School choice and segregation: evidence from an admission reform

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School choice and segregation: evidence from an admission reform*

by

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Abstract

This paper studies the effects of school choice on segregation. We analyze the effect of a reform in Stockholm that changed the admission system of public upper secondary schools. Before the year 2000, students had priority to the school situated closest to where they lived, but from the fall of 2000 and onwards, admission is based on grades only. We show that the distribution of students over schools changed dramatically as a response to extending school choice. As expected, the new admission policy increased segregation by ability. However, segregation by family background, as well as, segregation between immigrants and natives also increased significantly.

Keywords: School choice, Segregation.
JEL classification: I21, I28, J24

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1 Introduction

The debate around school choice is centered on two key questions. The proponents of school choice argue that the competitive forces released by school choice increase efficiency. This increase in efficiency benefits all students, also those not exercising choice themselves (e g Hoxby 2003). The opponents tend to be concerned about the effects on those left behind; arguing that choice merely increases segregation. According to a typical argument, the students will be increasingly sorted according to family background or ability. If peer groups are important to the student outcomes, the students who get into better schools benefit, both because of higher school quality, and because they interact with better peers. On the other hand, the students left behind suffer not only because of lower school quality but also because of the decrease in the average peer quality (e g Fiske & Ladd 2000).

By now, the evidence on the efficiency effects from school choice is accumulating mainly based on various voucher programs and charter schools operating in the United States. In contrast, peer effects and, therefore, the consequences of changes in the way that students are allocated across schools have proven to be hard to estimate. Most promising attempts to evaluate peer effects have been based on small scale controlled experiments (Falk & Ichino 2003) and on natural experiments randomly assigning individuals to peer groups (Sacerdote 2001; Katz, Kling & Liebman 2001)

In this paper we examine how a large scale reform that expands school choice affects sorting of students across schools. We use data from a reform that changed the admission rules to the upper secondary schools and evaluate the effects of these changes on segregation. We focus on sorting in three dimensions: ability, family background and immigrant status. As we will demonstrate below, the reform increased sorting in all observable dimensions. Our results are similar to findings from English data by Burgess *et al* (2004), who report that sorting according to ability, ethnicity and income are positively related to the feasibility of school choice, and that different admission systems produce different degrees of segregation. The key difference between their paper and the current study is that while Burgess *et al* examine the relationship between degree of choice and segregation in a cross-section, we study the effects of a reform that extended choice by weakening the link between school assignment and the neighborhood.

In some sense school choice existed in Sweden already since the beginning of the 1990s, long before the 2000 admission reform. The students could apply to any school within the municipality and even across the municipality borders if the home municipality agreed to pay the costs. However, if the schools were oversubscribed the admission was based on the place of residence and those living closest to a school were given first preference. Therefore, the admission system prior to the recent reform resembled intra-district open-enrollment policies in the US (Cullen *et al* 2000).

The admission system in Stockholm changed fundamentally in 2000. All residence-based admission criteria were abolished and admissions became based on previous grades only. The intention was to reduce the effects of residential segregation and to open up the option of attending the most prestigious schools in downtown Stockholm for all students, irrespective of where they lived.

As a first step in our analysis we calculate various mobility measures to demonstrate that the reform that opened new options had an impact on the school choices. We then evaluate the effects of the reform on segregation. We analyze data from the two years immediately before the reform and compare various measures of segregation to the two years after the reform. To isolate the effect of the reform from other simultaneous changes, we compare the changes in segregation across schools to changes in segregation across residential areas, and compare the changes in Stockholm where the admission system changed to the changes in surrounding communities where the admission system retained residence-based selection rules. In contrast to many previous papers we also calculate standard errors for the measures of segregation and adjust the measures so that we compare the observed level of segregation to the expected level under random allocation. This enables us to attach standard errors to our difference-in-differences estimates and to conclude that the admission reform increased segregation in a statistically significant way.

In the next section, we will describe in some detail the admission system and the changes due to the reform. Section 3 describes the data. In section 4, we report measures examining the effects of the admission reform on student mobility patterns and after that, in section 5, discuss some measurement issues related to segregation. In section 6 we report the main results on the effects of the reform on segregation, and in section 7 we make some concluding comments.

2 The Swedish school system

The Swedish public school system begins with pre-school, and continues with nine years of compulsory schooling. A student can then apply to the upper secondary school. About 90% of the student population complete the ninth grade and are eligible for upper secondary schooling. Of those, 98% continue to upper secondary schooling. With completed upper secondary schooling the student can apply for university or post-secondary education.

2.1 Regular compulsory school

All children between the ages of 7 and 16 have to attend school. Most schools are public and most children attend the school closest to home, but the parents can choose other public schools or private schools. Also the private schools are financed by grants from the students' home municipality, so it might be more appropriate to call them independent or charter schools. The private schools may have special focus, concerning pedagogical issues, language/ethnicity or religion, but most often they provide general education very much like the regular public schools. The private schools have to be approved by the National Agency for Education.

