.** 2009. "Heterogeneous preferences and the efficacy of school choice." *NBER Working Papers No. 2145*.
- Hoxby, Caroline.** 2000. "Peer effects in the classroom: Learning from gender and race variation." National Bureau of Economic Research.

- Hsieh, C, and M Urquiola.** 2006. “The Effects of Generalized School Choice on Achievement and Stratification: Evidence from Chile’s Voucher Program.” *Journal of Public Economics*, , (90): 1477–1503.
- Huber, Stephan, and Christoph Rust.** 2016. “Calculate Travel Time and Distance with OpenStreetMap Data Using The Open Source Routing Machine (OSRM).” *The Stata Journal*, 16(2): 1–8.
- Jenkins, Stephen P, John Micklewright, and Sylke V Schnepf.** 2008. “Social segregation in secondary schools: how does England compare with other countries?” *Oxford Review of Education*, 34(1): 21–37.
- Ladd, Helen F., and Edward B. Fiske.** 2001. “The uneven playing field of school choice: Evidence from New Zealand.” *Journal of Policy Analysis and Management*, 20(1): 43–64.
- Lavy, Victor.** 2010. “Effects of free choice among public schools.” *The Review of Economic Studies*, 77(3): 1164–1191.
- Levin, Henry M.** 1998. “Educational vouchers: Effectiveness, choice, and costs.” *Journal of Policy Analysis and Management*, 17(3): 373–392.
- Mancebón, M. J., J. Calero, Á Choi, and D. P. Ximénez-De-Embún.** 2012. “The efficiency of public and publicly subsidized high schools in Spain: Evidence from PISA-2006.” *Journal of the Operational Research Society*, 63(11): 1516–1533.
- Mizala, Alejandra, and Miguel Urquiola.** 2013. “School markets: The impact of information approximating schools’ effectiveness.” *Journal of Development Economics*, 103(1): 313–335.
- Murillo, Fracisco Javier, and Cynthia Garrido.** 2018. “Magnitud de la Segregación escolar por nivel socioeconómico en España y sus Comunidades Autónomas y comparación con los países de la Unión Europea.” *RASE: Revista de la Asociación de Sociología de la Educación*, 1(11): 37–58.
- Murillo, Fracisco Javier, Cynthia Garrido, and Guillermina Belavi.** 2017. “Segregación escolar por origen nacional en España.” *OBETS. Revista de Ciencias Sociales*, , (12): 395–423.
- Musset, Pauline.** 2012. “Shool choice and equity: current policies in OECD countries and literature review.” *Education Working Paper*, , (66): 1–51.
- OECD.** 2019. “How are school-choice policies related to social diversity in schools?” *PISA in Focus*, Éditions OCDE(96).
- Oosterbeek, Hessel, Sándor Sóvágó, and Bas Klaauw.** 2019. “Why are schools segregated? Evidence from the secondary-school match in Amsterdam.”
- Rothstein, Jesse.** 2006. “Good Principals or Good Peers? Parental Valuation of School Characteristics, Tiebout Equilibrium, and the Incentive Effects of Competition among Jurisdictions.” *The American Economic Review*, 96(4): 1333–1350.

- Söderström, Martin, and Roope Uusitalo.** 2010. "School choice and segregation: Evidence from an admission reform." *Scandinavian Journal of Economics*, 112(1): 55–76.
- Teske, Paul, and Mark Schneider.** 2001. "What research can tell policymakers about school choice." *Journal of Policy Analysis and Management*, 20(4): 609–631.
- Tiebout, Charles M.** 1956. "A pure theory of local expenditures." *Journal of political economy*, 64(5): 416–424.
- Yang Hansen, Kajsa, and Jan Eric Gustafsson.** 2016. "Causes of educational segregation in Sweden – school choice or residential segregation." *Educational Research and Evaluation*, 22(1-2): 23–44.

Appendices

The appendix supplements the paper “School Choice Priorities and School Segregation: Evidence from Madrid”. It presents details on priority criteria, an examples of the census block section, years of schooling, population trends in the region of Madrid, housing prices and school average performance, characteristics of assigned school, sample restrictions, theoretical properties of the Boston Mechanism, Difference-in-Difference Approach, alternative measure of segregation by parental education, and school classification.

A Description of priority criteria

Table A 1: Tie-break criteria in the region of Madrid.

