Ethnic Segregation Between Hungarian Schools: Long-run Trends and Geographic Distribution*

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Using all of the available data on the ethnic composition of Hungarian primary schools, this paper documents the degree of between-school segregation of Roma versus non-Roma students in the 1980–2011 period. We calculate the measures of segregation within school catchment areas as well as within micro-regions and the larger municipalities (towns and cities). Catchment areas are clusters of villages, towns and cities that are closed in terms of student commuting, and they are defined by us using the observed commuting patterns. Our results show that ethnic segregation between Hungarian schools strengthened substantially between 1980 and 2011. Segregation appears to have decreased between 2006 and 2008 and increased again afterwards, but the noise in the data prevents us from drawing firm conclusions. In the cross section, school segregation is positively associated with the size of the educational market and the share of Roma students, similar to the results from US metropolitan areas. These relationships strengthened over time in Hungary, and the change in segregation is associated with changes in the number of schools and the share of Roma students.

KEYWORDS:
School segregation.
Roma minority.

* We thank *Melinda Tir* for her assistance with data management, *Tímea Molnár*, *Péter Dívós* and *Ágnes Szabó-Morvai* for their earlier work on programming and *László Göndör* for his help with the maps. We thank *Gábor Bernáth*, *János Zolnay*, as well as the editor and the referee for their thoughtful comments. All the remaining errors are ours. Individual research grants from the Institute of Economics of the Hungarian Academy of Sciences are gratefully acknowledged.

Over ten percent of the Hungarian students in primary schools are Roma. The typical Roma students come from substantially poorer families and have lower achievement than the typical non-Roma students (*Kertesi–Kézdi* [2011]). The extent to which Roma and non-Roma students study in the same schools can have serious consequences for ethnic differences in accomplishment and other outcomes as well as for the integrity of Hungarian society.

Using all of the available comprehensive data on the ethnic composition of Hungarian primary schools, this paper documents the degree of between-school segregation of Roma versus non-Roma students between 1980 and 2011. We show the long-run trends and the geographic distribution, and we estimate regressions to uncover the associations between segregation and other characteristics of the areas, which are identified from the cross-section and from the long-differenced panel of the areas for which school segregation is defined.

It is necessary to have some institutional knowledge of the Hungarian school system to understand school segregation. We are interested in the primary schools that cover grades 1 through 8 (these include some secondary schools that cover grades 5 through 8). Importantly, and similar to other countries in the region, Hungary is characterized by the dominance of state-owned primary schools, and parents are free to choose schools for their children. On top of the enrolment from within their own district, which is defined by the municipality, schools can admit children living outside of the district. The total enrolment in schools is determined by their capacity, the level of demand from within and from outside of their district and the allocation decision by the municipality.

We estimate the degree of segregation within three types of geographic area: the 174 micro-regions, the larger school catchment areas (clusters of villages, towns and cities that are closed in terms of student commuting in the 2000s and have two schools or more) and the larger municipalities (towns and cities with two or more schools). Our preferred unit of measurement is the catchment area because it represents the territory that is the most relevant for school choice. In a sense, micro-regions are too large: school segregation within micro-regions is likely to be heavily influenced by the residential patterns across towns and villages. The towns and cities are too small: measuring segregation within their administrative boundaries misses potentially important commuting from and to villages in their agglomeration. The school catchment areas are not administratively registered units; they are defined by commuting possibilities. A contribution of our paper is to define the boundaries of those areas using the actual commuting patterns of all sixth graders observed in three different years.

Our preferred measure of segregation is the index of segregation (also known as the isolation index, see *Clotfelter* [2004]), but we also show results using the more traditional index of dissimilarity. There is no data from between 1992 and 2006, and the missing data decreases the reliability of the post-2006 figures. Aside from our best estimates, we also present conservative lower and upper bounds. We introduce time series of the average level of segregation and maps for its geographic distribution. Finally, we show cross-sectional and log-differenced regressions for partial correlations of the between-school segregation with the size of the educational market, the average school size and the fraction of Roma students.

