School Choice Priority Structures and School Segregation*

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Abstract

In this paper we study how school segregation and student welfare is affected by altering the priority structures in a school choice program. Together with the assignment mechanism, the priority structure determines which applicants are admitted to a school when the number of applicants exceed the number of available seats. The setting is a primary school choice program in a Swedish municipality, where allocation of students to public schools is done using a modified version of the increasingly popular deferred acceptance algorithm. We simulate the counterfactual allocation of students, using our own estimates of parental preferences for school attributes, under different types of priority structures. The results suggest that how priorities are determined affects the level of school segregation. When reserving seats for underrepresented groups, schools become less segregated in terms of parental education and foreign background compared to both lottery- and proximity-based priorities. In terms of student welfare, all three priority structures studied in this paper assign a high share of students to their preferred schools and we record relatively small differences in the distance to the assigned school. The lottery-based priority structure does however seem to underperform somewhat compared to the alternatives in these two dimensions. Further, different priority structures benefit different types of households. Most prominent is that proximity based priorities benefit highly educated and native households while reserving seats for underrepresented groups shifts welfare towards low educated and foreign households.

JEL Codes: I20, I24
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1 Introduction

Traditionally, in many school systems, children about to start primary school have simply been assigned to their neighborhood schools. In recent decades, school choice programs have rapidly been introduced all over the world. This has lead to a sharp increase in the number of households that, each year, are faced with the decision of where to send their children to school.[1] Empirical evaluations seem to indicate that introducing or expanding school choice opportunities leads to increased school segregation in various dimensions.[2] It is clear that school segregation is a big concern in the public debate, in Sweden and elsewhere. School segregation has also been shown to have adverse effects on student outcomes, labor market outcomes and crime.[3] A central question is therefore why school choice tends to increase segregation? The introduction of school choice enables households to apply to their preferred schools. As preferences for school attributes seem to vary systematically with observable household characteristics, one explanation could be that school choice allows households to self-segregate according to these preferences.[4]

The outcome of a school choice program is however not only a function of the households' preferences, but also of the design of the program. School choice programs can take many different forms, they can be general programs including all students and schools within a specific geographic area, they can target specific groups of students or include only specific types of schools. No matter the scale of the program, a necessary component is the priority structure - a rule determining admission to oversubscribed schools. We ask if the seemingly segregating effects can be mitigated by altering these priority structures and whether different types of priority structures benefit different types of households? To study this, we turn to the mechanism design literature.

The first paper to address the school choice problem from a mechanism design perspective was Abdulkadirolu & Sönmez (2003). They concluded that there are flaws in many commonly used school assignment mechanisms and proposed two alternative mechanisms - The Deferred Acceptance (DA) and The Top Trading Cycles (TTC) mechanism. Since then, there has been a growing academic interest in the design of school choice programs. The main focus has been on the assignment mechanism as such and the properties of the allocations they produce. This discussion has led to the adoption of new assignment mechanisms, most famously in Boston and New York.[5] Less attention has been given to the importance of the priority structure. As pointed out by, among others, Fack *et al.* (2017), *"Despite the fact that admission criteria impact student sorting and student welfare ... they have been relatively under-studied in the literature"*.[6] We study how different priority structures impact school segregation and student welfare in a school choice program using a modified version of the DA algorithm to assign students to public schools.[7]

We observe all school choices of primary school starters in the Swedish municipality of Botkyrka from 2011 to 2014. The focus on primary school starters is motivated by the fact that many children in Botkyrka attend the same school for their entire elementary education, making the choice of primary school an important one. The Botkyrka School Choice Program uses a modified version of the DA mechanism combined with

[1] One could say that there is a school choice component in a household's decision on where to reside. However, when referring to the term school choice in this paper we mean a system in which households can express preferences for schools and these preferences are taken into consideration in the assignment process.

[2] See Hsieh & Urquiola (2006), Bifulco & Ladd (2007), Söderström & Uusitalo (2010) and Böhlmark *et al.* (2016).

[3] See e.g. Hanushek *et al.* (2000), Billings & Rockoff (2013), Johson (2015), Gamoran & An (2016) and Billings *et al.* (2016).

[4] See e.g. Hastings *et al.* (2009), Borghans *et al.* (2015), Burgess *et al.* (2015) for papers documenting heterogeneity in preferences for school attributes.

[5] Abdulkadirolu *et al.* (2005a) discuss the assignment mechanism used in Boston until 2005 and their recommended alternatives and Abdulkadirolu *et al.* (2009) discuss the redesign of the assignment process for NYC high schools in 2003-2004.

[6] There are some exceptions, for example, Calsamiglia & Güell (2014) find that when proximity based priorities are used in the Boston mechanism, the student allocation is very similar to a neighborhood based allocation.

[7] The DA algorithm is becoming increasingly popular and is now used in e.g. Amsterdam, Boston, Paris and New York (Fack *et al.* , 2017) and is one of the assignment mechanisms recommended by Abdulkadirolu & Sönmez (2003).

a priority structure based on proximity and already enrolled siblings to assign students to public schools. The school choice process is centralized and includes all primary schools in the municipality.[8] In order to perform an ex ante policy evaluation, we rely on a structural approach.[9] Using a rank ordered mixed logit model and observed school choices we estimate parental preferences for school attributes. These preferences are used to construct school rankings for artificial cohorts of students. These students and their imputed school rankings are used in simulations to evaluate the impact of different priority structures. We record the level of segregation, and a number of proxies for student welfare (such as the average distance from home to the assigned school and the share of students that are admitted to their most preferred school) for the whole population as well as for different subgroups. Our empirical strategy is similar to the one used by Gallego & Hernando (2008) and Fack *et al.* (2017).

Our simulations rely on school rankings generated using estimated preferences for school attributes. In order for these rankings to be valid in our counterfactual scenarios we need households to be truth-telling when submitting their school choices. In the general case, the deferred acceptance mechanism is strategy proof. Haeringer & Klijn (2009) do however show that putting a restriction on households regarding how many schools they can rank, reintroduces strategic incentives. In Botkyrka, as in many other places, there is such a restriction (three schools in Botkyrkas case). We evaluate the size of this problem by using the concept of "safe schools", i.e. schools where a household can be sure to get admitted if they apply to it.[10] We show that if a household has ranked a "safe school" as their top or second choice, they can be assumed to be truth-revealing. Due to the significant overcapacity that Botkyrka's school choice program is operating under during this time period we can categorize 95 percent of households as truth-revealing.

We evaluate three different priority structures. The first priority structure we impose gives priority to students according to the distance between the students' homes and the school in question (proximity). The second priority structure assigns each student a randomly drawn lottery number and gives priority based on that. The last priority structure is designed to contribute to the socioeconomic and ethnic diversity at the schools, and falls under what Abdulkadirolu & Sönmez (2003) call controlled choice. At each school, s_j seats are reserved for students of type j, where s_j equals the share of type j students in the current cohort of primary school starters, times the total capacity of the school. Within type, priorities are determined by distance between the students' homes and the school. Similar types of priority structures are currently in use in actual school choice programs.

As long as proximity is not the only school attribute that parents care about, we would expect that a system where seats are reseved for underrepresented groups will produce a lower level of school segregation compared to a system where priority is based on proximity. How a system using lottery-based priorities will perform in terms of school segregation is, ex ante, less clear. It will remove the privilege of those residing near popular schools, it does however also make it easier for students to opt out of nearby schools they don't like. Hence, depending on the search patterns and the level of residential segregation, this could both increase or decrease the level of segregation compared to a system were priorities are based on proximity. In terms of welfare, the average distance to the assigned school is likely to increase whenever priorities are not based on proximity. Given the importance most households seem to put on proximity, this is a potential welfare loss. However, an increase in distance could also reflect the fact that households that are willing to travel further to get into a more preferred school can now do this, in which case the increased home to school distance would reflect an increase, rather than a decrease in welfare. When it comes to the share of students assigned to their most preferred schools, we have less clear predictions.

[8]Voucher schools are excepted from using the DA mechanism and the municipal priority structure.

[9]Pathak & Shi (2017) suggest that the use of structural demand models in the school choice context can be effective when studying counterfactual outcomes.

[10]A concept organically proposed in Calsamiglia *et al.* (2010).

The paper closest to ours is Fack *et al.* (2017) that studies the effects on student sorting when altering the priority structures used in the Paris high school choice program. In their empirical analysis they focus mainly on the effects on ability sorting and the welfare effects on high- and low-ability students. They find that there are clear tradeoffs between sorting and aggregate welfare and between the welfare of high- and low-ability students. They briefly look at sorting in terms of socioeconomic background and find that a priority structure where low-income students are given a "bonus" in terms of priority, produces a lower level of sorting compared to systems based on lotteries or grades. We contribute to these findings in three ways. Firstly, we examine the question in a different setting, specifically one where children are younger. This is relevant as mobility varies with age, with older children being more likely to consider traveling further to school. Hence, the priority structure could be less important when children are younger. Secondly, and somewhat related to the first point, we examine other priority structures. Fack *et al.* (2017) use the default system in Paris, where students that receive means-tested low-income financial aid (15 percent of students) get priority to their preferred school. We use a system specifically designed to minimize segregation, both in terms of parental education and migration background. Thirdly, we have access to high-quality Swedish register data and can therefore perform detailed subgroup analysis.

The results suggest that using reserved seats for children from different socioeconomic groups produces a lower level of school segregation compared to proximity- or lottery-based priorities. Segregation in terms of foreign background is about four points lower as measured by the Duncan Dissimilarity Index (two points measured by Theil Entropy Index) and segregation in terms of parental eduction is two/one point(s) lower. When comparing to a system based on proximity, this reduction in segregation comes with a small increase in the average distance from the students' homes to their assigned school (40 meters from a baseline of 957 meters) and a minor decrease (less than one 1 percentage point from a baseline of 83 percent) in the share of students getting admitted to their most preferred school. The increase in average distance to school is however driven by students getting their most preferred school and hence it is unclear if this should be considered an actual cost. The lottery-based system is underperforming compared to the two other systems, producing both a larger average distance to school and a lower share of students admitted to their most preferred school. Even though the system based on proximity and the one based on reserved seats, on average, produce similar results in terms of distance to school and the share of students getting admitted to their top choice, there are clear winners and losers off the two systems. Highly-educated households with a native background benefits from the system based on proximity, while low educated households with a native background and highly-educated households with a foreign background, benefit from a system based on reserved seats.

The paper is outlined as follows. Section 2 presents the institutional setting followed by Section 3 describing the data and presenting summary statistics. Next, Section 4 deals with the priority structures that will be used to study counterfactual outcomes and Section 5 outlines the empirical strategy. In Section 6 we present our results. Section 7 concludes.

2 Institutional setting

The Swedish elementary school system covers ten grades with children usually starting school the year they turn six. The first year (grade K) is voluntary while the remaining nine years are mandatory (grade 1-9). Despite the first year being voluntary, almost everyone (97 percent) attends. Since the early 1990s municipalities are responsible for providing and financing the primary education of all children residing in the municipality. There are two types of schools. Public schools that are run by the municipalities and voucher schools operated by independent providers, but publicly funded. All schools follow the same curriculum, stipulated in national legislation. School funding is based on vouchers directly connected to each student but municipalities are allowed to adjust the amount based on a student's background or disabilities.[11] Neither public nor voucher schools are allowed to charge any fees.

School choice was formally introduced in 1992, together with the reform that allowed voucher schools to operate. Prior to this, students, in general, attended their local public school. Initially, school choice was decentralized to the school level requiring parents that did not want their children to attend their local public school to contact other schools directly and ask if there was room for their child there. Naturally, the vast majority continued to attend their local public school. At the turn of the millennium the expansion of voucher schools took off.[12] Partly in reaction to this expansion, municipalities, beginning in the mid-2000 started to implement centralized school choice programs. By now, most municipalities, at least in the urban areas, have centralized school choice programs where households can apply to all public schools in their municipality. In addition, households are allowed to apply to all voucher schools, both within and outside their own municipality. It is also possible to apply to public schools in other municipalities, but these schools have no obligation to accept students not residing in their municipality.[13]

As primary education in Sweden is decentralized, there is considerable variation in the design of the school choice programs. There is some national legislation regulating how priorities to oversubscribed schools should be determined. Municipalities have to allocate students to schools based on their expressed preferences while at the same time making sure that no students are admitted to a school too far away from their homes.[14] Voucher schools are restricted to accept students based on a first-come first-served basis, already enrolled siblings and the distance from the students home to the school. In practice, voucher schools seldom use the last ground for admission but give priority based on enrolled siblings and time in the school-specific queue.[15]

2.1 The Botkyrka School Choice Program

Botkyrka is the fifth largest municipality in Stockholm county. It has a diverse population of 90,000 inhabitants, 56 percent of which have a foreign background.[16] There are 23 primary schools offering grade K in Botkyrka, about two thirds of these cover all years up to grade 9. Given this, most children stay in the same school for their entire elementary education. Although most schools are public, there are five voucher schools, enrolling about 8 percent of the students in Botkyrka combined.[17] Figure 1 displays the location of all schools that were available to choose from in 2014, as well as the number of primary school starters residing in each SAMS[18] area in the municipality. The schools are concentrated to three different neighborhoods, one in the north, one in the east and one in the west. Descriptive statistics of both schools and primary school starters will be presented for the whole population as well as for each neighborhood.

The average cohort of primary school starters in Botkyrka during this time period consists of just under 1,000 students. About 95 percent of households with a child about to start primary school participate in

[11] In Botkyrka, 28-44 percent of the school budget is compensatory (Ernst & Young AB, 2014).