Ties are broken in favor of the pupils who has higher points on			
	Before 2012/2013	2012/2013	2013/2014
1	Siblings	Siblings	Siblings
2	Proximity	Proximity	Proximity
3	Disability	Disability	Disability
4	Large family	Alumni family member	Alumni student
5	Low annual income per capita	Large family	Large family
6	Random lottery	Low-income	Low-income
7		Random lottery	School discretionary
8			Random lottery

Notes: IPREM is the acronym in Spanish for the Multiple Effects Income Public Index, which was 7,455.14 euros in the period of study. The Minimum Insertion Subsidy (*Renta Mínima de Inserción*) is a special subsidy granted to people with lower income than IPREM. School discretionary is a point that the schools have freedom to assign by “public and objective” criteria.

Table A 2: Municipalities with the single-zone school choice setting.

Academic year	2011/2012	2012/2013	2013/2014
Municipalities with single-zone school choice	142 small size municipalities	Alcobendas Algete Colmenar Viejo Tres Cantos Aranjuez Arroyomolinos Brunete Humanes Navalcarnero Pinto San Martín de Valdeiglesias Valdemoro Villaviciosa de Odón Arganda Daganzo Mejorada del Campo San Fernando de Henares San Martín de la Vega Villalbilla Las Rozas de Madrid Moralzarzal Torrelodones	Madrid San Sebastián de los Reyes Alcorcón Fuenlabrada Getafe Leganés Móstoles Parla Alcalá de Henares Coslada Rivas-Vaciamadrid Torrejón de Ardoz Boadilla del Monte Collado-Villalba Galapagar
# Municipalities with inter-district school choice	142	164	179
#Municipalities in the region of Madrid	179	179	179

B Section Example

Figure B.1 shows an example of the layout of the sections in the Madrid districts of “Centro” and “Retiro”.

Figure B.1: Census blocks in the city of Madrid.



C Years of Schooling

Census education categories are the followings:

1. Cannot read, cannot write
2. No studies
3. Incomplete Primary
4. Middle school, Primary or Compulsory Secondary Education
5. Vocational Training (Elemental)
6. Vocational Training (Advanced)
7. High school
8. Other Intermediate Graduates
9. University School Graduates
10. Technical Engineer
11. College Graduated
12. No-university Graduated
13. PhD and other Post-graduates

We group all these 13 categories into 6 new categories. Categories 1 and 2 are grouped as No studies. Category 3 remains as Incomplete Primary Education. Categories 4 and 5 form the Lower Secondary Education. Categories 6, 7 and 8 are gathered together in Upper Secondary Education. Categories 9 and 10 form the Lower Tertiary Education. Groups 11, 12 and 13 are joined in category Post-Graduate education. In order to assign an equivalent amount of years of schooling, we make the assumption that parents were educated under the legal framework of the Education Act LGE (*Ley General de Educación*), which was in place for pupils born before 1985. We do this as the average maternity age for the first offspring was 29.5 years old in 2007 (therefore those students aged 3 in 2010) and 30.5 for 2013 (therefore those students aged 3 in 2016). This means that with a large probability, mothers of students born in 2007 and 2013 were at school as part of the LGE framework. The LGE framework consisted of 8 years of basic primary schooling, with 5 years of primary school and 3 years of lower secondary school. We assume category *No Studies* as only 3 years of primary and *Incomplete primary* as just 5 years of schooling. After that Basic schooling, there was vocational training with degrees of 2 to 4 years. We assume Categories 4,5 and 6 to be in between Basic schooling (8 years and some vocational training), averaging 9 years of schooling. Categories 7 and 8 pertain to High School and Other intermediate graduates, which corresponded to 12 years of schooling. Finally, university graduates and technical engineers are assumed to do 18 years of schooling, and post-graduate studies are given an average of 3 additional years of education. The equivalence of years

of schooling for a specific census block is given by the following formula, where each percentage of census population is multiplied by the equivalent years of schooling.

$$YS_s = Non-studies_s * 3 + Primary_s * 5 + LowSecondary_s * 9 + UpperSecondary_s * 12 + LowTertiary_s * 17 + College_s * 20 \quad (5)$$

D Population trends in the Region of Madrid

Table D 1: Total population with 3-year old children in the Region of Madrid by Immigrant status.