Our results indicate that school segregation, on average, is moderate in Hungary. The mean of the index of segregation is approximately 0.2 in the geographic areas covered by our analysis and is approximately 0.3 in the areas around the three largest cities. Note that Hungarian schools are characterized by fixed assignment to groups within schools ("classes"). Within-school between-class segregation may therefore be as important for inter-ethnic contact as between-school segregation. Unfortunately, our data does not make calculating indices within-school ethnic segregation possible. But it allows for looking at the segregation of students whose mother has eight grades of education or less, both between schools and within schools. On average, the level of their within-school segregation is about 40 percent on top of the level of their between-school segregation (details of the calculations are available from the authors upon request). This suggests that the level of ethnic segregation, if measured across classes instead of schools, is likely to be about 40 percent higher than the level of ethnic segregation across schools (0.28 instead of 0.20 on average, and 0.4 instead of 0.3 in the areas around the largest cities).

The data also show that, on average, the level of school segregation within Hungarian towns strengthened substantially between 1980 and 2011. According to our benchmark estimates, between-school segregation appears to have decreased between 2006 and 2008 and increased again afterwards. However, the trends after 2006 cannot be robustly identified due to severe data limitations. In the cross-sectional regressions, school segregation is positively associated with the size of the educational market and the share of the ethnic minority, similar to results from US metropolitan areas, and these relationships strengthened over time. In the regressions estimated in long term differences, the change in segregation is also linked with these factors, but the associations are weaker except for the change in the size of the Roma minority

The rest of the paper is organized as follows. Section 2 introduces the data, Section 3 defines the effective catchment areas of schools, and Section 4 presents the measures of segregation. Section 5 shows the average levels of segregation and its times series, and Section 6 introduces its geographic distribution. Section 7 details the regression results, and Section 8 concludes the paper.

1. Data and methods

The level of school segregation for a particular area is measured using the total number of students and the fraction of Roma students in each school within the area. We use two sources that cover the population of Hungarian primary schools. Before 1992, all schools filled out a compulsory questionnaire that contained, among other things, the total number of students and the number of Roma students in the school. The latter was based on counts by classes, carried out by teachers. We have data from the years 1980, 1989 and 1992. The reporting on Roma students was discontinued after 1992.

The data on the fraction of Roma students are available from 2006 in the Hungarian National Assessment of Basic Competences (NABC). It is a standards-based assessment, with tests on reading and mathematical literacy in grades 6 and 8 in primary schools (grades 4 and 8 in 2006 and 2007). The NABC became standardized in 2006, and we use data from 2006 through 2011 for our analysis. Aside from testing the students, it collects additional data on students and schools. School-level data are provided by the school principals in May of each year, when the testing takes place. Among other things, these contain information on the number of students and the school principal's estimate of the fraction of Roma students in the school. These estimates are likely to contain significantly more noise than the figures from 1992 and before, but we have no reason to believe that they are biased (they were not used for targeting any policy measure and they were not published, either).

The information is collected from each school site, that is, from each unit of the school with a separate address. This level of data collection is important because in some towns, the schools as administrative units comprise units at multiple locations, sometimes far from each other. Throughout the entire study, we use the word "school" to denote the school site and "institution" for the level of administrative organization that can contain more than one school site.[1]

Our analysis contains data on the population of Hungarian schools that teach primary school students, in other words, students in grades 1 through 8.[2] Of these schools, the NABC covers all that had students in grade 4 or 8 in 2006 and 2007, and all schools that had students in grades 6 and 8 from 2008 onwards. Coverage by the NABC is limited because it misses the institutions that teach students with special educational needs (S.E.N. students) except in 2006. Another source of bias is that the

[1] With very few exceptions, institutions were single-address schools before the early 1990s, so the data from between 1980 and 1992 are at the school and the institutional level at the same time.