[12] Böhlmark & Lindahl (2015) show that the share of the students enrolled in voucher schools increased from 1.6 percent in 1998 compared to 11 percent by 2009.

[13] Under special circumstances, a child can have the right to attend a public school located in another municipality (`http://www.skolverket.se/regelverk/mer-om-skolans-ansvar/val-av-grundskola-1.210176`).

[14] Children always have the right to stay in a school they are already enrolled in, at least as long as it is located in the municipality they live in.

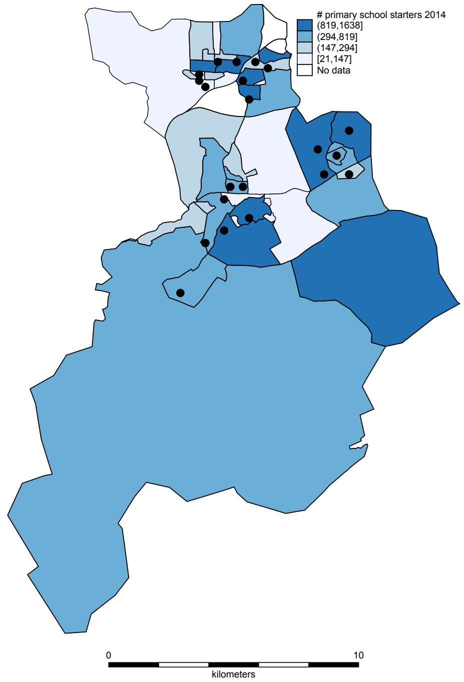
[15] The regulations can be found in Swedish at `http://www.skolverket.se/regelverk/mer-om-skolans-ansvar/val-av-grundskola-1.210176`.

[16] A person is categorized as having a foreign background if he/she is born abroad and/or if both his/her parents are born abroad.

[17] Four of the voucher schools are likely to cater to a very specific group of households. Two are religious (one Christian and one Muslim), one is bilingual (Finnish-Swedish) and one uses a specific teaching method inspired by Freinet.

[18] SAMS stands for Small Areas for Market Statistics and is a partitioning of Sweden into about 9,500 smaller areas, based on municipal partitioning and electoral districts, depending on the size of the municipality.

Figure 1: Map of school location and number of primary school starters in Botkyrka



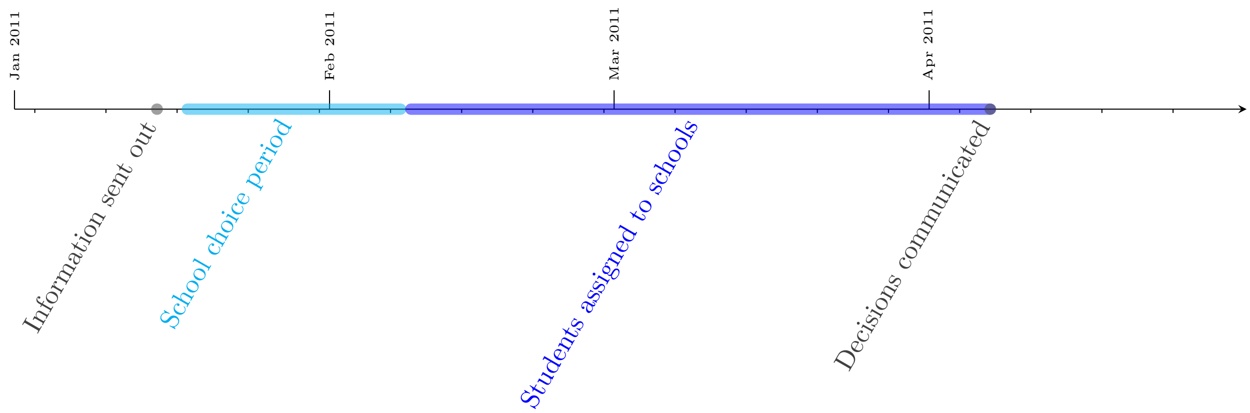
Note: This map is generated using all primary school starters in 2014 and the primary schools available for them to choose from. Each SAMS area (©SCB) in the municipality is color coded by the number of primary school starters residing in that area.

the municipality's centralized school choice program. The timeline of this program is illustrated in Figure 2. In January, all households with a child expected to start grade K in the upcoming academic year are sent a letter informing them about the school choice program. The letter also contains information about both the public and voucher schools in the municipality. This is followed by a three week period during which parents can register their school choices using an online tool. All parents have to submit three ranked choices from a list of all public and voucher schools in the municipality. Households can also state that they have applied to a school outside the municipality, although they cannot send their application to these schools through the online tool. About three percent of the households use this option. Once the school choice period ends, students are allocated to schools and in April households are informed about which school they have been assigned to. Participation is encouraged by the fact that there is no default school where a child is guaranteed a seat if the household does not participate in the program. This gives strong incentives to submit an application list.

Allocation to public schools is done using a modified version of the Deferred Acceptance algorithm. Voucher schools are excepted from this and prioritize students that list them as their top choice, on a first come first served bases and already enrolled siblings. In practice, this implies that admission takes place in two rounds, beginning with the admission to the voucher schools followed by admission to public schools (Where students already admitted to voucher schools are excluded). This is however not something households are informed about and in data we observe households ranking voucher schools as their second or third most preferred school as well.

The deferred acceptance algorithm was proposed by Gale & Shapley (1962) and is becoming an increasingly more common mechanism to assign students to schools. Different versions of this algorithm are used in

Figure 2: Timeline of the Botkyrka School Choice Program



Boston, New York, Amsterdam and Paris (Fack *et al.* , 2017). The following description of the algorithm is based on Abdulkadirolu & Sönmez (2003). Assume that all students have strict preferences over all schools and that all schools have a strict priority ordering of all students.

Step 1 Each student applies to his/her top choice. Each school tentatively accepts one student at a time according to their priority ordering until their capacity is reached or there are no more applying students.

Step k Each student rejected in round k−1 applies to the next school in their ranking. Each school considers all tentatively accepted and new applicants together and tentatively accepts one student at a time, according to their priority ordering, until their capacity is reached or no applicants remain.

The algorithm terminates when no student is rejected, at which point all students are placed at their final assignment. In the deferred acceptance algorithm, a student who has been tentatively accepted at a school can be rejected from the same school in a later round, as priorities are independent of how a student ranks the school. This property of the DA algorithm ensures that it is strategy proof, as shown by Abdulkadirolu & Sönmez (2003).[19] Botkyrka deviates somewhat from this procedure, as households are only allowed to rank three schools. Haeringer & Klijn (2009) show that this reintroduces strategic incentives. When rankings are truncated, households may want to "play it safe" and include less preferred schools in order to avoid a situation where the student is rejected from all the schools they have applied to. Another important point, made by Fack *et al.* (2017), is that the strategy proofness of the DA mechanism only implies that being truthful is a *weakly* dominant strategy. We will discuss the concept of truthfulness and its consequences for this study in more detail in Section 5.3.

The priority orderings of public schools in Botkyrka are based on proximity and already enrolled siblings. Children that have a sibling enrolled in grade K-4 at a school have priority to that school over children that do not. To get a strict priority ordering, children with and without siblings are ranked using a relative distance measure meant to minimize the walking distance of all children. It is defined as the distance to the nearest school (except the one for which one is calculating the relative distance to) minus the distance to

[19]The deferred acceptance is also stable (eliminates justified envy), which is not the case for the other strategy proof algorithm proposed by Abdulkadirolu & Sönmez (2003) (TTC). On the other hand, the TTC is Pareto-efficient which is not the case for DA. In practice, school officials face a trade-off between stability and efficiency and the increasing popularity of the DA suggest that stability is given more weight than efficiency in these situations.

the school in question. A higher relative distance measure gives higher priority.[20] Figure 10 in Appendix B provides an example of how relative distance is calculated. Children in households that do not submit a ranked list of schools and children that are not admitted to any of their chosen schools are assigned to schools where there is free capacity once all other children are assigned to schools.

3 The data

From Botkyrka municipality we have access to all school choices registered in the online tool from 2011 to 2014. In total we observe the school choices of 3,820 primary school starters. The data includes the three ranked choices of each household. Using individual identifiers we can link these choices to register data provided by Statistics Sweden. Further, using the multigenerational register, we can link the primary school starters to their parents and siblings. In addition, we have access to data on all students enrolled in a primary school in Botkyrka during this time period, allowing us to create measures of the student composition at each school.[21] This is complemented with data on school performance, survey data on what students and parents think about their schools and teacher characteristics. Table 7-8 provide definitions of all variables at the individual and school level.

Table 1 reports summary statistics of the pooled population of primary school starters 2011-2014. We can see that there are large differences between neighborhoods. The North is characterized by a high fraction of students with foreign background and low educated parents, whereas the opposite is true for the East. In all areas, about half of the primary school starters have an older sibling enrolled in a primary school in Botkyrka. Once the primary school starters have enrolled, they have on average a distance of about 1,000 meters to school. Primary school starters in the West travel a bit further compared to the two other neighborhoods, which is likely due to the fact that this neighborhood includes the more rural parts in the south-west of Botkyrka.

In Table 2, summary statistics of the available schools (at the school-year level) are reported. First, we note that the differences in characteristics between the primary school starters in the three different neighborhoods are translated into differences in the schools' student compositions. Schools in the North have a much higher fraction of students with a foreign background and a less educated parents. The average score on the standardized tests is 13.8 points on a scale from 0 to 20, with the North performing below average and the other two neighborhoods performing above average. In all neighborhoods, the average capacity in grade K is about the same (55 seats). Additional variables on the school level that are used in robustness tests are presented in Table 10.

[20] The distance is the walking distance measured using only roads that the municipality have assessed to be safe for a 6-year old to walk on. This is done to ensure that children do not need to be accompanied by an adult to get to school.

[21] We do not observe this for the students attending the two confessional schools, Statistics Sweden do not provide information on students in religious schools to protect their religious rights. Hence, even though there are 23 schools available to choose from in Botkyrka our analysis will only be based on 21 of these.

Table 1: Summary statistics of primary school starters by neighborhood

	Total mean/sd	North mean/sd	West mean/sd	East mean/sd
Native, highly educated	0.34	0.09	0.38	0.67
	(0.47)	(0.29)	(0.49)	(0.47)
Native, low educated	0.25	0.17	0.35	0.24
	(0.43)	(0.38)	(0.48)	(0.43)
Foreign, highly educated	0.18	0.29	0.15	0.06
	(0.39)	(0.45)	(0.36)	(0.24)
Foreign, low educated	0.23	0.45	0.11	0.03
	(0.42)	(0.50)	(0.31)	(0.18)
Sibling in the school system	0.49	0.48	0.51	0.49
	(0.50)	(0.50)	(0.50)	(0.50)
Distance to attended school	1027.93	880.41	1362.41	788.76
	(1313.60)	(1217.64)	(1646.54)	(694.88)
Distance to top choice	1051.14	925.04	1383.17	783.01
	(1332.84)	(1268.26)	(1647.61)	(696.30)
No of schools in nbd	7.30	9.00	7.00	5.00
	(1.61)	(0.00)	(0.00)	(0.00)
Attending voucher school	0.08	0.18	0.03	0.01
	(0.27)	(0.38)	(0.16)	(0.07)
Observations	3820	1564	1260	996

Note: This table presents the mean and standard deviation of each variable. The sample includes all primary school starters choosing schools in Botkyrka 2011-2014. *Highly educated* indicates that at least one parents has an education level above upper secondary school. *Foreign* indicates that the student was born abroad and/or that both parents born abroad, otherwise the student is categorized as *native*. *Sibling in the school system* indicates if there is a sibling currently attending grade K-9 in any primary school in Botkyrka. *Distance to attended school* and *top choice* measures the home to school distance to the attended school and the school listed as the top choice in meters. *No of schools in the neighborhood* counts how many schools that are available to choose from within the student's own neighborhood. *Attending voucher school* is the share of students enrolling in a voucher school.

Table 2: Summary statistics of schools by neighborhood

	Total mean/sd	North mean/sd	West mean/sd	East mean/sd
Average test score	13.84	13.27	14.03	14.59
	(1.00)	(0.94)	(0.91)	(0.57)
Foreign background	0.48	0.80	0.32	0.12
	(0.31)	(0.09)	(0.18)	(0.03)
Highly educated parents	0.46	0.32	0.49	0.67
	(0.16)	(0.07)	(0.10)	(0.09)
School capacity	54.94	55.00	55.09	54.60
	(18.15)	(12.62)	(24.15)	(17.97)
Observations	84	36	28	20

Note: This table presents the mean and standard deviation of each variable. The sample includes one observation per year of all schools available for choice in Botkyrka 2011-2014. *Average test score* is the school's average score (max = 20) on the standardized tests in Swedish and mathematics taken in grade 3. *Foreign background* indicates the share of students born abroad or with both parents born abroad. *Highly educated parents* indicates that at least one parent has attended higher education. *School capacity* is the average number of seats available at each school for primary school starters.

Choice opportunities: Since Botkyrka is an urban municipality, most households have several schools within a reasonable distance from their home. Table 3 shows that, on average, households have about five schools within two kilometers from where the live. Increasing the distance from two to three kilometers gives, on average, two additional schools to choose from. As we know, from previous research, that proximity of the school is an important factor in school choice, this is important since it establishes that there is a real choice of schools even for households that have strong preferences for proximity. Table 3 also suggests that there are significant differences in school attributes even for households restricting their choice set to schools close to their home. For example, for the average households, the school within 2 kilometers of their home, with the highest fraction of students with a foreign background, has a 22 percentage points larger share of students with a foreign background compared to the school within 2 kilometers of their home with the lowest share of students with a foreign background. Looking at test scores we can see that the average household can improve by almost two points by choosing the highest performing instead of lowest performing school within two kilometers of their home. In other words, if households care about these attributes they have strong incentives to participate in the school choice program even if proximity restricts the set of schools relevant to consider.