Grades are given from the eighth grade. Grades per subject are set by the teachers, and include one of the following possible grades: Pass (G), Pass with Distinction (VG), and Pass with Special Distinction (MVG). The system of grades was changed in 1995, and those leaving the ninth grade in 1998 were the first cohort with the new system where teachers shall base their assessment according to stated achievement goals. In principle, these criteria are absolute, not relative, but there is no guarantee that grading standards are equal across schools. In cases where a student fails to achieve a passing grade in a subject, no grade is given. The final certificate from the ninth grade is called "merit-värde". It consists of the sum of the 16 best classes, where G earns a student 10 credits, VG 15 credits and MVG 20 credits. A student who has finished the ninth grade, and has passed in Math, Swedish and English is eligible for upper secondary schooling.

2.2 Upper secondary school

All municipalities in Sweden are by law obliged to offer upper secondary schooling to all students that have completed their compulsory schooling. The upper secondary school consists of 17 national programs and several special

programs, all built on separate courses chosen by the student. All programs last for three years and provide eligibility for the university and other post-secondary level schools. Most municipalities do not have all programs, and the student then has the right to attend such a program in another municipality, financed by the municipality where he or she resides.

Also most upper secondary schools are public schools run by the local municipality. At the upper secondary level, there are two types of private schools. Most schools offer education corresponding to the public upper secondary schools (and receive municipal grants). In addition, there are schools offering supplementary programs, for example, fine arts and handicraft. In 1998, there were 60 private upper secondary schools located in 35 of the 288 Swedish municipalities. The total number of students in private schools was 8 822, that is about 2.8% of the student population. In Stockholm, there were 13 private schools where 6.5% of the student population attended. The number of private schools is continually increasing. In 2001, there were already 149 private upper secondary schools in Sweden, with a total of 17 887 students.

2.3 The Stockholm admission reform

The design of the local educational system rests in the hands of the municipality. In Stockholm, the political right carried through a reform of public upper secondary schooling in 2000. Up to 1999 a student had priority to the upper secondary school that was situated closest to home. This residence-based admission system was called "närhetsprincipen". A student only applied for a program, with grades deciding admission. Students could express wishes about which school to go to, but the ones living close to a specific school had priority. In practice, this implied that the Local Admissions Unit ("Intagningsenheten") first counted the number of places per program in the municipality. They then ranked the student choices according to grades, and accepted students to a certain program. Given acceptance, the Local Admissions Unit distributed the students to the specific schools based on residence and communication opportunities.

The cohort that applied to upper secondary school in the fall of 2000 was the first cohort of students who applied to both program (including specialization) *and* school. Students were then ranked according to their grades, and those with highest grades among the applicants to each school were admitted. This grade-based system became known as "betygsprincipen". If a student was

not accepted to his/her first choice, the second is considered and so forth (USK 2002).

Stockholm is not the only municipality reorganizing the admission to upper secondary school. Gothenburg and Malmö, the second and the third largest cities in Sweden, have also reformed their admission systems. In Gothenburg, the private schools use a strict grade procedure, while the public schools use a hybrid form of lottery and grades. In Malmö, in those cases where the program is available at different schools, the applicants are allocated to schools according to the grades.

3 Data and descriptive statistics

Our data comes from the database of the Institute for Labour Market Policy Evaluation (IFAU) in Uppsala. The data cover all students in the educational system. From this database we select all students who graduated in the spring of 1998, 1999, 2000 or 2001 from a regular compulsory school situated in the Stockholm County, which consists of the Stockholm City and the surrounding municipalities. We then follow these students, creating four cohorts of first year students in the upper secondary school. The two first cohorts applied to the upper secondary school prior to the admission reform and the two latter cohorts after the reform.

For these four cohorts we have information about the students' gender, age, immigrant status, parish of residence, regular compulsory school attended, final grades when leaving regular compulsory school, upper secondary school attended, parental income, parental education and parents' immigrant status. A family in this data is defined as those living in the same household as the student, when the student was 16 years old.

3.1 Definition of variables

Table 1 displays descriptive statistics. Since we will later use a difference-in-difference analysis, we show the figures separately for the Stockholm City and the rest of the county, labeled "Comparison".

Grades (GPA) can take the values from 0 (worst) to 320 (best). 1st generation immigrant refers to students that are born outside Sweden, and "1st & 2nd generation immigrant" to those who are born outside Sweden or has at least one parent born outside Sweden. Parental income is the sum of the two parents'

income. Therefore, parental income captures the effect of having parents that are working or not working, and also the effect of living with one or two parents. Parental education indicates that the student has at least one parent with a university degree. Private regular and private upper secondary schools are defined according to the status of schools where the student attended.