	2010	2011	2012	2013	2014	2015	2016
A. Region of Madrid							
Spanish	62,293	63,636	65,905	62,266	60,796	60,296	59,042
Non-Spanish	8,800	9,762	10,771	11,759	10,992	9,394	91,64
Total	71,093	73,398	76,676	74,025	71,788	69,690	68,206
B. City of Madrid							
Spanish	27,202	27,919	29,126	27,045	26,053	25,666	NA
Non-Spanish	3,601	3,881	4,118	4,921	4,495	4,000	NA
Total	30,803	31,8	33,244	31,966	30,548	29,666	NA

Notes: This Table is based on own computations from INE (*Padron*). NA indicate that data are not available for this particular year.

E Housing Prices and School Average Performance.

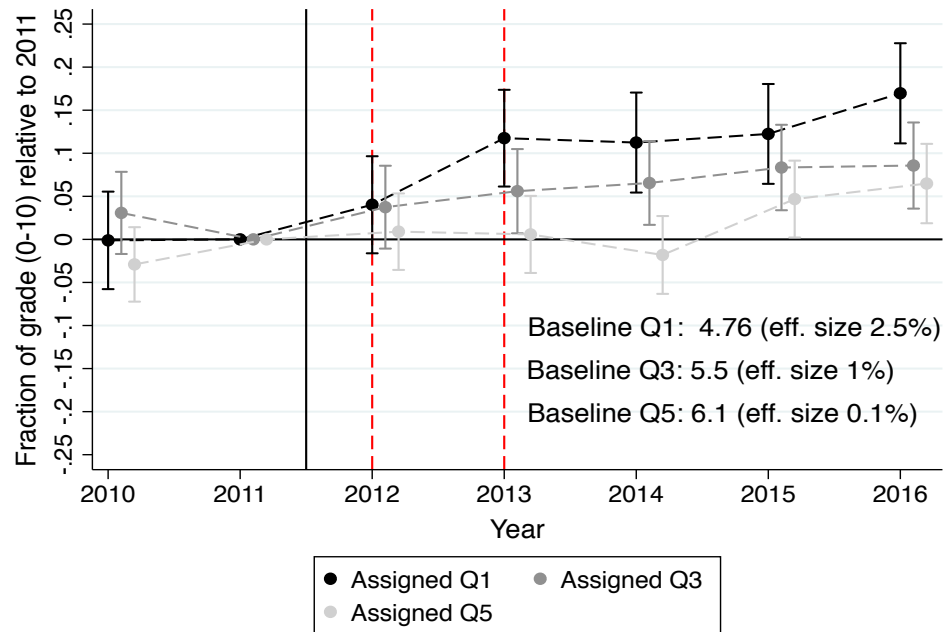
Table E 1: Housing Prices and School Average Performance.

Dependent variable: Log Housing Prices	(1)	(2)	(3)
Constant	7.887*** (0.019)	8.035*** (0.033)	8.037*** (0.034)
Avg. school performance of district	0.502*** (0.033)	0.502*** (0.027)	0.450*** (0.059)
Year 2010		0.063 (0.045)	0.064 (0.046)
Year 2012		-0.109** (0.046)	-0.110** (0.048)
Year 2013		-0.214*** (0.051)	-0.217*** (0.053)
Year 2014		-0.247*** (0.059)	-0.248*** (0.063)
Year 2015		-0.279*** (0.054)	-0.284*** (0.057)
Year 2016		-0.250*** (0.057)	-0.256*** (0.058)
Year 2010*Avg. school performance of district			-0.018 (0.079)
Year 2012*Avg. school performance of district			0.014 (0.082)
Year 2013*Avg. school performance of district			0.066 (0.092)
Year 2014*Avg. school performance of district			0.040 (0.110)
Year 2015*Avg. school performance of district			0.116 (0.097)
Year 2016*Avg. school performance of district			0.145 (0.101)
Observations	147	147	147
R-squared	0.588	0.725	0.733

Notes: Log Housing prices are housing prices at the district level by year t . Avg. school performance district refers to the average peer performance in the *CDI* standardized test by school district previous to the 2012's reform. Years refer to year fixed effects. Robust standard errors are displayed in parenthesis.