Table 3: Number of schools and difference in attributes by home to school distance

	0.5km	1km	2km	3km	5km
	mean/sd	mean/sd	mean/sd	mean/sd	mean/sd
Number of schools	0.54	1.91	4.93	6.56	11.61
	(0.60)	(1.25)	(2.15)	(2.24)	(3.71)
Difference (max-min)					
Share foreign background	0.01	0.11	0.22	0.28	0.68
	(0.04)	(0.11)	(0.14)	(0.16)	(0.18)
Share highly educated	0.00	0.09	0.19	0.24	0.44
	(0.02)	(0.08)	(0.08)	(0.08)	(0.11)
Test scores	0.09	0.88	1.72	1.89	2.79
	(0.34)	(0.84)	(0.88)	(0.86)	(0.82)
Observations	3820	3820	3820	3820	3820

Note: This table displays the mean and standard deviation of each variable. The sample includes all primary school starters during 2011-2014. *Number of schools* indicates how many schools the average student has to choose from within x kilometers. The remaining variables display the difference between the maximum and minimum value of the schools within x kilometers in terms of *Foreign background*, *Highly educated parents* and *Test scores*.

Choice behavior: In Table 4 we report some summary statistics of the school choice behavior in our sample, focusing on the location of the chosen schools. Even though proximity is likely to be an important determinant of school choice, it is evident that some households are willing to travel in order to get into a school that better matches their preferences. Seven percent of all households list at least one school outside their own neighborhood among their choices. The proportion of households trying to opt out of their neighborhood is higher in the North and West than the East. Note also that the fraction applying to a voucher school is much higher in the North compared to the other two neighborhoods. This is most likely due to the fact that four of the five voucher schools are located in the North (one is located in the West). Finally, a very high fraction of all primary school starters are assigned their top choice. We observe that 90 percent of all students attend their top choice. Note that this is a lower bound as choices are registered in January while attendance is measured in October and during these months households might change schools (for example because they changed their mind or because they relocated). This high number is most likely due to the fact that the municipality has a significant overcapacity (10-20 percent) in its school system.[22]

[22] The overcapacity observed in Botkyrka during the time period studied is explained by the fact that these four cohorts of primary school starters were relatively small compared to the cohorts before them. The municipality was expecting future cohorts to increase in size and hence thought a shorter period of overcapacity in the schooling system was motivated.

Table 4: School choice behavior by neigborhood

	Total mean/sd	North mean/sd	West mean/sd	East mean/sd
Outside neighborhood				
Top choice	0.04	0.06	0.03	0.01
	(0.18)	(0.23)	(0.18)	(0.09)
Any choice	0.07	0.09	0.08	0.02
	(0.25)	(0.29)	(0.27)	(0.13)
Two or more choices	0.04	0.06	0.03	0.01
	(0.18)	(0.23)	(0.17)	(0.08)
Outside Botkyrka				
Any choice	0.03	0.05	0.01	0.00
	(0.16)	(0.22)	(0.12)	(0.04)
Voucher				
Any choice	0.15	0.31	0.06	0.01
	(0.35)	(0.46)	(0.23)	(0.08)
Attends				
Top choice	0.90	0.85	0.94	0.94
	(0.29)	(0.36)	(0.24)	(0.23)
No choice	0.05	0.09	0.02	0.01
	(0.21)	(0.28)	(0.13)	(0.12)
Outside neighborhood	0.03	0.05	0.03	0.01
	(0.17)	(0.21)	(0.17)	(0.08)
Observations	3820	1564	1260	996

Note: This table displays the mean and st. deviation of each variable. The population includes all primary school starters during 2011-2014. The first three variables indicate whether *top choice*, *one choice* or *two or more choices* are schools located outside one's neighborhood. *Any choice outside Botkyrka* is an indicator for listing at least one school located outside the municipality. *Voucher, any choice* is an indicator for listing at least one voucher school. *Attends top choice* is an indicator for attending the top choice school and *no choice* indicates that the student was not assigned to any of the three schools applied to. *Outside neighborhood* indicates that the student was assigned a school outside it's own neighborhood.

4 Counterfactual scenarios

As mentioned, we will evaluate three different priority structures. In this section we describe these three alternative priority structures.

Proximity based priorities: The first priority structure we impose gives priority to students according to how close to the school they live. Each school ranks all students according to how far away from the school they live, giving priority to those residing closer to the school. The distance is calculated as the straight line distance between the student's residence and the school's location. Proximity based priorities are common in Sweden, although, recently, municipalities have started to use different kinds of relative distance measures rather than the absolute distance to a school. They are also used in the UK (Burgess *et al.* , 2015)

Lottery based priorities: This priority structure assigns each student a randomly drawn lottery number. Each school ranks all students according to this lottery number, giving priority to those with a lower number. The lottery number determines the student's priority at every school, i.e. the student with lottery number 1 will have the highest priority to all schools, the student with lottery number 2 will have the second highest priority at all schools and so on. This follows Abdulkadirolu *et al.* (2009), showing that this way of assigning lottery numbers is favorable in terms of student welfare compared to a scenario where each student is given a separate lottery for each school. Note also that with this specific priority structure, the DA mechanism is equivalent to the random serial dictatorship (also described in Abdulkadirolu & Sönmez (2003)). Lottery based admission is used in e.g. Amsterdam, Beijing and New York city (see De Haan *et al.* (2015), He (2017) and Abdulkadirolu *et al.* (2005b)).

Proximity based priorities with reserved seats: The last priority structure is designed to contribute to the socioeconomic and ethnic diversity at the schools, and falls under what Abdulkadirolu & Sönmez (2003) call controlled choice. In their version, it consists of (racial) quotas that are imposed on the schools. However, Kojima (2012) shows that this implementation of affirmative action in school choice can actually hurt rather than help the students of the type meant to benefit from the policy. Using simulations, Hafalir *et al.* (2013) confirm that these results are not an exception but rather to be expected when using quotas of this kind. Instead, they suggest a different implementation of affirmative action in school choice called minority reserves, where minority students are given higher priority as long as the seats reserved for the minority are not full. We follow their implementation of affirmative action and define four student types based on foreign background and parental education. At each school, s_j seats are reserved for students of type j, where s equals the share of type j students in the current cohort of primary school starters, times the total capacity of the school. Within type, priorities are determined by distance from the students home to school. In each round, if there are less applicants of type j than the number of seats reserved for this type, s_j, those seats will be open for students of other types. For a more detailed description of how assignment with reserved seats is performed, see Appendix F. There are several examples of school choice programs where affirmative action has been incorporated. One such example is the high school system in Paris, using quotas for certain groups in order to give disadvantaged students access to better high schools and reduce school segregation (Fack *et al.* , 2017). In the US, such policies are sometimes the result of court ordered desegregation guidelines (Abdulkadirolu & Sönmez, 2003).

Note that a student's priority at a school is not dependent on how that student ranked the school. That is true for all three priority structures under study. Further, in our simulation we construct complete school rankings for all students. These facts combined with our use of the (student-proposing) DA mechanism will guarantee that there are no strategic incentives in our counterfactual scenarios. Note also that the alternative priority structures are imposed on public as well as voucher schools.

5 Empirical strategy

To evaluate the impact of alternative priority structures we rely on estimated preference parameters to create complete rankings of all schools for all students. This section describes the simulation strategy as well as the discrete choice framework used to estimate the preference parameters.

5.1 Simulations

We draw a random sample of 1,140 primary school starters, from our pooled population 2011 to 2014, keeping their observed background characteristics and residential location.[23] For each primary school starter we construct a complete ranking of all schools available to choose from, using estimated preference parameters for different school attributes (see section 5.2 for details) to calculate their utility according to the following specification of student i's utility from attending school j

$$U_{ij} = \boldsymbol{X'_{ij}}\boldsymbol{\beta_i^x} + \epsilon_{ij} \tag{1}$$

where $\boldsymbol{X}_{ij}$ is a vector of school characteristics that vary at the school or school-individual level. The preferences for these attributes are captured by $\boldsymbol{\beta}_i^x$ and ϵ_{ij} is a random component that is assumed to be iid with a type 1 extreme value distribution. We allow households to have preferences for a number of school characteristics. These include: school performance (measured by the average pass rate on standardized tests in grade 3), the share of students with highly educated parents, the share of students with foreign background, the distance between the school and the student's home, if the school is located in the same neighborhood as the household and whether the household already has other children attending that school. Further, we assume that households consider the latest available information on school attributes and expect them to stay the same. We think that this is a plausible assumption about how parents inform themselves and make their school choices, especially since the educational market in Botkyrka municipality is quite stable across the time period of study (Figure 12 shows the number of students, the share of students with highly-educated parents, the share of students with foreign a background and average test score for each school and each year and suggests that school attributes are stable during the relevant time period).

For our first randomly drawn sample, each household's utility for each school is calculated using the school type characteristics as observed in the last year of our data, 2014. Based on these utility calculations we create complete rankings over all schools for each households. The primary school starters are allocated to schools using deferred acceptance and one of the priority structures under evaluation. Once allocated, the student composition of the schools is updated according to the recently entered cohort and a new sample is randomly drawn and allowed to enter the system. We use 100 iterations and study the evolution over a ten year period. As in Fack *et al.* (2017), the simulations are dynamic in the sense that we allow each new cohort of households to rank the schools based on school attributes that are updated given the allocation of previous cohorts.

We are interested in a number of outcomes. The primary outcome of interest is the level of school segregation for the entering cohort. We study segregation along two dimensions, parental education and foreign background. Segregation between groups divided into organizational units (such as schools) can be measured using either measures of evenness or measures of exposure (Massey & Denton, 1988). Exposure measures are sensitive to the share of minority students in the population, which evenness measures are generally not. As Allen & Vignoles (2007) point, out the share of minority students is not something that educational policy can directly affect and therefore we will use measures of evenness when evaluating the effects of school performance information on school segregation.

[23]We choose 1,140 as the size of our artificial cohorts in order to limit overcapacity in the system. As mentioned, Botkyrka, under this time period operates with a large overcapacity in its school choice system. A large overcapacity makes the priority structures irrelevant. In the long run it is also not sustainable. Hence, in our counterfactuals we choose a cohort size that better matches the total capacity (2 percent overcapacity).

We will follow Massey & Denton (1988) and report the Duncan Dissimilarity Index. The Dissimilarity Index (DDI) is defined as $DDI = \frac{1}{2}\sum_{i=1}^{n}|\frac{a_i}{A} - \frac{b_i}{B}|$ where a_i is the number of individuals in group A in school i and b_i is the number of individuals in group B in school i, and A and B measure the total number of individuals in these two groups. The Dissimilarity Index ranges from zero (no segregation) to one (total segregation) and has a clear interpretation as the percentage of one of the two groups that would have to move to a different organizational unit (school), in order to produce a distribution in each organizational unit that matches the distribution of the entire population (zero segregation) Duncan & Duncan (1955).

The Duncan Dissimilarity index is however not without drawbacks. Most notably, it fails the transfer principal (James & Taeuber (1985) and White (1986)). This means that it is insensitive to redistribution of minority group members among organizational units with minority proportions above or below the overall minority proportion. Only transfers of minority members from units where they are overrepresented to units where they are underrepresented (or vice versa) affect the value of the index. Therefore, we also report the effects on the Thiel Entorpy Index (Originally proposed by Theil & Finizza (1971)), another measure of evenness for which the transfer principle holds, in order not to miss any effects. The Thiel Entorpy Index (TEI) is defined as $TEI = \frac{1}{N}\sum_{i=1}^{N}\frac{x_j}{\mu}ln(\frac{x_j}{\mu})$ where N is the number of schools, x_j is a characteristic of school j (such as the share of students with a foreign background assigned to school j) and μ is the mean of x for all schools in N. The Thiel Entropy Index can be interpreted as the difference between the diversity (entropy) of the system and the weighted average diversity of individual organizational units, expressed as a fraction of the total diversity of the system (Reardon & Firebaugh, 2002).

Further, to determine the political feasibility of each priority structure, we look at the distance to the assigned school as well as whether the alternative priority structures manage to satisfy parents with regards to their school choices. We look at the fraction of students assigned to their preferred schools.

Finally, we abstract from factors that might be affected by the changing student composition. First, each school's test score is assumed to be constant during the simulations, even though it may be affected by such changes. Second, we do not allow teachers to respond to the changes in student composition, by taking a job at another school.

5.2 Preference parameter estimation

To estimate parental preferences, we need a model of how households behave in the school choice context. We assume that households are utility maximizing agents deriving utility from attending school j according to Equation (1). Assume that household i can choose between all schools $j \in J_i$, where J_i is the choice set of household i.[24] Let y_i be an indicator equal to j if household i chooses school j. Utility maximization requires that

$$y_i = j \quad \text{iff} \quad U_{ij} > U_{il} \quad \forall l \in J_i \tag{2}$$

The probability of household i choosing school j is then:

$$Pr[y_i = j] = Pr[U_{ij} > U_{il} \quad \forall l \in J_i] \tag{3}$$

[24] We define J as consisting of all schools in the municipality. Since the educational system is decentralized to the municipal level and households have the right to choose between any public school in their municipality, the natural definition of the choice set includes all schools located in the municipality. The Botkyrka School Choice Program provides information on and allows applications to all schools in Botkyrka, but not for schools located outside the municipality. The fact that we observe only three percent (see Table 4) choosing a school outside their municipality suggests that it is reasonable to restrict the choice set to schools located in the municipality. The limited number of schools ($N = 21$) also makes it reasonable to assume that households can consider all schools available in the municipality.