From Table 1 it can be noted that the student population is rather stable in terms of most background variables. Most notable exception is that the share of students attending private schools is increasing over time. The increase in the number of schools is also driven by opening of new private schools. Another trend that is worth noting is that the average grades appear to be increasing over time.

In terms of characteristics of the secondary school students displayed in Table 1, the students from outside Stockholm are rather similar to the students within the city. The Stockholm students are slightly more likely to be immigrants, and have more educated parents and better grades, but the differences are not large. Hence the other 25 municipalities in the County should be well suited to be used as a comparison group for the Stockholm students. Maybe the best argument for the choice of the comparison group is the current discussion of creating one unified upper secondary school area of the entire County.

The Stockholm municipality is divided into 28 geographical parishes, the unit which we use in measuring mobility and residential segregation. A parish is also the smallest geographical unit available in our data. The size of the parishes varies substantially. Smaller parishes are located in the central part of the city. On average, a parish has about 200 students per cohort. The inner city parishes are wealthier and more educated. The public upper secondary schools are spread out over the whole municipality, while the private schools are more concentrated in the central part.

Table 1. Descriptive statistics

		1998	1999	2000	2001
GPA	Stockholm	204.03	208.38	211.23	211.92
		(60.05)	(62.86)	(67.84)	(68.86)
	Comparison	201.37	202.69	202.24	205.08
		(58.63)	(62.27)	(64.83)	(65.21)
Female	Stockholm	0.486	0.488	0.489	0.493
		(0.500)	(0.500)	(0.500)	(0.500)
	Comparison	0.486	0.482	0.482	0.481
		(0.500)	(0.500)	(0.500)	(0.500)
Age	Stockholm	16.049	16.060	16.062	16.064
		(0.223)	(0.250)	(0.267)	(0.264)
	Comparison	16.046	16.050	16.050	16.045
		(0.214)	(0.222)	(0.227)	(0.215)
1st generation immigrant	Stockholm	0.138	0.159	0.147	0.158
		(0.345)	(0.366)	(0.355)	(0.365)
	Comparison	0.103	0.116	0.113	0.125
		(0.304)	(0.320)	(0.317)	(0.331)
1st & 2nd generation immigrant	Stockholm	0.332	0.348	0.341	0.347
		(0.471)	(0.476)	(0.474)	(0.476)
	Comparison	0.302	0.313	0.314	0.310
		(0.459)	(0.464)	(0.464)	(0.463)
Parental income (thousands of Swedish crowns per year)	Stockholm	359.9	360.2	389.7	410.4
		(352.0)	(330.6)	(445.7)	(414.6)
	Comparison	364.5	383.0	395.4	420.5
		(300.1)	(330.8)	(365.0)	(387.6)
Parental education	Stockholm	0.530	0.535	0.536	0.529
		(0.499)	(0.499)	(0.499)	(0.499)
	Comparison	0.455	0.447	0.450	0.457
		(0.498)	(0.497)	(0.498)	(0.498)
Share in private regular school	Stockholm	0.050	0.065	0.066	0.067
		(0.219)	(0.247)	(0.248)	(0.250)
	Comparison	0.030	0.041	0.041	0.039
		(0.170)	(0.198)	(0.198)	(0.193)
Share in private upper secondary school	Stockholm	0.120	0.150	0.179	0.197
		(0.325)	(0.356)	(0.383)	(0.398)
	Comparison	0.141	0.177	0.204	0.243
		(0.348)	(0.382)	(0.403)	(0.429)
Parishes	Stockholm	28	28	28	28
	Comparison	110	109	109	99
Schools	Stockholm	39	41	47	49
	Comparison	53	58	68	72
Students	Stockholm	5 566	5 826	5 945	6 187
	Comparison	10 784	10 855	11 412	11 710

Standard deviations are in parenthesis below means.

4 Mobility

As an indication of what happened after the reform, we begin with studying student mobility. We suspect that the mobility has increased and allocation of the students across schools has changed as a result of the reform. In Table 2 we display measures capturing the mobility patterns in the Stockholm City.

The average commuting distance from home to school is a rough measure of mobility across geographical regions. We can locate each school and each student to a certain parish. Based on the map coordinates of the mid-point of each parish, we can calculate the commuting distance. In Table 2 it is clear that the distance increases, particularly for the reform year, from 4.2 km to 4.8. We did suspect that this increase in mobility was due to private schools. Calculating the average commuting distance for public schools only, gives 4.1 km in 1999 and 4.7 km in 2000. The mobility pattern does not seem to be driven by private schools.

The second row of Table 2 calculates the share of students going to school in another area than where they live. The area is defined by the home parish and all adjoining parishes. A sharp increase is observed. In 1998 the fraction of students going to school in another area than where they live was 45%, and in 2001 it had increased to 63%.