[2] Traditionally, secondary schools would start with grade 9. In the early 1990s, some secondary schools began to recruit students in the lower grades and have incoming classes in grade 7 or as early as grade 5. These secondary schools are concentrated in the largest cities, most of them in Budapest. See *Horn* [2012] for a more detailed discussion. Our data cover all students in grades 1 through 8 including those enrolled in secondary schools. For simplicity, we call these institutions primary schools as well.

information on the fraction of Roma students is missing in some schools that do participate in the assessment. In addition to the problem of S.E.N. students, therefore, nonresponse is an additional cause of missing data.

Missing data can bias the segregation indices. Suppose, for example, that the schools in which the principal fails to provide information have no Roma students at all. In that case, our measures overestimate exposure and therefore underestimate segregation because the missing schools have exposure levels below the average. In theory, it is also possible that the schools with missing data have an ethnic composition that is very close to the town-level average. In that case, our measure of segregation would be biased upwards. Similarly, missing data can bias the estimates of the size of the Roma student population. If the schools with no information all have zero Roma students, the true share of Roma students among all students is lower than the estimate. If, instead, all of the schools with missing information are all-Roma schools, the true fraction of Roma students is higher than the estimates. Note that the bias is different for the segregation measures (a measure of dispersion) and the overall share of Roma students (a mean).

Table 1

Number of institutions and schools in Hungary in the administrative and NABC data, 2006–2011

Year	Number of institutions		Number of school sites	
	all (from KIR-STAT)	in the NABC data	in the NABC data	in the NABC data with non-missing fraction of Roma students
2006	3334	3267	3966	3444
2007	3247	3048	3420	2883
2008	2693	2465	3130	2885
2009	2541	2371	3097	2858
2010	2481	2307	3060	2792
2011	2454	2278	2925	2763

Note. "Schools" are defined by their physical location (address); "institutions" can contain more than one school. We consider primary schools (and their institutions) to be the schools that teach students from grade 1 through grade 8. KIR-STAT (statistical data collection part of the central Hungarian educational information system) is the administrative register for all educational institutions in Hungary. NABC (the National Assessment of Basic Competences) is the national standard-based assessment, with tests on reading and mathematics for grades 6 and 8 (grades 4 and 8 in 2006 and 2007). Students with special educational needs do not participate in the assessment, except in 2006. The school-level data in NABC cover all schools with at least one student who took part in the assessment.

Table 1 shows the prevalence of missing data. The table shows the number of institutions from the administrative files (KIR-STAT), the number of institutions in the NABC data, the number of schools in the NABC data (recall that we define a school as a facility

with a separate mailing address; some institutions have more than one school), and the number of schools with valid data. Administrative sources (KIR-STAT) have information on the number of students at the institution level but not at the school level as we define it. KIR-STAT has no information on the ethnic composition of schools.

Table 1 shows that both of the missing schools in the NABC data (and thus the missing information on all students) and the missing information on the Roma students in the NABC data are potentially important. We address the first problem by linking the schools through time and imputing student numbers from KIR-STAT. We address the problem of the missing Roma data in three alternative ways. The benchmark imputation is our best estimate. We complement the benchmark with an imputation that leads to the lowest possible value for the segregation index and one that leads to the highest possible one. Similarly, we compute the lower and upper bound estimates for the fraction of Roma students.[3] In most of the analysis, we focus on the results using the benchmark imputation, but we show the results with the alternative missing data treatments as well when they are important.

2. Defining catchment areas

School choice results in the extensive commuting of students between their residence and school. In this setting, the natural geographic unit for studying school segregation is the smallest area that covers all of the schools available to the students living in the area. In other words, it is the smallest area that is closed in terms of potential commuting. School segregation measured within larger units is influenced by residential patterns that commuting cannot overcome; school segregation measured within smaller units misses schools that should be considered.