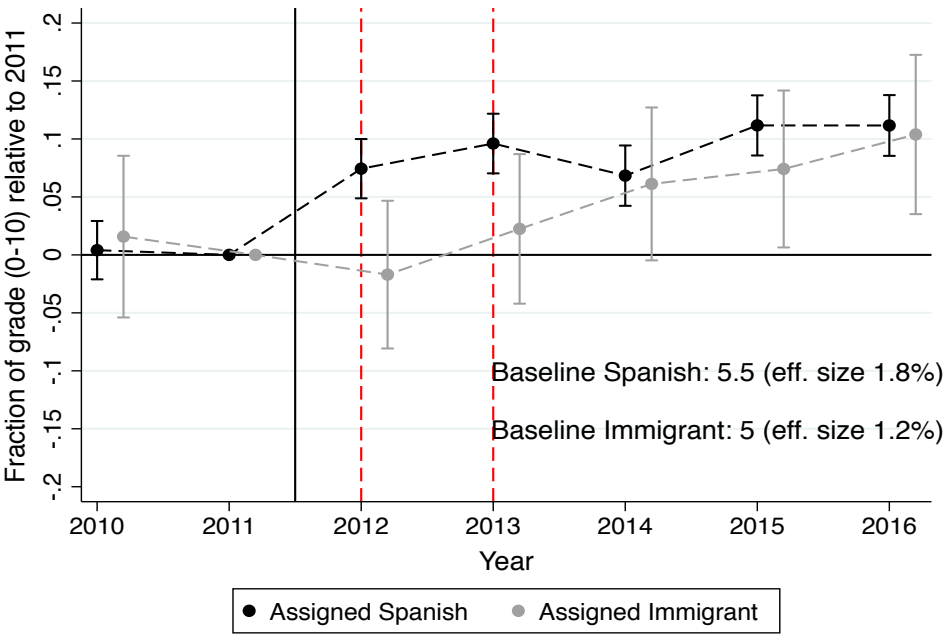
F To which schools are pupils assigned?

Figure F.1: Average Performance of Assigned School (0-10) by Parental Education.



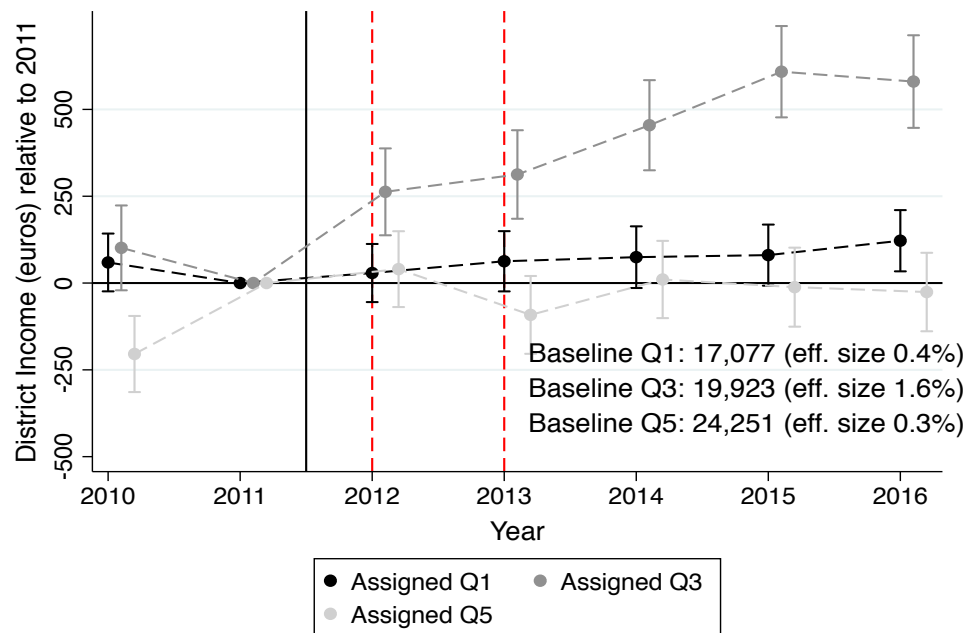
Note: Black and grey dots represent point estimates. Horizontal lines depict confidence intervals at the 95% level of confidence. The red stripes reflect the two consecutive changes in the choice priority system in 2012 and 2013.

Figure F.2: Average Performance of Assigned School (0-10) by Immigrant Status.