Table 2. Different mobility measures

	1998	1999	2000	2001
Average commuting distance (km)	4.1	4.2	4.8	5.2
Share of students going to school in another area than where they live	0.45	0.48	0.55	0.63
Market share of three most common schools in parish	0.57	0.53	0.44	0.42

Finally we calculate an index that aim to measure the variation in the school choices among the students who live in the same parish. It is the "market share" of the three largest schools attended by the students in the same parish. It is calculated by parish and then averaged over parishes using the number of students in the parish as weights. The measure indicates that the variation in

school choices among the students who live in the same parish has increased. The increase is rather large. In 1998 the average market share of the three most popular schools in each parish was 57%. By 2001, the market share of the three most popular schools has declined by 15 percentage points to 42%. The steepest decline in the market share of the most popular schools coincides with the admission reform in 2000. However, part of the increase in dispersion in school choices appears to be unrelated to the reform**.** Most natural explanation is the growth of the private schools but even this does not fully explain the trend in the dispersion. A similar analysis for the public schools only displays larger levels, but very similar changes.

5 Measuring segregation

Finding that students traveled greater distances to schools, and that the dispersion of choices among students from the same parish increased, shows that the reform had its expected effect: the place of residence became less important for school choices after the reform. This implies that some other factors, especially previous grades, have become more important, and that the students will be increasingly sorted or segregated across schools according to the ability differences.

The methods for measuring segregation have a long history in the sociological literature. Various segregation indices have been designed since the 1950's. Typical early applications were concerned with dichotomous racial categorizations, most often between white and minority populations.

The most common measure of segregation is the dissimilarity index, often called the Duncan index according to Duncan & Duncan (1955). The dissimilarity index is defined as

$$D = \frac{1}{2}\sum_{s=1}^{J}\left|\frac{A_s}{A} - \frac{B_s}{B}\right|,$$

where J is the number of categories (e g schools), A is the number of individuals belonging to group A (e g race) and B the number of individuals belonging to group B. A_s and B_s are the corresponding numbers of individuals belonging to these groups in category s. The index measures the sum of the absolute

differences in the fraction of the groups in each category. If the groups are evenly divided across categories, so that the fraction of the group in each school equals its share in the population, the index is zero indicating that there is no segregation. The index reaches its maximum value of one when there is total segregation, so that the student body in each school consists of only a single group. Another common interpretation of the dissimilarity index is that it expresses the proportion of members of one of the two groups that need to move in order to achieve an equal distribution of both groups in all categories.

A major weakness of the dissimilarity index is that it can measure only segregation among dichotomous groupings. Because segregation indices were mainly used to measure segregation between the black and white populations, there was not much need to develop measures that could accommodate more than two groups. More recent developments in the racial patterns, as well as, applications of segregation measures to other problems have created a need to develop measures that can be applied to multiple groups.

A simple "segregation index", that can be used with continuous variables, and which is also probably most intuitive for the economists, is the ratio of the between school variance to the total variance (R^2). Essentially this measures the fraction of the total variance that is due to variation across schools. One can define R^2 as

$$R^2 = \frac{\sum_{s=1}^{J} \frac{n_s}{N} \left(\bar{y}_s - \bar{y}\right)^2}{\sum_{i=1}^{N} \left(y_i - \bar{y}\right)^2 / N},$$

where y_i is refers to the characteristics of the individual i, $\bar{y}_s$ to the average over students in school s, and $\bar{y}$ to the overall mean. R^2 reaches the maximum value of 1 when all units within groups are equal, so that across group variance equals total variance, and it is zero when there is no variation across groups, i.e. the means of each group are equal. A simple way of calculating R^2 is to regress individual outcomes on the full set of school dummies and calculate R^2 from this regression.

5.1 Sampling variation and random segregation

There are two important issues that have to be accounted for when interpreting the segregation indices. First, like all sample statistics also the segregation indices are influenced by sampling variability. This is particularly important

when analyzing changes in segregation. We would like to evaluate whether the observed changes in segregation are statistically significant or whether they could occur by chance. Still, most studies of segregation provide no information on the sampling variability of the estimates. This is slightly odd given that often the whole purpose of condensing information to a single segregation index is to be able to compare the levels of segregation in different places or the changes in segregation over time.

Second, even if the population were randomly allocated to the different categories, the allocation would not be completely even. The usual segregation indices measure the extent that the allocation deviates from evenness, instead of measuring the deviation from the random allocation. Simulation results by Carrington & Troske (1997) indicate that the most common indices of segregation indicate substantial segregation even when the population is randomly allocated across groups. The deviation from evenness is particularly strong when the categories are small or when the minority share is small. As an extreme example, Carrington & Troske note that if a large population of men and women are randomly allocated into categories of two, 50% of categories would consist of one man and one woman, while the other 50% would consist of only men or only women. Most segregation indices would report substantial gender segregation in this case. Furthermore, the dependence of segregation indices on the size distribution of the categories causes problems when comparing the segregation indices calculated over categories of varying size.