Given our assumed distribution of ϵ_{ij} the choice probability can be expressed as:

$$Pr[y_i = j] = \frac{e^{\boldsymbol{X}'_{ij}\boldsymbol{\beta_i}}}{\sum_{k=1}^{m} e^{\boldsymbol{X}'_{ik}\boldsymbol{\beta_i}}} \tag{4}$$

The above equation can be estimated using a mixed logit model which relaxes the IIA assumption and thus avoids the restrictive substitution patterns IIA implies. Since $\boldsymbol{\beta}_i$ consists of random parameters, we need to integrate the choice probability over all possible values of $\boldsymbol{\beta}$:

$$L_{ij}(\boldsymbol{\beta}_i) = Pr[y_h = j] = \int \frac{e^{\boldsymbol{x}'_{ij}\boldsymbol{\beta_i}}}{\sum_{k=1}^{m} e^{\boldsymbol{x}'_{ij}\boldsymbol{\beta_i}}} f(\boldsymbol{\beta})d\boldsymbol{\beta} \tag{5}$$

where $f(\boldsymbol{\beta})$ is the density function of $\boldsymbol{\beta}$ (in this context also referred to as the mixing distribution).[25] As the coefficients are allowed to vary over individual households, we must make an assumption about thier distribution. In our case, all variables are assumed to be random with a normal distribution, except the distance to school and whether a sibling is enrolled in grade K to 4 which are assumed to be fixed across individuals.

We have access to three ranked choices for each household. The fact that we have access to ranked data is helpful for identification. As Berry *et al.* (2004) point out, it gives us a "direct, data-based measure of substitution" which means that we can require the model to reproduce this observed pattern of substitution by restricting the parameters to match all three choices made by each household. Hence, this is a source of variation that doesn't require any exogenous change in the choice sets. It is intuitive to think about this as three sequential choices. Let y_i^1 be the top choice, y_i^2 the second choice and y_i^3 the third choice. Then, the probability that household h would choose school j^1, j^2 and j^3 in that order is the product of the individual probabilities of these choices:

$$Pr[y_i^1 = j^1, y_i^2 = j^2, y_i^3 = j^3] = \int \prod_{r=1}^{3} \frac{e^{\boldsymbol{x}'_{ij^r}\boldsymbol{\beta_h}}}{\sum_{k \in J_i^r} e^{\boldsymbol{x}'_{ik}\boldsymbol{\beta}_i}} f(\boldsymbol{\beta})d\boldsymbol{\beta} \tag{6}$$

Note that the choice set is different for the top, second and third choice. For the first of the three terms in the product, the choice set J_i^1 consists of the $j = 1, ..., m$ schools. But once the household has listed their top choice, there are only $m - 1$ schools left to choose from. For the third choice, the choice set consists of $m - 2$ schools. Equation (6) describes the choice probability for a single household i. Summing over all households, we get the log likelihood function:

$$LL = \sum_i \sum_{j \in J^1} \sum_{j \in J^2} \sum_{j \in J^3} d_{ij}^1 d_{ij}^2 d_{ij}^2 ln(Pr[y_i^1 = j^1, y_i^2 = j^2, y_i^3 = j^3]) \tag{7}$$

where d_{hj}^r is equal to one if household i listed school j on rank r. In this setup there is no closed form $\boldsymbol{\beta}$. Hence, simulation is used to obtain draws of $\boldsymbol{\beta}$ from its distribution $f(\boldsymbol{\beta})$ and for each draw, calculating the choice probability in equation 6. This is repeated 200 times, and inserting the simulated choice probability in equation (7) gives us an estimated log likelihood. The value of the parameters that maximize this equation is the maximum simulated likelihood estimator, or in other words, the value of the parameters of the distribution of $\boldsymbol{\beta}$ that maximizes the likelihood of us observing the school choices made by households.

The results are presented in Table 6.[26] We estimate the model on the entire population (pooling all cohorts

[25] We specify a continuous mixing distribution. It is also possible to have a discrete mixing distribution, in which case the mixed logit model turns into a latent class logit model.

[26] In general, the results are in line with previous papers on parental preferences for school attributes, suggesting that parents

2011 to 2014) as well as for subgroups defined by foreign background and parental education. Estimation by subgroup will become important for our simulations, since Table 6 suggests that preferences vary by group. The school attributes included in the model are measured one year prior to the school choices being made. The coefficients should be interpreted as the change in utility from a one unit change in the corresponding school attribute. Standard errors are clustered at the 250×250 meters level (Table 11 in Appendix G presents results with clustering at the 500×500 and 750×750 level as well. Changing the level of clustering does not affect the results in any significant way).[27]

Note that we are not claiming that these parameters represent the true underlying preferences for school attributes but rather that we have put enough structure on this problem to be able to use the parameters in our counterfactual analysis. To further convince ourselves that the estimated preference parameters are valid for counterfactual analysis, we perform a validation exercise. First, we randomly divide our sample into five equally sized folds. We reestimate our model five times, each time excluding one of the folds and use the estimated parameters to construct complete rankings for those in the excluded fold. We then compare our predicted school rankings to the observed lists. Figure 3 displays histograms of the absolute difference between our predicted rankings and the choices observed i the data, separately for the top, second and third choices. We note that we can accurately predict the top choice of 73 percent. 42 percent of second choices are accurately predicted and 24 percent of third choices. We also note that few predictions are far off. For example, for the top choice our prediction is within two ranks for 89 percent of the population. Corresponding numbers for second and third choices are 82 and 78 percent.

value proximity and peer composition. Our results deviate in that school performance does not seem to be as important as previous studies suggest. There are several potential explanations for this difference such as that we are studying school choice for younger children compared to most previous studies.

[27]Note that we are abstracting from modeling choice of residential location. Since admission in the Botkyrka School Choice Program is dependent upon one's residential location relative to school locations, households may choose their residential location in order to increase their probability of acceptance at a preferred school. If this behavior is present, we could overestimate the preferences for proximity relative to other school attributes. To test whether this is an issue in our setting, we assume that households would list the school they moved close to, as their top choice. We estimate our preferred specification on the whole population excluding the top choices. In addition, we estimate the same model on the subset of households that have not changed their residential location since their child was born - reasoning that these households are unlikely to have chosen their residential location based on the location of a specific primary school. Finally, we also reestimate our model with a choice set restricted to the the 10 schools closest to a student's home only. The results from these exercises are presented in Table 12. The results do not differ much from those in our preferred specification, with the exception that the preference parameter for enrolling your child in the same school as a sibling, drops when top choices are excluded. This is expected, since excluding the top choice is likely to be equivalent to excluding the school where siblings already are enrolled, from their choice set. We conclude that residential sorting does not seem be a significant problem in our setting.

Also note that the variables included in our main model are motivated by what previous research has found to matter when households are choosing schools. As we have a rich data set including a multitude of school attributes, we can however test whether inclusion of additional variables matter. Table 13 presents the results from our extended model including a broader set of school attributes (definitions of these variables can be found in Table 8) including a dummy for voucher schools, whether the school offers all grades up to grade 9, average test score for students of their own type, the fraction of certified teachers, the student-teacher ratio, whether their own ethnic group is overrepresented at the school, the share of students from their own socioeconomic group, the share of newly arrived students at the school, the average income level and unemployment events of parents and the share of households receiving social benefits. The inclusion of these variables does not substantially change the coefficients of the variables included in our preferred specification.

Table 5: Preference parameters from rank ordered mixed logit model

	All		Native background				Foreign background			
			High education		Low education		High education		Low education	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Home-school distance (log meters)	-1.788***		-2.053***		-1.775***		-1.535***		-1.809***	
	(0.0626)		(0.108)		(0.0763)		(0.0954)		(0.0850)	
Sibling in school	3.085***		3.464***		3.127***		3.131***		2.769***	
	(0.0922)		(0.235)		(0.190)		(0.230)		(0.143)	
Neighbourhood school	2.579***		2.770***		2.565***		1.871***		1.933***	
	(0.129)		(0.231)		(0.199)		(0.235)		(0.256)	
School average test score (stand)	0.0393	0.109	0.102**	-0.201	0.0471	-0.179**	0.0603	0.135	-0.00828	0.246***
	(0.0302)	(0.119)	(0.0518)	(0.124)	(0.0415)	(0.0903)	(0.0612)	(0.644)	(0.0513)	(0.0854)
Foreign (share)	-2.677***	2.757***	-4.155***	-2.636***	-4.290***	-2.897***	-1.771***	2.521***	-0.900**	-2.761***
	(0.241)	(0.229)	(0.376)	(0.678)	(0.337)	(0.331)	(0.421)	(0.290)	(0.368)	(0.453)
High education (share)	3.024***	0.765	4.826***	1.072	2.189***	-0.860	1.360**	0.918	1.223**	0.102
	(0.316)	(0.581)	(0.481)	(2.698)	(0.474)	(0.737)	(0.557)	(2.074)	(0.607)	(0.596)
Observations	206405		70180		51008		37655		47562	

Note: This table presents the estimated mean and standard deviation of the preference parameters. The sample includes all primary school starters in Botkyrka 2011-2014. *Home-school distance* is the logarithm of the distance between the home and the school, measured in log(meters). *Sibling in school* is a dummy for having a sibling in the school. *Neighborhood school* is a dummy for the school being located in the student's own neighborhood. *Test scores* is the (standardized) score on the national exams taken by all students in all schools in year 3. *Foreign* is the fraction of students at the school that are (i) born abroad or (ii) have both parents born abroad and *Highly educated* is the fraction of students with parents that have at least some post-secondary education. Standard errors are clustered at the 250 times 250 meters level.

5.3 Assessment of truthfulness

This section is devoted to assessing the truthfulness in the households submitted choice lists. We have shown that our estimated preferences predict choices well in our observed data. This is however not enough for our counterfactual analysis to be valid. We need our estimated preferences to predict choice behavior not just in the setting they were estimated but also under altered priority structures. For this we need two things, (i) no strategic incentives in the counterfactual scenarios and, (ii) truth-telling households in our observed data. As explained in section 4 our three counterfactual scenarios should not give rise to any strategic incentives and hence the first point is not a concern. When it comes to truth-telling in our observed data there are two concerns, truncated lists and the possibility that households are "skipping the impossible".

We start with the problem of truncated lists. Although deferred acceptance is strategy proof, Haeringer & Klijn (2009) show that a restriction on households regarding how many schools they can rank reintroduces strategic incentives. Households may want to include one (or more) "safe school(s)" to avoid a situation where their child is not admitted to any of their submitted choices. It is not uncommon for school choice programs to have a limitation on the number of schools allowed on the application list. Abdulkadirolu *et al.* (2005b) and Abdulkadirolu *et al.* (2009) report that in NYC, students applying to high schools were allowed to list five programs before the re-design of the system in 2003-2004 and twelve programs after, with more than 500 programs to choose from. With the five-school restriction, about 50 percent of households ranked less than the maximum allowed number of schools, after the redesign the corresponding number was 72-80 percent. Hence, the restricted number of choices does not necessarily induce strategic incentives for all households. Nevertheless, we will assess the application lists using the concept of "safe schools" to say something about the degree of truthfulness (during the discussion of truncated lists we will abstract from the problem of "skipping the impossible") in our setting.[28]

Let school j be defined as a safe school for household i if the probability of admission to this school is equal to 1. Then, in our setting with three choices, we claim the following.

Claim 1 *If the top choice is a safe school, the top choice is truthful.*

Claim 2 *If the top choice is not a safe school but the second choice is a safe school, both the top and second choice are truthful.*

Proofs of these claims are provided in Appendix E, together with the necessary assumptions. These claims imply that the submitted choice lists can be considered truth-revealing if they include a safe choice, unless the first safe choice is also the last choice.[29]

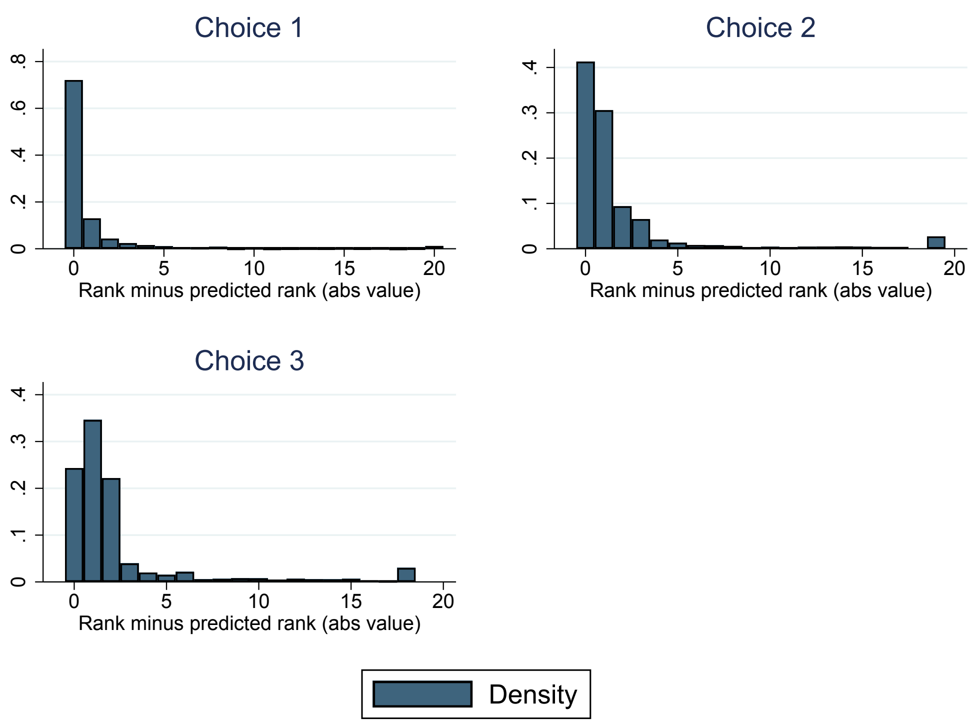
We take this concept to the data. We have access to the school capacity of the public schools that the municipality used in their placement algorithm for the years 2012-2014. We start by defining all public schools that were undersubscribed in all these three years as safe schools for all students. We define an undersubscribed school as a school that has more capacity than students assigned to it once the term starts. Even though we lack school capacity data for 2011 we think this is a fair definition as the cohort of school starters in 2011, by a margin, is the smallest cohort of the four cohorts we observe. Next we define school j as safe for household i if all households observed during 2011 to 2014 residing in the same geographic unit (250×250 m) who applied to school j were admitted or if household i already has a child enrolled in school j in grade K to 4. Note that we cannot determine whether a voucher school is a safe school or not.[30] Using these definitions, we find that more than 95 percent of all households list a safe school as either their top or

[28] This is based on Calsamiglia *et al.* (2010).