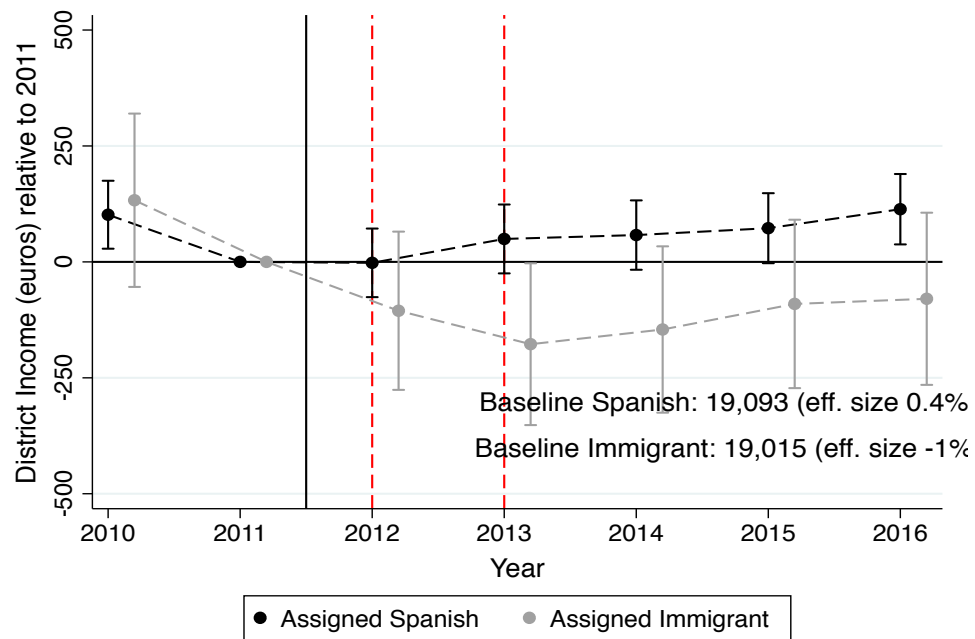
Note: Black and grey dots represent point estimates. Horizontal lines depict confidence intervals at the 95% level of confidence. The red stripes reflect the two consecutive changes in the choice priority system in 2012 and 2013.

Figure F.3: District Income (euros) of Assigned School by Parental Education.



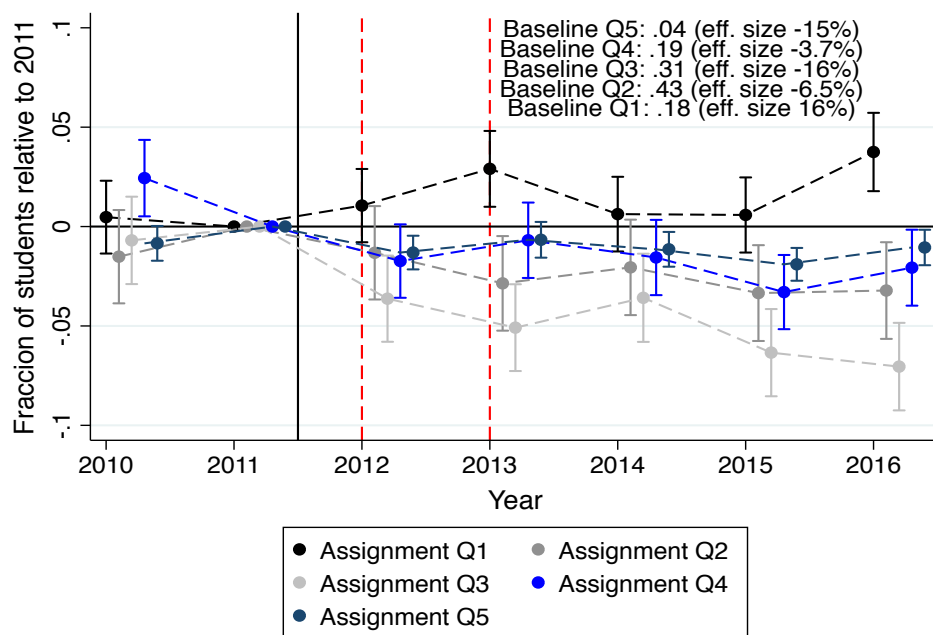
Note: Black and grey dots represent point estimates. Horizontal lines depict confidence intervals at the 95% level of confidence. The red stripes reflect the two consecutive changes in the choice priority system in 2012 and 2013.

Figure F.4: District Income (euros) of Assigned School by Immigrant Status.