Both these problems are important for analyzing the change in the segregation after the admission reform in Stockholm. Calculating standard errors or confidence bands for the indices is, of course, necessary if we wish to claim that segregation changed due to the reform. We would also like to compare the extent of segregation across the schools to the residential segregation. Both schools and our geographical units are rather small (In 2000, the average cohort size in Stockholm schools was 135, and the average parish had 212 students). Also the size distribution of schools and parishes is different implying that the segregation indices measuring segregation across schools would get different values than indices measuring segregation across parishes even if the student population were randomly allocated both across the schools and across the geographical units. Even more importantly, the number of schools has increased over time, and this increase could change the values of the segregation indices even if no changes in segregation occurred.

In this paper we follow the suggestion of Carrington & Troske (1997) and adjust the segregation indices to measure the deviation from randomness, instead of measuring the deviation from evenness. We, therefore, first calculate the expected values of each segregation index according to the random allocation, given the school size distribution each year. Since analytical expressions for finite samples and varying category sizes are hard to calculate, we do this by simulation. We reallocate randomly the students to schools keeping the size distribution of schools fixed. We draw 500 random replications from this reshuffled data and take the mean of these random draws as the expected value of the segregation index.

We then calculate the adjusted segregation indices by subtracting the expected segregation index from the observed segregation index. For example, the adjusted segregation index in the case of the dissimilarity index is then

$$\hat{D} = \frac{D - D^*}{(1 - D^*)},$$

where D^* is the expected segregation index under random allocation. As the original dissimilarity index, also the adjusted index ranges from 0 to 1, with 0 indicating that segregation equals expected segregation under random allocation, and 1 that there is complete segregation.[1]

In our sample the expected values of the segregation indices under random allocation appear to be only moderate in size. For example, the expected dissimilarity index on segregation of income groups across schools in 1998 is 0.066, and the same index on segregation between natives and immigrants in 1998 is 0.087. The increase in the number of schools and the corresponding decrease in the average school size do not appear to have a major effect. The expected values of segregation indices change only slightly when the number of schools increases. A partial reason for this is that new schools are rather small and their weight on the segregation indices rather small.

Finally, to evaluate the extent of sampling variation in the adjusted segregation indices, we calculated the bootstrap standard errors for all the segregation measures. We drew with replacement 500 replications of size N from the

[1] In principle, it is also possible that there is excess unevenness if the observed segregation is smaller than expected segregation under random allocation. In this case $D < D^*$, and the adjusted segregation index would get negative values.

original sample and calculated the segregation indices for each draw. The standard deviation of these draws provided us with the standard error for each segregation index. Since we adjust each segregation index, we also need to adjust the estimates for the standard error by dividing the bootstrap estimate with (1-*D**).

6 Results on segregation

We have measured segregation along three dimensions: ability, immigrant status and family background. For each dimension, we calculate measures of segregation for the Stockholm schools and the comparison schools. We then evaluate the effect of the reform by comparing the change in Stockholm City to the change in the rest of the Stockholm County. We also calculate measures of residential segregation, and compare the changes in school and residential segregation in Stockholm. The entire analysis is conducted for both the Duncan (dissimilarity) index and the R^2-index. In all cases, the two indices produce the same qualitative result: segregation increases. The only difference between the two indexes is in the significance level.[2]

In the next three subsections we present the baseline results on the changes in segregation after the admission reform. After showing these results we will discuss the effect of the private schools and the effects of schools that closed down or opened up during the period under study.

6.1 Ability

We use grades when leaving regular compulsory school as a measure of ability. Since the mean and the variance of grades vary over time, we use percentile ranked grades in our calculations for the R^2-index. This does not make a big difference: both the levels and the changes in segregation indices are very similar in the original grades than when using percentiles. When calculating the Duncan index, we compare the highest achieving quartile to the rest but the

[2] We also calculated the Theil entropy index of segregation, but the qualitative results were very similar. We have chosen to display only the Duncan index and the R^2-index because of the popularity and commonness of the two measures. Results with the Theil-index are available from the authors upon request.

results appear to be quite robust to other groupings. The results on segregation on ability are presented in Table 3.

According to the results, there is a sharp increase in segregation by ability in the Stockholm schools. In 1998, 30.4 percent of the variation in the previous grades could be explained by the school attended. This fraction increases to 58.3 percent by 2001. The estimates are precise with small standard errors so that the differences across years are statistically significant. Interestingly, segregation increases already before the reform. For example, the R^2-index increases by 9.5 percentage points already between 1998 and 1999, a year before the reform. The increase in the reform year between 1999 and 2000 are still clearly larger than increases before or after the reform.