[29] Note that this generalizes to truncated lists of any length.

[30] As mentioned earlier, voucher schools admit students on a first come first served basis and we do not observe the time spent in the school's queues. Nor do we have access to the actual capacity of the voucher schools.

Figure 3: Cross validation



Note: This figure displays histograms of our predicted rank of choices for top, second and third choices separately using a 5-fold cross validation approach.

second choice. This is due to the, previously mentioned, significant overcapacity that the Borkyrka school choice program operates under. Note also that the remaining 5 percent are not categorized as non-truthful, rather we cannot make a statement about their truthfulness. Given this, we claim that non-truthfulness due to truncated lists is not a problem in this setting.

Next is the problem of "skipping the impossible". This problem arises because the DA mechanisms truth-telling properties rely on week dominance (Fack *et al.* , 2017). This means that the households do not really have an incentive to reveal the truth but rather they have no incentive to not do so. Hence, the mechanism could give rise to multiple equilibria. The main implication of this is that households can be inclined to "skip the impossible", i.e. not list schools that they perceive as impossible to be admitted to. As changes to the priority structures can alter the set of schools that are "impossible" for different groups of students to get admitted to, this is a concern. Again, the overcapacity in Botkyrka is helpful to us. Between 2012 and 2014 not one of the 18 public schools were oversubscribed for all three years. One school was oversubscribed two out of three years and two where oversubscribed one out of three years. Based on this we argue that the problem with "skipping the impossible" should be limited. During the relevent time period there are basically no schools that are impossible for any student go get into.[31] In our counterfactual scenarios situations could arise where specific schools are "impossible" to get into for certain students. Especially as we increase the cohort size. This is however not a problem as the outcomes of interest in our counterfactual scenarios are related to assignment and, by definition, assignment is not affected by the household's choice whether to include "impossible schools" or not.

Taken together, the significant overcapacity in Botkyrka during this time period helps us mitigate the problem of households not being truth-telling. In fact, given the overcapacity in Botkyrka, our estimation, based on truthfulness, would be almost identical if we were to estimate based on stability (as recommended in (Fack *et al.* , 2017)). The main difference would be that while estimating based on stability, we would have restricted our focus to only the students' top choices.

6 Results

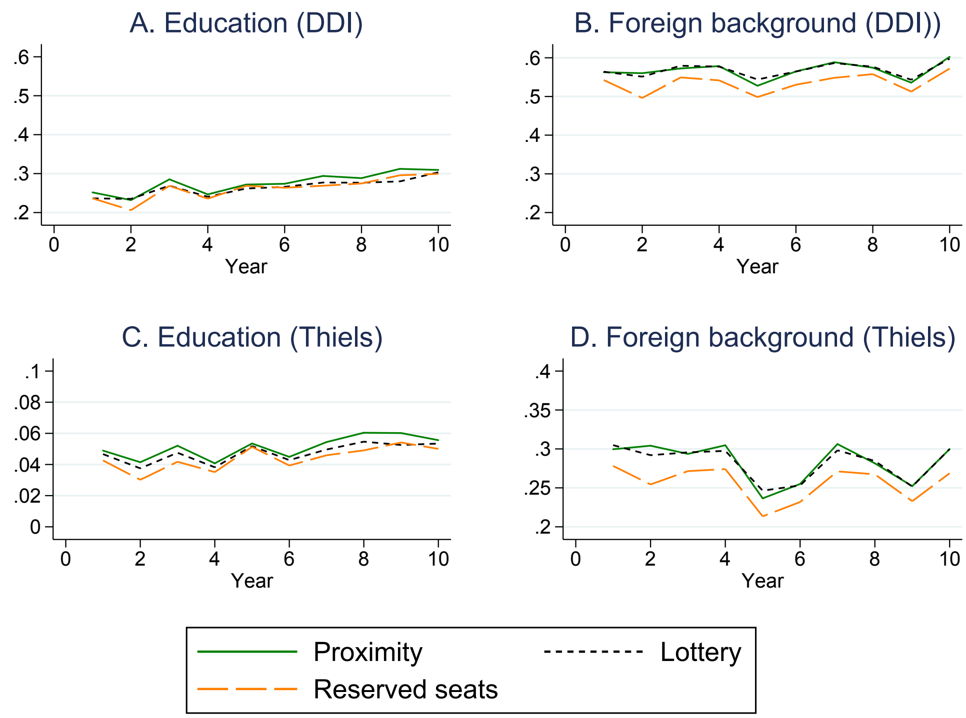
Figure 4 displays the level of segregation in terms of parental education and foreign background for each cohort entering the school system. We note that the evolution of the segregation over time does not seem to vary with the priority structure implemented.[32] The lack of differences in time trends between the counterfactual scenarios studied suggest that the initial reallocation of students is not large enough to incentivize the next cohort of school choosing households to alter their choice behavior. This allows us to pool the simulations over the years and look at the distribution of the simulation outcomes. These distributions can be seen in Figure 5. When it comes to segregation in terms of foreign background, the distribution clearly shifts to the left when we go from a proximity-based priority structure to one based on reserved seats. The DDI decreases with 4 points (from 0.57 to 0.53) and the Theil Index decreases with 2 points (from 0.28 to 0.26). We can see a similar pattern in segregation in terms of parental education. When going from a priority structure based on proximity to one based on reserved seats the DDI decreases with 2 points (from 0.28 to 0.26) and the Theil Index decreases with 1 point (from 0.05 to 0.04). The lottery-based priority structure produces similar levels of school segregation as the priority structure based on proximity.

For school districts considering whether to implement a new priority structure, an important concern may be the expected response of parents and students living in their district. For this reason, we study

[31]We cannot tell if any of the five voucher schools should be defined as "impossible", however, given that four of them are small and cater to specific groups we do not think this matters much.

[32]This is true for all outcomes of interest. This can be seen in Figure 13.

Figure 4: Level of segregation under alternative priority structures over time (mean)

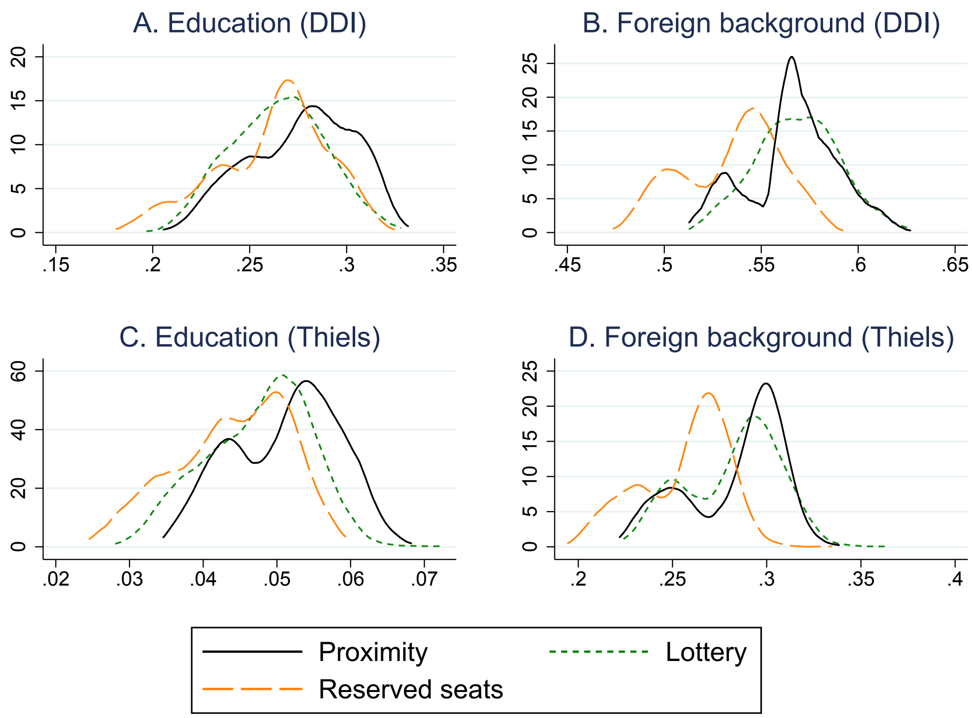


outcomes related to student welfare. First, when looking at the primary school level, proximity of the school is an important consideration. Further, the legitimacy of the school choice system may depend on whether or not it is able to satisfy households' choices. Subfigure A in Figure 6 presents the distribution of simulations results for the share of students assigned their most preferred school. We can see that the the priority structure based on proximity performs the best in this dimension with 83 percent of all households assigned their most preferred school. It is however only outperforming the priority structure based on reserved seats with less than one percentage point. The lottery-based priority structure performs a little worse, assigning 82 percent of households to their most preferred school. In Subfigure B we look at the share of students assigned to any of their three most preferred schools. The proximity-based priority structure and the priority structure based on reserved seats, perform about the same in this dimension, assigning 90 percent of students to one of their top three most preferred schools. The priority structure based on lottery performs a little bit worse compared to the other systems, assigning 89 percent of students to one of their top three preferred schools. Subfigure C in Figure 6 shows the simulation results for the average distance from the students home to their assigned school for the different priority structures. In terms of distance to the assigned school, we observe an increase of about 40 meters (from 957 to 997) when abandoning a proximity based priority structure and instead implementing one based on reserved seats. Again, the lottery-based priority structure preforms the worst with an average distance to school of 1,090 meters. In Subfigure D in Figure 6 we also present the utility. The differences between the different priority structures are small.[33]

In Figure 7 we present results for the average distance to school but with the sample divided into the households that got admitted to their most preferred school and those that did not. We can see that the

[33]Given the ordinal nature of utility and the fact that it is unclear to what extent our estimated parameters represent true underlying preferences, we will not be drawing any conclusions about the utility. We do however include it for completeness.

Figure 5: Level of segregation under alternative priority structures (kernel density functions)



increase in distance, when going from a proximity-based priority structure to a priority structure based on reserved seats that we observed in Figure 6, is driven by those assigned to their most preferred school. The students not assigned their most preferred school do not end up in schools further away from home. This implies that this increase in distance is driven by students that want to travel further in order to get into a more preferred school. Hence it is unclear to what extent it should be considered a cost. We can also see that the lottery-based priority structure deviates considerably from the two other systems with a longer distance for those assigned to their most preferred school and a shorter distance for those who are not. This is most likely due to this priority structure allowing students from the South of the municipality to get into their most preferred schools, which the two other priority structures will not.

In Figure 8 and 9 we show how the proxies for welfare vary for different subgroups depending on the priority structure implemented. We can see that both in terms of distance to school and the probability of being admitted to one's most preferred school, highly-educated natives are best off when priority is based on proximity. Foreign households with high education and native households with low education do, instead, benefit most from the priority structure based on reserved seats.

7 Concluding remarks

In this paper we study the effects on school segregation and student welfare when altering the priority structure in a school choice program using deferred acceptance to assign students to schools. Three types of priority structures are evaluated: proximity-based, lottery-based and one based on reserved seats. Given the widespread use of the deferred acceptance mechanism in school choice programs and the potential importance of priority structures when allocating students, this is an understudied subject.