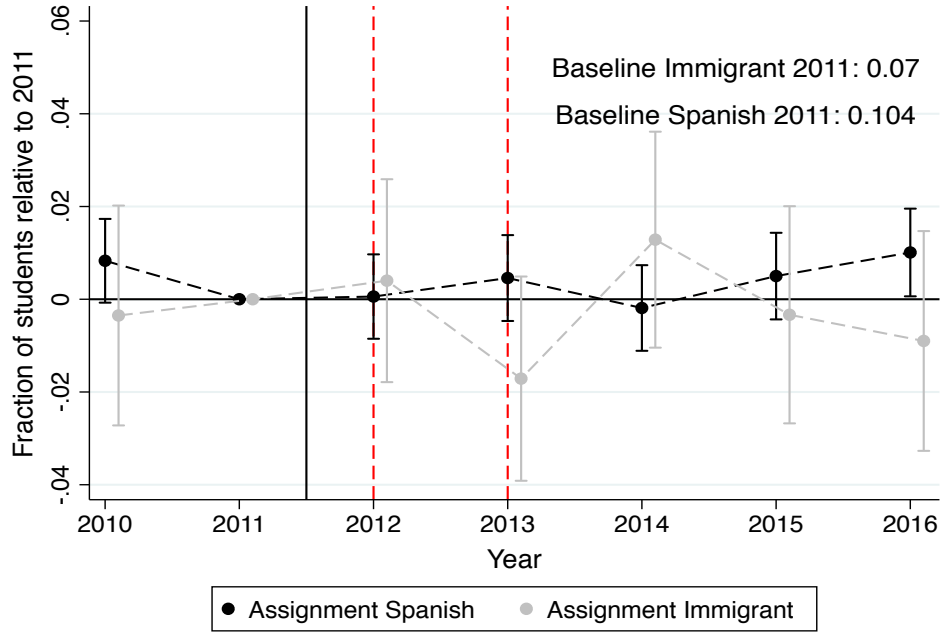
Note: Black and grey dots represent point estimates. Horizontal lines depict confidence intervals at the 95% level of confidence. The red stripes reflect the two consecutive changes in the choice priority system in 2012 and 2013.

Figure F.5: Predetermined School Segregation of District of Assigned School by Parental Education.



Note: Black and grey dots represent point estimates. Horizontal lines depict confidence intervals at the 95% level of confidence. The red stripes reflect the two consecutive changes in the choice priority system in 2012 and 2013.

Figure F.6: Predetermined School of District of Assigned School by Immigrant Status.



Note: Black and grey dots represent point estimates. Horizontal lines depict confidence intervals at the 95% level of confidence. The red stripes reflect the two consecutive changes in the choice priority system in 2012 and 2013.

G Sample Restrictions

Despite the fact that the administrative dataset of applications is unique and exhaustive, adding other sources of information for the analysis implies some observations which are missing. For example, our analysis focuses on all students who apply for a school where information on the test scores (our measure of school quality) is available. We are able to identify the school test score measure for about 90% to 95% of the observations. Given the importance of identifying geographical distance patterns, we discard students whose address information is missing or not valid. School application forms are manually submitted to the school or the central administration which then introduce the information into the digital centralized system (Calsamiglia and Güell, n.d.), which may result in invalid information. We are able to identify the address of about 99% percent of the final population of interest. The analysis is based on a population of about 26,000 to 29,000 observations, depending on the school year.

Table G 1: Sample Restrictions: School Applicants in the city of Madrid over 2010-2016.

Number of Applicants	2010	2011	2012	2013	2014	2015
Total unique applications	37,146	39,986	37,300	36,273	35,727	34,124
Students with no siblings	32,009	30,594	30,930	30,022	29,341	27,762
School test scores	29,977	28,884	29,488	28,714	27,810	26,487
Valid Address	29,666	28,720	29,338	28,577	27,807	26,491
Total Final Sample	29,736	28,700	29,205	28,478	27,579	26,271

Notes: Each year corresponds to the year of application and the school year starting in September of that year. This Tables does include all applications irrespective of the preschool or school year in weich families applied for.