Part of the observed increase in segregation appears to be unrelated to the reform. Most plausible explanations have to do with the changes in the residential segregation and with the increase of the fraction of students going to private schools. None of these explanations fully explains the observed patterns. First, as can be seen in Table 3, residential segregation has increased in Stockholm, but more so between 2000 and 2001. Around the reform year, between 1999 and 2000, residential segregation was rather stable in Stockholm. As we will show later, the growth of the private school sector or closing of some public schools do not explain the results either.

To isolate the reform effect from other simultaneous changes we calculated difference-in-difference estimates. We compared the changes in segregation across schools in Stockholm in the consecutive years to the corresponding changes in the comparison area. We also made a similar comparison between changes in segregation across schools and segregation across residential areas.

The results indicate a large reform effect. Between 1999 and 2000 the segregation indices increased 12–15 percentage points more in Stockholm than in the comparison group and segregation across schools increased 11-14 percentage points more than segregation across the residential areas. These estimates are statistically significant and different measures of segregation give similar estimates. Segregation across Stockholm schools increased more than segregation in the comparison area or segregation across residential areas the year before the reform, but the difference is smaller than in the reform year.

To sum up we conclude that ability sorting in the Stockholm schools has dramatically increased as a result of the reform. We find it puzzling that segregation increases already before the reform and return to the possible explanations below.

Table 3. Segregation by ability

	Segregation between schools			
	1998	1999	2000	2001
R^2				
Stockholm	0.304	0.399	0.537	0.583
	(0.009)	(0.010)	(0.009)	(0.008)
Comparison	0.184	0.212	0.228	0.250
	(0.006)	(0.007)	(0.007)	(0.008)
Duncan				
Stockholm	0.308	0.408	0.541	0.615
	(0.014)	(0.013)	(0.012)	(0.011)
Comparison	0.226	0.287	0.274	0.319
	(0.011)	(0.012)	(0.011)	(0.012)
	Segregation between parishes			
R^2				
Stockholm	0.044	0.059	0.057	0.084
	(0.006)	(0.006)	(0.006)	(0.007)
Comparison	0.055	0.058	0.058	0.058
	(0.005)	(0.005)	(0.005)	(0.005)
Duncan				
Stockholm	0.116	0.112	0.132	0.172
	(0.014)	(0.013)	(0.015)	(0.014)
Comparison	0.131	0.134	0.104	0.140
	(0.011)	(0.011)	(0.010)	(0.010)

	Difference-in-difference					
	Stockholm Schools vs Comparison Schools			Stockholm Schools vs Stockholm Parishes		
	98/99	99/00	00/01	98/99	99/00	00/01
R^2	0.067***	0.122***	0.025	0.080***	0.140***	0.020
	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)	(0.015)
Duncan	0.039	0.146***	0.029	0.104***	0.113***	0.034
	(0.025)	(0.024)	(0.023)	(0.027)	(0.026)	(0.026)

Significance level: *** = 1%, ** = 5% and * = 10%. Bootstrapped standard errors are in the parentheses. Both the indices and their standard errors are adjusted so that they measure deviation from random allocation and not from even allocation (See text). We used the delta method to calculate standard errors for the difference-in-difference estimates.

6.2 Immigrant status

Table 4 displays the segregation indices between natives and immigrants. In the table we present results where we count both the first and the second generation immigrants as immigrants. The results indicate that segregation between natives and immigrants increased sharply after the reform in the Stockholm schools. According to the Duncan index, 19.6% of the immigrant students in the Stockholm schools in 2001 would have to be moved to another school to achieve a distribution that corresponds to a random allocation. The comparable number in 1999 was 13.0%. The point estimates are significantly different at the five percent level. During these years there was a slight upward trend also in residential segregation. The Duncan index calculated across parishes increased from 28.2% to 30.9%, though the increase was not statistically significant. There is no clear pattern in the Comparison group.

The difference-in-difference estimates support the view that the admission reform had an effect on segregation. Between 1999 and 2000 the R^2-index increased by 2.8% more in the Stockholm schools than in the Comparison schools. The increase in the Stockholm schools was also larger than in the Stockholm parishes during the reform year, but the difference was not statistically significant. Overall there does not seem to be any tight relationship between segregation across schools and residential areas in Stockholm. For example, between 1998 and 1999 residential segregation increased, while school segregation actually decreased.

When restricting the definition of immigrants to the "1st generation", the segregation levels are lower, but the changes are essentially similar. We also note that the segregation between schools did not change much prior to the reform, but that there is an increase in Stockholm and a decrease in the Comparison group after the reform. We have tried different definitions of the immigrant status, such as born outside the Nordic countries, or born outside the OECD countries. These different definitions do not affect the results.

It is worth pointing out that the difference between residential segregation and school segregation in Stockholm decreased after the reform, mainly because segregation across schools increased.