In this section, we define the effective catchment areas of primary schools. Our smallest geographic units of observation are the municipalities (villages, towns, and cities; there are over 3000 in Hungary). A catchment area can consist of a single municipality and a single school, more than one municipality and a single school, or

[3] The benchmark procedure uses the data from previous and subsequent years for the schools that do not experience large changes in total student numbers. Approximately 30 schools are still missing data in each year after this procedure. The imputation that results in the lowest possible value of the segregation index uses the area-level average fraction of Roma students for the missing data (all initially missing data, including those that were filled in with our best estimate in the benchmark procedure). The imputation that leads to the highest value of the index of segregation imputes zero or one for the missing fraction of Roma students in a way that leaves the overall fraction of Roma students unchanged, up to indivisibility issues (it assigns the value of one to the smaller schools and zero to the larger schools following the observed relationship in the non-missing data). The imputation that leads to the lowest (highest) fraction of Roma students is simply zero (100 percent).

multiple municipalities and/or multiple schools. Ideally, all students who live in a catchment area go to a school within the area, and nobody from outside the area goes to the schools within the area. The goal is to partition Hungary into a complete collection of disjoint areas. Ideally, they should not be too large. Areas that are too large would not only work against the purpose of the exercise (by making area-level analysis difficult) but would go against spirit of the definition (very few schools would be available for any particular student within the area).

We used individual data collected from the NABC data for the students' residence and the location of their schools for three years. We created a directed and weighted graph using the individual data on commuting connections. Municipalities are the nodes (vertices) and the numbers of students commuting between the nodes are the links (edges). The direction of the link is from the node of residence to the node of the school, and the weights are the number of commuters. The largest weights in this graph are on the links that connect the nodes to themselves (loops): these are the students whose school and residence is within the same municipality.

Catchment areas are a partition of the set of all municipalities: every municipality belongs to one and only one catchment area. In the language of graph theory, catchment areas are the connected components in the entire graph. Connected components are defined for undirected (symmetric) and unweighted graphs: graphs that indicate whether two nodes are connected or not without any further information. For this problem, the original graph can be transformed into an undirected and unweighted graph with the help of a threshold value: two nodes are connected if and only if the number of students commuting between them exceeds a threshold level in any direction. Given the undirected and unweighted graph, the breadth-first-search algorithm finds all of the connected components in the graph and thus creates a partition of the set of all municipalities.[4]

The data on students' residence come from administrative records of all sixth-graders from three years, 2008, 2009, and 2010. The overall number of observations is 304 125. Simple coding errors or administrative mistakes could create apparent links between two municipalities with no links. The probability of such events is never zero, but the same event is unlikely to happen twice. For this reason, we have chosen two for the threshold value used to transform the weighted into the unweighted graph: nodes are considered to be connected if the data imply that more than one student is commuting in any direction between them.[5]

[4] See, for example, http://en.wikipedia.org/wiki/Breadth-first_search for a detailed description of the algorithm.

[5] If a municipality has no school and it sends one student only in these three years to any other municipality, that link is preserved. Similarly, the links that were below the threshold value of one student were preserved if they represented over 20 percent of all students from the sending municipality. Municipalities without schools that are not connected to any other municipality in the data were linked to the nearest neighbouring municipality that has a school (using geographic coordinates).

It turns out, however, that this benchmark graph has one giant component and many tiny ones. The graph contains 99 components; out of these, 96 have 13 or fewer nodes (the distribution is, of course, very skewed). Of the remaining three components, one has 44 nodes, one has 229 nodes, and the largest has 2 669 nodes.[6] The giant component contains Budapest and most cities from all regions of Hungary. This partition is clearly useless for any practical analysis. Therefore, we created an alternative partition: we broke the largest three components into smaller clusters by increasing the threshold value for links to 5 students per year on average (a total of 15 students for the three years) or at least 20 percent of the originating node (the municipality of residence).[7] The resulting partition contains 1 055 catchment areas. The largest area contains 71 municipalities, and it covers the Budapest agglomeration. The other large areas contain large cities and their agglomerations.[8]

Table 2 shows the most important summary statistics on the catchment areas.[9] Not surprisingly, the size distribution is skewed, and the areas with the highest number of municipalities are even larger in terms of student population because they contain the largest cities.