Figure 6: Student welfare (kernel density functions)

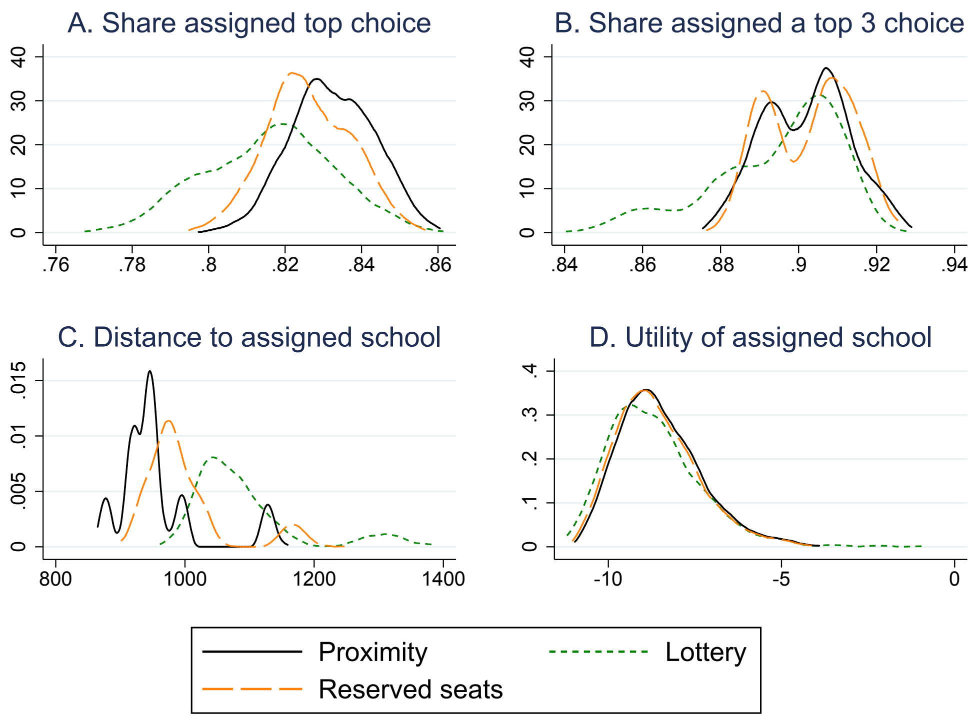
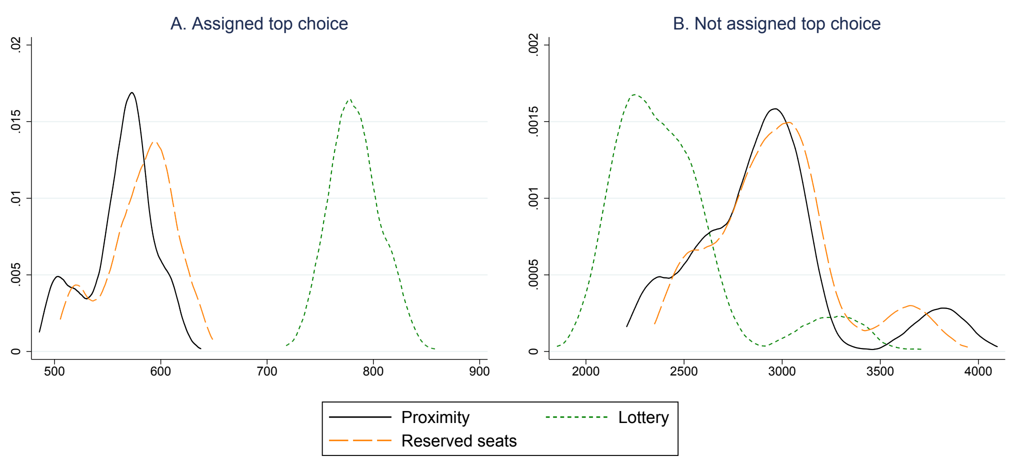
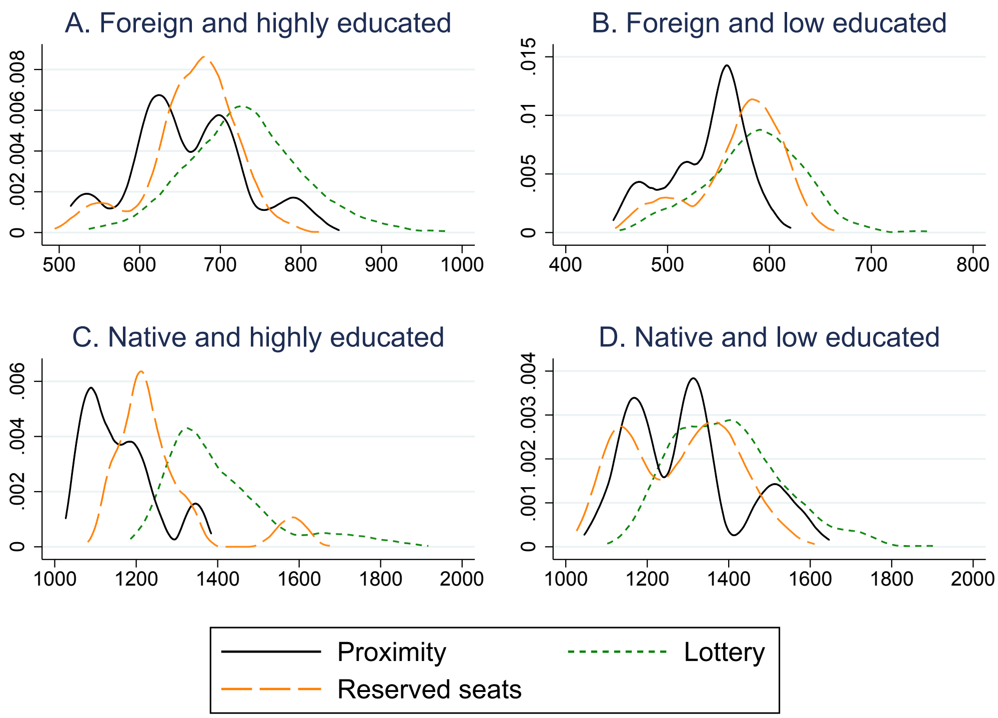


Figure 7: Home-school distance by assigned top choice or not (kernel density functions)



We find that segregation, both in terms of foreign background and parental education, is lower when using a priority structure based on reserved seats compared to when using a proximity- or lottery-based priority structure. The reallocation of students is immediate after implementation of the new priority structure and is stable over time. When comparing with a system based on proximity, this reduction in segregation comes with a small increase in the average distance to school and a minor decrease in the share of students getting admitted to their most preferred school. The increase in average distance to school is however driven by students being admitted to their most preferred schools. The lottery-based system underperforms compared

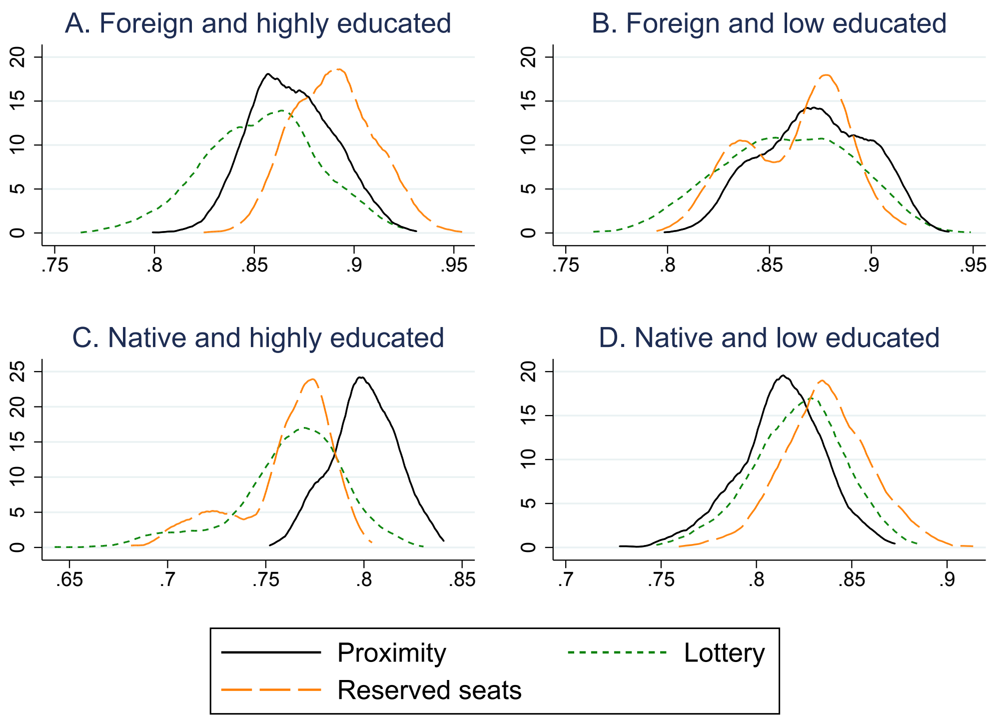
Figure 8: Home-school distance by subgroup (kernel density functions)



to the two other systems in these dimensions. Even though the system based on proximity and the one based on reserved seats produces similar results on average, there are clear winners and losers from the two systems. Highly-educated native households lose their residential privilege when proximity-based priorities are abandoned, while low educated households with a native background and highly-educated households with a foreign background benefit from a system based on reserved seats.

Botkyrka is a highly segregated municipality with distinct neighborhoods clearly separated from each other. This may affect the extent to which our results generalize to other settings. The effect on segregation implementing a priority structure based on reserved seats or a lottery may be muted because most parents do not consider it to be an option to allow their six-year old to commute to another neighborhood several kilometers away. In other settings and with older children the effects are likely to be larger. With that said, the observed effects on school segregation when reserving seats are not large, implying that it might not be a silver bullet we can use to eradicate school segregation. Still, the effect on school segregation is not negligible and the cost in terms of satisfying households' preferences for schools and the additional distance to assigned schools are small. Reserved seats for underrepresented groups should therefore not be discarded as a tool to reduce school segregation. When considering changing from a proximity-based priority structure to one based on reserved seats one should however be clear that it comes with a redistribution of welfare. Further, the results seem to imply that a system with lottery-based priorities does not perform well in any dimension compared to the two other systems.

Figure 9: Share admitted to top choice by subgroup (kernel density functions)



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A Variable definitions

Table 6: Definition of variables at the individual and individual-school level

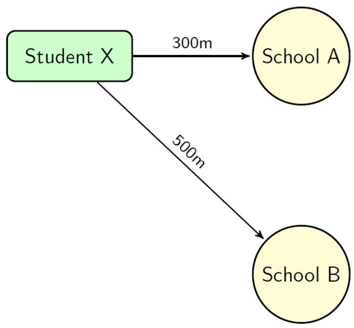
Variable	Definition
Individual level	
Home school distance	Distance between the students residential location and the school location. Measured in meters for the descriptive tables and in log of meters in the mixed logit models.
Sibling in the school system	Dummy equal to 1 for primary school starters with a sibling that will attend grade 1 to 9 in any school in the municipality.
Number of schools in nbd	Number of schools located in the neighbourhood (Norra Botkyrka, Tumba, Tullinge) in which the student lives.
Disposable income	Average yearly parental disposable income measured in 100SEK.
Highly educated	A dummy equal to 1 if at least one parent have studied at a level higher than upper secondary school. At the school level, we measure the fraction of students with highly educated parents.
Foreign background	A dummy equal to 1 if the student is born abroad or if both parents are born abroad. At the school level, we measure the fraction of students with foreign background.
Impoverished	A dummy variable equal to 1 if the household received any social assistance or housing allowances. At the school level, we measure the fraction of students from impoverished households.
Days unemployed	Parental average number of days with unemployment insurance during the year.
Individual-school level	
Sibling in school	Dummy equal to 1 for primary school starters with a sibling that will attend the school applied to in grade 1 to 9.
Neighbourhood school	Dummy variable equal to 1 if the school is located in the same neighbourhood as the student's residential location.
Test scores own group	Measures for each individual and each school the average test score for students with the same immigration and educational background.
Own ethnicity overrepresented	Measures for each individual and each school whether the students ethnic group is overrepresented or not (i.e. the share of the ethnic group at the school is larger than the share of that ethnic group in the municipality).
Share own socioeconomic group	Measures for each individual and each school the share of students in the same socioeconomic group.

Table 7: Definition of variables at the school level

Variable	Definition
Pass rate	Fraction of students passing the standardized tests in year 3.
Certified teachers	Fraction of certified teachers at the school.
Student-teacher ratio	Number of students at the school divided by the number of teachers at the school.
Student well-being	The schools average score on the student-surveys administered by the municipality to all students enrolled in a public school, asking about the students well-being at the school.
Foreign background	Share of students at the school with foreign background, defined as being born abroad or having both parents born abroad.
Highly educated	A student is classified as having highly educated parents if at least one parent have at lest 2 years of education at a level higher than upper secondary school.
Average school capacity	The average of the number of seats available for primary school starters at each school.
Newly arrived	Share of students at the school that are newly arrived, i.e. arrived to Sweden less than 4 years ago.
Average disposable income	Parental yearly average income for each student, where income is measured in 100SEK.
Share impoversihed	The share of students at the school classified as impoverished.
Average days unemployed	The parental average number of days as unemployed during the preceding calendar year.
Socioeconomic composition	The school's average score on the socioeconomic index, as defined in table 7.
All grades up to 9	Dummy variable equal to one if the school offers all grades from 0 to 9.
Boys	Male share of the students at the school.
Voucher school	Dummy variable equal to one for voucher school and zero otherwise. Voucher schools are publicly funded, but privately operated.
Test score	Average test score of students on the standardized tests in year 3, at the school level.
Student well-being	The schools average score on the student-surveys administered by the municipality to all students enrolled in a public school, asking about the students well-being at the school.

B Institutional details

Figure 10: Illustration of relative distance



Relative distance measure for student X:
School A: $500 - 300 = 200$m
School B: $300 - 500 = -200$m

Higher relative distance gives priority.