Table 4. Segregation by immigrant status

	Segregation between schools			
	1998	1999	2000	2001
R^2				
Stockholm	0.053	0.051	0.067	0.087
	(0.007)	(0.006)	(0.007)	(0.007)
Comparison	0.067	0.079	0.066	0.086
	(0.005)	(0.006)	(0.005)	(0.006)
Duncan				
Stockholm	0.140	0.130	0.162	0.196
	(0.014)	(0.012)	(0.013)	(0.012)
Comparison	0.168	0.181	0.172	0.202
	(0.010)	(0.010)	(0.010)	(0.010)
	Segregation between parishes			
R^2				
Stockholm	0.134	0.145	0.151	0.162
	(0.010)	(0.009)	(0.009)	(0.010)
Comparison	0.111	0.122	0.113	0.127
	(0.006)	(0.006)	(0.006)	(0.006)
Duncan				
Stockholm	0.265	0.282	0.287	0.309
	(0.014)	(0.013)	(0.013)	(0.013)
Comparison	0.235	0.236	0.226	0.247
	(0.011)	(0.010)	(0.010)	(0.009)

	Difference-in-difference					
	Stockholm Schools vs Comparison Schools			Stockholm Schools vs Stockholm Parishes		
	98/99	99/00	00/01	98/99	99/00	00/01
R^2	-0.013	0.028**	0.001	-0.012	0.010	0.009
	(0.012)	(0.012)	(0.012)	(0.016)	(0.016)	(0.017)
Duncan	-0.023	0.042*	0.003	-0.027	0.026	0.012
	(0.023)	(0.023)	(0.023)	(0.027)	(0.026)	(0.025)

Significance level: *** = 1%, ** = 5% and * = 10%. Other notes under Table 3.

6.3 Family background

We measured family background with two variables, parents' education and parents' income, but report in Table 5 only the results on parent' education. Also here segregation across schools clearly increased. The R^2-index increases from 10.4% in 1998 to 13.9% in 2001. The point estimates are significantly different at the five percent level. In the comparison group the segregation is fairly constant; the R^2-index is 10.0% in 1998 and 10.1% in 2001. Also residential segregation is stable in both groups.

The difference-in-difference results indicate a clear reform effect. During the reform year, segregation increased by 2.8 percentage points more in the Stockholm schools than in the Comparison schools when measured with the R^2-index. The Stockholm schools became also significantly more segregated than the Stockholm parishes.

Concerning parental income (not reported in the table), the results were rather similar. As with grades, we percentile ranked the parental income for the R^2-index. There was a sharp increase in school segregation in Stockholm that could not be seen in the comparison group. Residential segregation remained stable over the years in both groups. In the difference-in-difference analysis, Stockholm schools become significantly more segregated than Comparison schools and Stockholm parishes in the reform year. The differences in other years are not statistically significant.[3]

According to all indices, the school segregation and residential segregation on family background were at the same level in 1998. After the reform the school segregation in Stockholm sharply increased while residential segregation remained stable. We find the evidence clear; sorting on family background increased with the expansion of school choice.

[3] For example, the increase in the Duncan index for the Stockholm schools was 5.5% larger than Comparison schools, and 6.9% larger than Stockholm parishes. Both differences were statistically significant.

Table 5. Segregation by parental education

	Segregation between schools			
	1998	1999	2000	2001
R^2				
Stockholm	0.104	0.116	0.138	0.139
	(0.008)	(0.008)	(0.008)	(0.008)
Comparison	0.100	0.108	0.102	0.101
	(0.005)	(0.006)	(0.006)	(0.006)
Duncan				
Stockholm	0.222	0.245	0.275	0.291
	(0.013)	(0.013)	(0.012)	(0.011)
Comparison	0.215	0.233	0.231	0.225
	(0.010)	(0.010)	(0.010)	(0.010)
	Segregation between parishes			
R^2				
Stockholm	0.088	0.089	0.081	0.086
	(0.007)	(0.008)	(0.007)	(0.007)
Comparison	0.092	0.088	0.080	0.080
	(0.006)	(0.005)	(0.005)	(0.006)
Duncan				
Stockholm	0.224	0.216	0.204	0.214
	(0.013)	(0.013)	(0.013)	(0.012)
Comparison	0.201	0.199	0.187	0.191
	(0.009)	(0.010)	(0.009)	(0.009)

	Difference-in-difference					
	Stockholm Schools vs Comparison Schools			Stockholm Schools vs Stockholm Parishes		
	98/99	99/00	00/01	98/99	99/00	00/01
R^2	0.004	0.028**	0.003	0.011	0.030**	-0.004
	(0.014)	(0.014)	(0.014)	(0.016)	(0.015)	(0.015)
Duncan	0.006	0.032	0.022	0.030	0.042*	0.005
	(0.023)	(0.022)	(0.021)	(0.025)	(0.025)	(0.024)

Significance level: *** = 1%, ** = 5% and * = 10%. Other notes under Table 3.