H Theoretical Properties of the Boston Mechanism

The theoretical properties are extracted from Chen and Sönmez (2006). The Boston mechanism (BM) which works as follows: For each school, a priority ordering of students is determined based on state and local laws/policies. Each student submits a preference ranking of the schools. The final phase is student assignment based on submitted preferences and priorities. The outcome is obtained in several rounds. In Round 1, only the first-choices of the students are considered. For each school, consider the students who have listed it as their first-choice and assign seats of the school to these students one at a time following their priority order until either there are no seats left or there is no student left who has listed it as her first-choice. In general, at Round k consider the remaining students. In Round k only the kth choices of students are considered. For each school with available seats, consider the students who have listed it as their kth choice and assign the remaining seats to these students one at a time following their priority order until either there are no seats left or there is no student left who has listed it as her kth choice.

The major difficulty with the Boston student assignment mechanism is that it is not strategy-proof; that is, students may benefit from misrepresenting their preferences. Abdulkadiroglu, Atila and Sönmez (2003) point out that the Boston mechanism gives students and their parents a strong incentive to misrepresent preferences by improving the ranking of schools which they have a high priority.

I Difference-in-Difference Approach

Table I 1: Treatment-Control balance in fixed households characteristics in pre-reform years.

	Control Group (1)	Treatment Group (2)	Difference T – C (3)	> <i>p</i> -value (4)
Female	0.485	0.500	0.015	0.644
Immigrant	0.135	0.110	-0.025	0.133
Immigrant Mother	0.281	0.266	-0.015	0.623
Immigrant Father	0.372	0.324	-0.048	0.168
Lowest Quintile Education Block	0.103	0.121	0.018	0.521
Highest Quintile Education Block	0.110	0.242	0.131	0.053
Euclidean distance to closest school	217.804	250.967	33.163	0.061
Number of schools in a radius of 500 meters	3.583	3.393	-0.190	0.396
N	285	8,528		
Test of joint significance	<i>F</i> -stat: 1.206 (<i>p</i> -value: > 0.292)			

Notes: Standard errors are clustered at the census block level and displayed in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table I 2: Sensitivity Analysis: Effect of the reform on Out-of-District Assignment and Distance to Assigned School by treatment group definition.

Dependent Variable	Out-of-District Assignment					Distance to Assigned School				
	200m	250m	300m	350m (baseline)	400m	200m	250m	300m (baseline)	350m	400m
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Treatment	0.154*** (0.029)	0.136*** (0.027)	0.118*** (0.026)	0.107*** (0.025)	0.097*** (0.024)	24.998 (95.820)	14.136 (94.826)	0.281 (91.522)	16.270 (89.348)	13.445 (86.619)
Year 2012	-0.006 (0.024)	-0.004 (0.023)	-0.004 (0.023)	-0.002 (0.023)	-0.002 (0.023)	-41.802 (78.933)	-41.503 (78.949)	-42.383 (78.108)	-41.190 (77.265)	-42.193 (76.335)
Post 2013	-0.008 (0.016)	-0.007 (0.016)	-0.007 (0.015)	-0.006 (0.015)	-0.006 (0.015)	16.821 (77.083)	15.491 (77.708)	16.393 (76.834)	17.555 (76.362)	17.749 (76.091)
Treatment*Year 2012	0.016 (0.026)	0.018 (0.025)	0.021 (0.025)	0.018 (0.024)	0.018 (0.024)	68.346 (86.749)	88.614 (84.593)	91.449 (82.325)	69.240 (80.789)	78.577 (79.430)
Treatment*Post 2013	0.036** (0.018)	0.034** (0.017)	0.036** (0.017)	0.036** (0.016)	0.036** (0.016)	356.800*** (85.259)	323.511*** (83.623)	311.179*** (81.671)	284.180*** (80.393)	279.650*** (79.373)
School District Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Demographic Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	17,995	23,566	29,518	35,676	41,537	17,995	23,566	29,518	35,676	41,537

Notes: Each year corresponds to the year of application and the school year starting in September of that year. Standard errors are clustered at the census block level and displayed in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

J School Classification

Table J 1: Districts ranked by income.

Low Income District	Middle-Income District	High-Income District
Puente de Vallecas	San Blas - Canillejas	Centro
Villaverde	Moratalaz	Barajas
Usera	Ciudad Lineal	Moncloa - Aravaca
Carabanchel	Tetúan	Retiro
Latina	Fuencarral - El Pardo	Chamberí
Vicálvaro	Hortaleza	Chamartín
Villa de Vallecas	Arganzuela	Salamanca

Notes: Data from district average income is derived from Municipal census data in the city of Madrid.