C Additional summary statistics

Table 8: Summary statistics of primary school starters not addmitted at their top choice school

	Total mean/sd	North mean/sd	West mean/sd	East mean/sd
Native, highly educated	0.23	0.11	0.28	0.65
	(0.42)	(0.31)	(0.45)	(0.48)
Native, low educated	0.20	0.16	0.29	0.25
	(0.40)	(0.36)	(0.46)	(0.44)
Foreign, highly educated	0.26	0.31	0.25	0.05
	(0.44)	(0.46)	(0.44)	(0.23)
Foreign, low educated	0.32	0.43	0.18	0.04
	(0.47)	(0.50)	(0.39)	(0.19)
Sibling in the school system	0.27	0.27	0.29	0.27
	(0.45)	(0.44)	(0.46)	(0.45)
Distance to attended school	1541.16	1596.27	1798.17	1038.31
	(1685.24)	(1875.04)	(1642.25)	(872.73)
Distance to top choice	1796.12	1988.28	2114.89	896.50
	(1747.19)	(1973.18)	(1537.05)	(884.80)
Observations	367	236	76	55

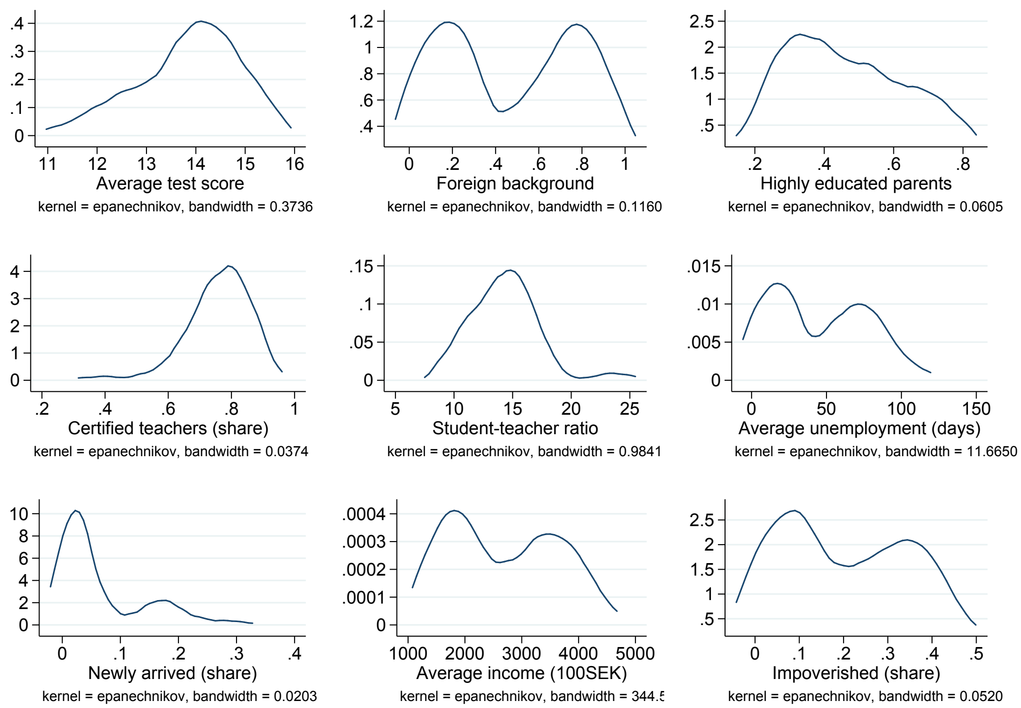
Note: This table presents the mean and standard deviation of each variable. The sample includes all primary school starters choosing schools in Botkyrka 2011-2014, that were not admitted at their top choice school. *Highly educated* indicates that at least one parents have an education level above upper secondary school. *Foreign* indicates that the student was born abroad or has both parents born abroad, otherwise the student is categorized as *native*. *Sibling in the school system* indicates if there is a sibling currently attending grade K-9 in any primary school in Botkyrka. *Distance to attended school* and *top choice* measures the home-school distance to the attended school and the school listed as the top choice in meters.

Table 9: Extended summary statistics of schools

	Total	North	West	East
	mean/sd	mean/sd	mean/sd	mean/sd
Average test score	13.84	13.27	14.03	14.59
	(1.00)	(0.94)	(0.91)	(0.57)
Foreign background	0.48	0.80	0.32	0.12
	(0.31)	(0.09)	(0.18)	(0.03)
Highly educated parents	0.46	0.32	0.49	0.67
	(0.16)	(0.07)	(0.10)	(0.09)
School capacity	54.94	55.00	55.09	54.60
	(18.15)	(12.62)	(24.15)	(17.97)
Voucher school	0.10	0.11	0.14	0.00
	(0.30)	(0.32)	(0.36)	(0.00)
Certified teachers (share)	0.76	0.74	0.74	0.81
	(0.10)	(0.08)	(0.13)	(0.08)
Student-teacher ratio	14.29	12.66	14.54	16.89
	(2.93)	(1.75)	(3.05)	(2.52)
Newly arrived (share)	0.06	0.11	0.04	0.01
	(0.07)	(0.08)	(0.05)	(0.01)
Average income (100SEK)	2681.17	1799.38	3003.58	3817.00
	(928.64)	(276.64)	(588.13)	(387.67)
Impoverished (share)	0.20	0.31	0.17	0.05
	(0.14)	(0.09)	(0.12)	(0.03)
Average unemployment (days)	45.30	76.45	29.37	11.54
	(31.44)	(15.35)	(17.95)	(3.70)
Offers all grades up to 9	0.67	0.78	0.86	0.20
	(0.47)	(0.42)	(0.36)	(0.41)
Observations	84	36	28	20

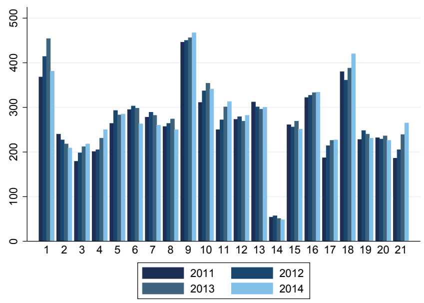
Note: This table presents the mean and standard deviation of each variable. The sample includes one observation per year of all schools available for choice in Botkyrka 2011-2014. *Average test scores* is the school average test score (max = 20) on the standardized tests in Swedish and mathematics taken in grade 3. *Foreign background* equals one for students born abroad or with both parents born abroad. *High education* indicates the share of students with at least one parent with higher education (above upper secondary school). *School capacity* indicates the average number of seats available in the schools for primary school starters. *Voucher school* is dummy equal to 1 for voucher schools. *Certified teachers* is the share of certified teachers at the school. *Student-teacher ratio* indicates the number of students per teacher. *Newly arrived* indicates the share of students that arrived to Sweden less than 4 years ago. *Average income* is the average parental income measured in 100SEK. *Impoverished* indicates the share of students living in households that receive social assistance or housing allowances. *Average unemployment days* indicates the parental yearly average of days with unemployment insurance. *Offers all grade up to 9* indicates that the school starts at grade K and continues up to grade 9.

Figure 11: Kernel density estimates of school attributes

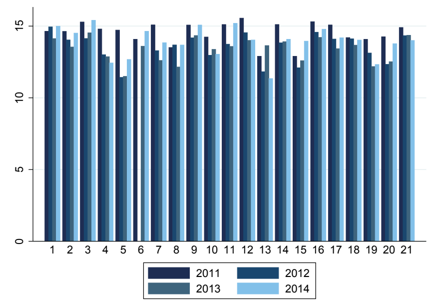


Note: These graphs are produced using the pooled sample for 2011-2014. *Average test scores* is the school average test score (max = 20) on the standardized tests in Swedish and mathematics taken in grade 3. *Foreign background* equals one for students born abroad or with both parents born abroad. *High education* indicates the share of students with at least one parent with higher education (above upper secondary school). *Certified teachers* is the share of certified teachers at the school. *Student-teacher ratio* indicates the number of students per teacher. *Average unemployment days* indicates the parental yearly average of days with unemployment insurance. *Newly arrived* indicates the share of students that arrived to Sweden less than 4 years ago. *Average income* is the average parental income measured in 100SEK. *Impoverished* indicates the share of students living in households that receive social assistance or housing allowances.

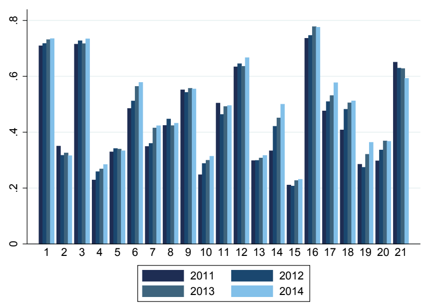
Figure 12: School attributes over time



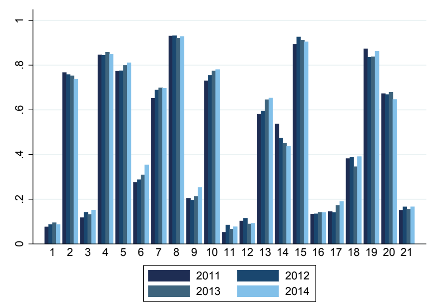
(a) Number of students (K-5)



(b) Average test score



(c) Share highly educated parents



(d) Share foreign background

Note: This graph presents the *number of students enrolled in grade K-5*, *the average test score* (max = 20) on the standardized tests in Swedish and mathematics taken in grade 3, *the share with highly educated parents* and *the share of students with foreign background* by year (2011-2014) for each school numbered from 1 to 21.

D Interpretation of preference parameters

$$U_{ij} = \beta_i^{knowledge} \mathbb{E}(K_{ij}) + \boldsymbol{P}_j' \boldsymbol{\beta}_i^{peers} + \boldsymbol{Z}_{ij}' \boldsymbol{\beta}_i^z + \epsilon_{ij} \tag{8}$$

where $\mathbb{E}(K_{ij})$ is the expected knowledge that student i would accumulate if they attended school j, $\beta_i^{knowledge}$ is the preference for knowledge, $\boldsymbol{P}_j'$ is a vector that describes the characteristics of the peers at school j and $\boldsymbol{\beta}_i^{peers}$ is a vector describing the preferences for the peer composition, $\boldsymbol{Z}_{ij}$ is a vector that describes other school attributes (including distance between the students home and the school) and the preferences for these attributes are captured by $\boldsymbol{\beta}_i^z$. ϵ_{ij} is a random component that is assumed to be iid with a type 1 extreme value distribution. In order to incorporate unobserved individual heterogeneity, preference parameters are allowed to vary across individuals. Further, we define the knowledge producing function as:

$$K_{ij} = \delta_{SQ} SQ_j + \boldsymbol{P}_j' \boldsymbol{\delta}_P + \upsilon_{ij} \tag{9}$$

Knowledge depends on the school quality (SQ_j)[34] and the peer composition at the school which is again described by the vector $\boldsymbol{P}_j'$. υ_{ij} is a iid error term that is assumed to be $\mathcal{N}(0, \sigma^2)$. If we plug the expected value of the knowledge producing function into the utility function, we get:

$$U_{ij} = \underbrace{\beta_i^{knowledge} \left(\delta_{SQ} SQ_j + \boldsymbol{P}_j'(\boldsymbol{\delta}_P + \boldsymbol{\beta}_i^p)\right) + \boldsymbol{Z}_{ij}' \boldsymbol{\beta}_i^z}_{=\boldsymbol{X}_{ij}' \boldsymbol{\beta}_i} + \epsilon_{ij} \tag{10}$$

We will estimate the parameters of equation 1, but note that the estimated preference for peers will not be an accurate estimate of β_i^{peers}, but a function of several underlying parameters $(\beta_i^{knowledge}(\delta_P + \beta_i^{peers}))$. This is due to the the fact that peer composition enters the utility function twice, as a direct component of utility and indirectly through it's effect on the knowledge production. This implies that we cannot really separate between preferences for knowledge production and peers in our estimation, which is more of a problem if one aims at determining the true underlying preferences. In this paper, we are mainly interested in using these parameters to be able to accurately predict which schools these households would choose in the counterfactual scenarios. This implies that it does not matter if they care about peers because they think that peers are important in itself or because they think that peers are a good proxy for school quality.

[34] In the main specification we will measure school quaintly using test scores. In the extended model we add other factors such as teacher qualifications and school resources.

E Truth-telling

Assumptions: Assume that all schools $j \in N$ are acceptable and that the households are not indifferent between any two schools $\in N$. Households are risk-neutral and rank the schools in order to maximize their utility as expressed in Equation 1. All schools have a strict priority ordering over students, independent of the households' ranking of schools. All students have a positive probability p of being accepted to any school $j \in N$, i.e. $\forall h, \forall j : p_j^i > 0$. p_j^i can be interpreted as household i's probability of having a priority above the capacity cut off for school j. A school j is defined as *safe* for household i if the probability of household h being admitted to school j is equal to 1, i.e. school j is a safe school for household h if $p_j^h = 1$. Assume also that households are able to determine whether a school is safe or not.

Proof of claim 1: Suppose that household h lists school j as their top choice, and that school j is a safe school. Since $p_j^h = 1$, the expected utility of submitting any ranking where school j is the top choice is U_j. Suppose now that there exist (at least) one other school k that is preferred to school j ($U_k > U_j$). If household h would modify the ranking and list school k as their top choice, their expected utility would be equal to $p_k U_k + (1 - p_k)U_j$. Since $0 < p_k < 1$ and $U_k > U_j$, it follows that $p_k U_k + (1 - p_k)U_j > U_j$ and household h would be better off with the modified ranking. Hence, if household h submits a safe school j as their top choice, there cannot exist any other school $k \in N$ that is preferred to school j.

Proof of claim 2: Suppose that household h lists the non-safe school k as their top choice and the safe school j as their second choice. The expected utility of this ranking is $p_k U_k + (1 - p_k)U_j$. Suppose that school k is not preferred to school j ($U_k < U_j$). If household h would modify their ranking and list school j as their top choice, they would get utility U_j since $p_j = 1$. Since $U_k < U_j$ and $p_k > 0$, this implies that $U_j > p_k U_k + (1 - p_k)U_j$, which means that household h would be better off with the modified ranking. Hence, given that school j is ranked second, it must be that school k is preferred to school j. Next, suppose that there is another school l that is preferred to school j ($U_l > U_j$). If household h would modify their ranking and rank school l above school j (as their top or second choice), they would get expected utility $p_k U_k + p_l(1 - p_k)U_l + (1 - p_k - p_l(1 - p_k))U_j$. Since $U_l > U_j$ and $p_l > 0$, this implies that $p_k U_k + p_l(1 - p_k)U_l + (1 - p_k - p_l(1 - p_k))U_j > p_k U_k + (1 - p_k)U_j$, and household h would be better off with the modified ranking. Hence, given that school j is ranked second, there cannot exist any other school $l \neq k \in N$ that is preferred to school j.