6.4 Possible explanations for the observed patterns

In addition to the admission reform, there were two other important events that might have had an impact on segregation. First, the fraction of the Stockholm students in the private schools increased from 12 to 20 percent between 1998 and 2001. Second, the number of schools increased from 39 to 49, mostly due to new private schools opening up. In fact, the number of new schools was even larger, because seven schools closed down between 1998 and 2001. Both the increase in the fraction of private school students and the changes in the school structure may have an effect on student sorting.

To isolate the effect of the admission reform from the effects of changes in the fraction of students in the private schools we repeated all calculations reported in tables 3 to 5 using only the public school students. We also repeated the calculation using only schools that existed over the whole four-year period.[4]

To our surprise neither the increase in the private schools nor the closing down or opening up schools had a major effect on the results. Neither could they explain why the segregation indices in some cases increased already before the reform. For example, segregation along ability, measured by the R^2-index, in the Stockholm public schools was 22.9% in 1998, 33.5% in 1999, 51.5% in 2000 and 57.5% in 2001. Comparing these numbers to the corresponding index in the first row of Table 3, reveals that the level of segregation is lower when only public schools are included but that changes are very similar. Also in the public schools, there is a large increase in the reform year but a puzzling increase already year prior to the reform. Concerning segregation along the immigrant status, it increased slightly more in the public schools than in all schools. This makes the difference-in-differences estimates comparing Stockholm schools to Stockholm parishes in Table 4 statistically significant in the reform year. Focusing on surviving schools does not make a large difference in segregation along any dimensions either. If anything, the reform effect stands out more clearly.

The final issue that we examined was to what extent segregation along family background and immigrant status are driven by sorting by ability. Grade-based admission system can be expected to increase sorting by ability and hence also any other characteristics that happen to be correlated with ability. To examine this issue we made an attempt to calculate segregation

[4] Full results on all indices calculated over the subsample of the public schools, and schools that existed over the whole four-year period, are available from the authors upon request.

indices conditional on ability. For the R^2-index this is relatively straight-forward. We simply regressed immigrant status and parents' education on ability and school dummies and calculated "partial R^2", i.e. the variance attributable to school dummies in this regression. To allow a flexible relationship between ability and other outcome measures we entered ability in this regression as decile dummies. The results are reported on the row "partial R^2" in Table 6. For the ease of comparison we also replicate the original results on unconditional indices from Tables 4 and 5.

For both immigrant status and the parents' education conditioning on ability decreased the segregation measures. Conditioning on ability also removed the reform effect from the segregation along parents' education. However, the pattern in segregation along the immigrant status remained similar to that reported in Table 4. Even conditional on ability there was a strong increase in the segregation index between 1999 and 2000 and no clear change in the other years.

Table 6. Segregation conditional on ability

	Immigrant status			
	1998	1999	2000	2001
R^2				
Stockholm	0.053	0.051	0.067	0.087
Comparison	0.067	0.079	0.066	0.086
Partial R^2				
Stockholm	0.046	0.041	0.056	0.062
Comparison	0.060	0.068	0.056	0.078
	Parental education			
	1998	1999	2000	2001
R^2				
Stockholm	0.104	0.116	0.138	0.139
Comparison	0.100	0.108	0.102	0.101
Partial R^2				
Stockholm	0.033	0.046	0.047	0.021
Comparison	0.046	0.050	0.042	0.039

7 Conclusions

A key motivation behind the admission reform in Stockholm was that the city is geographically quite segregated. There are large differences in the income and education levels across the residential areas. The immigrants tend to be heavily concentrated to certain neighborhoods. As a result of residence-based admission criteria, also the schools are segregated. The system was considered unjust because those from less advantaged neighborhoods had little chance of attending the best schools.

The admission reform in 2000 abolished all residence-based admission rules. This benefited those with highest grades as new options became available and school district borders no longer limited their school choices. The losers were those who no longer were accepted to their closest school due to competition from students living further away.

The change in the admission system is only one of the important changes that affect segregation of students. Segregation across residential areas has also increased. The increase in the private school sector also increases choice options and might lead into an increase in segregation across schools. However, the quantitative importance of these two changes appears to be minor compared to the effects of the admission reform. This should not be very surprising. Changes in residential segregation are slow compared to sudden changes caused by the change in the admission system. Also even though private school sector has grown rapidly it still represents a rather small fraction of students. For most students, the choice between different public schools is far more important than the choice between the public and the private schools.

As expected, grade-based admission system increased sorting of students to schools according to their ability. Less expected was that segregation also increased along all other observable dimensions, particularly along the ethnic and socio-economic lines. All these changes were reasonably large and statistically significant.

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