F Deferred Acceptance with reserved seats

Again, we assume that all students have strict preferences over all schools and that all schools have a strict priority ordering of all students. In addition, we introduce a finite number N of student types $j = 1, ..., N$. At each school, s_j seats are reserved for students of type j. The deferred acceptance algorithm modified to incorporate reserved seats would then assign students to schools in the following way:

Step 1 **a)** Each student applies to her top choice. Each school tentatively accepts one student at a time according to their priority ordering until there are no applicants left or the school run out of reserved seats for type j in which case all remaining applicants of type j are rejected.
b) If there is capacity left at the school (which happens when there are less applicants than reserved seats for at least one student type j), all students rejected in this round are considered together and the school tentatively accepts one student at a time according to their priority.

Step k **a)** Each student rejected in the previous round applies to her next preferred school. Each school considers all tentatively accepted and new applicants together and tentatively accepts one student at a time according to their priority ordering until there are no applicants left or the school run out of reserved seats for type j in which case all remaining applicants of type j are rejected.
b) If there is capacity left at the school (which happens when there are less applicants than reserved seats for at least one student type j), all students rejected in this round are considered together and the school tentatively accepts one student at a time according to their priority.

The algorithm terminates when no student is rejected, at which point all students are placed at their final tentative assignment.

G Alternative specifications of the mixed logit model

Table 10: Preference parameters from rank ordered mixed logit model: varying the level of clustering

	Main model (250 m grid)		Main model (500 m grid)		Main model (750 m grid)	
	Mean	SD	Mean	SD	Mean	SD
Home-school distance (log meters)	-1.788***		-1.788***		-1.788***	
	(0.0626)		(0.0796)		(0.0870)	
Sibling in school	3.085***		3.085***		3.085***	
	(0.0922)		(0.103)		(0.122)	
Neighbourhood school	2.579***		2.579***		2.579***	
	(0.129)		(0.122)		(0.149)	
School average test score (stand)	0.0393	0.109	0.0393	0.109	0.0393	0.109
	(0.0302)	(0.119)	(0.0363)	(0.119)	(0.0450)	(0.137)
Foreign (share)	-2.677***	2.757***	-2.677***	2.757***	-2.677***	2.757***
	(0.241)	(0.229)	(0.299)	(0.260)	(0.308)	(0.291)
High education (share)	3.024***	0.765	3.024***	0.765	3.024***	0.765
	(0.316)	(0.581)	(0.479)	(0.681)	(0.617)	(0.743)
Observations	206405		206405		206405	

Note: This table present the estimated mean and standard deviation of the preference parameters. The sample includes all primary school starters in Botkyrka 2011-2014. *Home-school distance* is the logarithm of the distance (meters) between the home and the school. *Sibling in school* is a dummy for having a sibling in the school. *Neighborhood school* is a dummy for the school being located in the own neighborhood. *Test scores* is the (standardized) score on the national exams taken by all students in all schools in year 3. *Foreign* is the fraction of students at the school that are (i) born abroad or (ii) have both parents born abroad and *Highly educated* is the fraction of students with parents that have at least some post-secondary education. Standard errors are clustered at the 250×250, 500×500 or 750×750 meters grid.

Table 11: Preference parameters from rank ordered mixed logit model: testing for residential sorting

	Total		No top choices		No movers		Restr. choice set	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Home-school distance	-1.788***		-1.608***		-1.874***		-1.778***	
	(0.0626)		(0.0777)		(0.0797)		(0.0666)	
Sibling in school	3.085***		1.704***		3.137***		3.139***	
	(0.0922)		(0.144)		(0.118)		(0.0886)	
Neighbourhood school	2.579***		2.785***		2.708***		1.722***	
	(0.129)		(0.129)		(0.181)		(0.138)	
Avgerage test score	0.0393	0.109	0.0280	0.0377	0.0593	-0.131	0.0347	0.160*
	(0.0302)	(0.119)	(0.0327)	(0.0603)	(0.0370)	(0.112)	(0.0308)	(0.0876)
Foreign (share)	-2.677***	2.757***	-2.537***	1.876***	-3.065***	2.841***	-3.504***	4.192***
	(0.241)	(0.229)	(0.217)	(0.307)	(0.321)	(0.290)	(0.340)	(0.339)
High education (share)	3.024***	0.765	3.340***	0.166	2.896***	0.934	3.537***	2.094***
	(0.316)	(0.581)	(0.310)	(0.126)	(0.393)	(0.678)	(0.319)	(0.691)
Observations	206405		134230		116207		93752	

Note: This table present the estimated mean and standard deviation of the preference parameters. The sample includes all primary school starters in Botkyrka 2011-2014. *Home-school distance* is the logarithm of the distance between the home and the school, measured in log(meters). *Sibling in school* is a dummy for having a sibling in the school. *Neighborhood school* is a dummy for the school being located in the own neighborhood. *Test scores* is the (standardized) score on the national exams taken by all students in all schools in year 3. *Foreign* is the fraction of students at the school that are (i) born abroad or (ii) have both parents born abroad and *Highly educated* is the fraction of students with parents that have at least some post-secondary education. Standard errors are clustered at the 250 times 250 meters grid.

Table 12: Preference parameters from rank ordered mixed logit model: extended model with additional school attributes included

	All school choices				Excluding voucher schools			
	Main model		Extended model		Main model		Extended model	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Home-school distance (log meters)	-1.788***		-1.959***		-1.960***		-2.012***	
	(0.0626)		(0.0584)		(0.0698)		(0.0619)	
Sibling in school	3.085***		3.243***		3.111***		3.116***	
	(0.0922)		(0.100)		(0.0943)		(0.0935)	
Neighbourhood school	2.579***		2.060***		2.462***		2.310***	
	(0.129)		(0.128)		(0.140)		(0.130)	
School average test score (stand)	0.0393	0.109	0.00484	0.0789	0.0887**	0.232***	0.161***	0.200
	(0.0302)	(0.119)	(0.0370)	(0.0616)	(0.0355)	(0.0726)	(0.0422)	(0.122)
Foreign (share)	-2.677***	2.757***	-2.340***	2.076***	-2.348***	3.198***	-1.826***	3.004***
	(0.241)	(0.229)	(0.541)	(0.354)	(0.284)	(0.249)	(0.248)	(0.212)
High education (share)	3.024***	0.765	2.344***	-0.190	3.786***	0.317	3.219***	0.696
	(0.316)	(0.581)	(0.646)	(0.328)	(0.312)	(2.110)	(0.350)	(1.574)
Voucher school			0.0350					
			(0.121)					
School offers all grades up to year 9			0.287***					
			(0.0742)					
Test scores, own group (stand)			-0.0186	-0.0204				
			(0.0294)	(0.0230)				
Fraction of certified teachers (stand)			0.150***	0.353***				
			(0.0310)	(0.0569)				
Student-teacher ratio (stand)			0.184***	-0.00737				
			(0.0368)	(0.0165)				
Own ethnicity overrepresented			0.938***	1.279***				
			(0.0945)	(0.189)				
Share same socioeconomic group			1.081***	0.267				
			(0.191)	(0.645)				
Newly arrived (share)			-0.887	-2.460*				
			(0.680)	(1.440)				
Average income (100SEK)			-0.0000837	-0.0000375				
			(0.000247)	(0.0000621)				
Impoverished (share)			-2.935***	4.038***				
			(0.946)	(0.412)				
Average unemployment (days)			0.00990**	0.00723				
			(0.00492)	(0.00914)				
Average student well-being							-0.117	0.980**
							(0.124)	(0.389)
Observations	206405		186395		195124		167891	

Note: This table present the estimated mean and standard deviation of the preference parameters. The sample includes all primary school starters in Botkyrka 2011-2014. *All school choices* are based on all primary school starters in Botkyrka 2011-2014, *Excluding voucher schools* is based on the same population but excludes voucher school choices. *Home-school distance* is the logarithm of the distance between the home and the school, measured in log(meters). *Sibling in school* is a dummy for having a sibling in the school. *Neighborhood school* is a dummy for the school being located in the own neighborhood. *Test scores* is the (standardized) score on the national exams taken by all students in all schools in year 3. *Foreign* is the fraction of students at the school that are (i) born abroad or (ii) have both parents born abroad and *Highly educated* is the fraction of students with parents that have at least some post-secondary education. For additional variables included, see definitions in Table 7-8. Standard errors are clustered at the 250 times 250 meters grid.

H Additional results

Figure 13: Level of student welfare under alternative priority structures over time (mean)

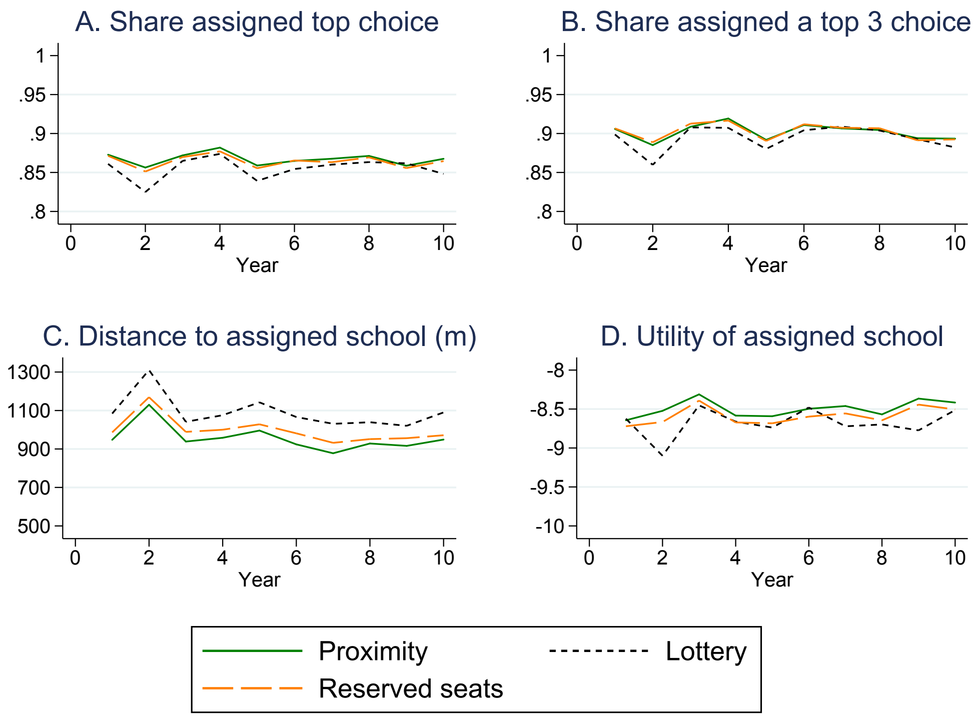


Figure 14: Share admitted to top three choice by subgroups (kernel density functions)

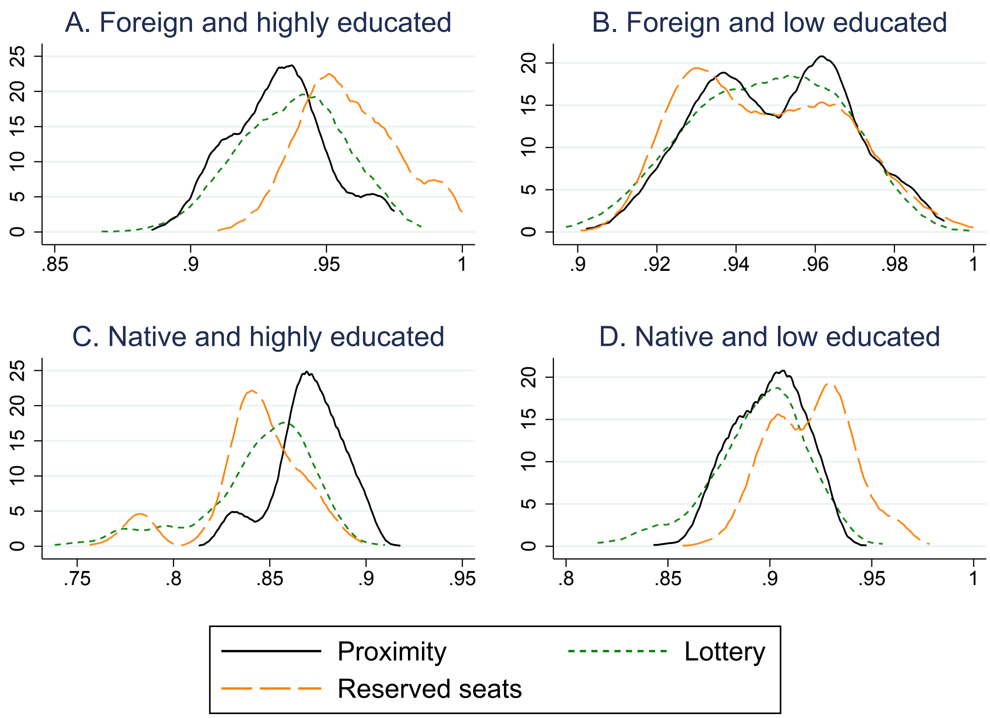


Figure 15: Utility by subgroup (kernel density functions)