Table 2

Number of municipalities, primary schools and students

Size of catchment area (number of municipalities)	Number of catchment areas	Average number of municipalities	Average number of primary schools	Average number of primary school students
1	624	1.0	1.2	232
2 to 4	297	2.7	2.1	408
5 to 9	74	6.3	7.1	1 885
10 to 19	37	12.9	9.4	2 192
20 to 49	20	30.5	25.4	6 102
50 to 71	3	60.0	224.9	65 045
Total	*1055*	3.0	3.3	782

Note. Information from schools is averaged over 2006 through 2011.

[6] The emergence of a giant component is a classic result in graph theory: if links are created randomly, almost all nodes are connected with a high probability when the number of links exceeds a threshold value.

[7] Similarly to the previous step, links were preserved even if they were below the threshold when a municipality has no school and it sends its students to one and only one other municipality. Municipalities without schools that are not connected to any other municipality in the data were linked to the nearest neighboring municipality that has a school (using geographic coordinates).

[8] The threshold values used in the new partition are obviously ad-hoc, but the results represent an intuitively compelling partition and any attempt to break the giant component would require assumptions of this kind.

[9] Additional data on the catchment areas, including the set of municipalities in them and further data on students, are available from the authors upon request.

3. Measuring school segregation

Following the literature (for example, *Clotfelter* [2004]), we measure segregation with the help of the following three indices: exposure of non-Roma students to Roma students (*ENR*), exposure of Roma students to non-Roma students (*ERN*), and the standardized version of these indices, referred to here as the segregation index (*S*). For completeness, we also look at the more traditional but theoretically less attractive index of dissimilarity (*D*). When we calculate the extent of exposure or segregation, we look at schools within a catchment area (or, alternatively, a micro-region, a town, or a city). To define and interpret these indices, we work with the following notation. Index i denotes the schools, and index j denotes the areas (these are the areas that contain the schools; students may reside outside the areas, see our discussion later). I_j is the number of schools in area j, N_{ij} is the number of students in school i in area j, N_j is the number of students in area j, R_{ij} is the number of Roma students in school i in area j, R_j is the number of Roma students in area j, r_{ij} is the fraction of the Roma students among all students in school i in area j, r_j is the fraction of the Roma students among all students in area j, $\left(1-r_{ij}\right)$ is the fraction of the non-Roma students among all students in school i in area j, $\left(1-r_j\right)$ is the fraction of the non-Roma students among all students in area j. Index ENR_j measures the exposure of an average (a randomly chosen) non-Roma student in area j to the possibility of meeting Roma students. ENR_j is equal to the fraction of Roma students in each school averaged over schools, where the average is taken with weights that are equal to the share of non-Roma students in the school in all non-Roma students in the area. Formally,

$$ENR_j = \sum_{i=1}^{I_j} r_{ij} \frac{N_{ij} - R_{ij}}{N_j - R_j}, \quad \text{so that} \quad 0 \le ENR_j \le r_j .$$

The minimum value of the exposure index is zero: in this case, no contact is possible between Roma and non-Roma students within the schools because the schools are either all-non-Roma (when $r_{ij} = 0$) or all-Roma (when $N_{ij} - R_{ij} = 0$). The maximum value of exposure is when the fraction of minority students in each school is equal to the fraction in the area: $r_{ij} = r_j$ for all i in j. For ENR_j to make sense, we need $0 < r_j < 1$, that is, there must be both Roma and non-Roma students in area j. This condition is satisfied in all of the areas that we consider.

The exposure of Roma students to non-Roma students (ERN_j) is analogous: it measures the exposure of an average (a randomly chosen) Roma student in area j to the possibility of meeting non-Roma students. ERN_j is equal to the fraction of non-Roma students in each school averaged over schools, where the average is taken with weights that are equal to the share of the school in the Roma student population of the area. Formally,

$$ERN_j = \sum_{i=1}^{I_j} \left(1 - r_{ij}\right) \frac{R_{ij}}{R_j}, \quad \text{so that} \quad 0 \le ERN_j \le 1 - r_j .$$

The minimum value of this exposure index is zero, also, and $ERN_j = 0$ exactly when $ENR_j = 0$. This value indicates that no contact is possible between Roma and non-Roma students within the schools because the schools are either all-Roma $\left(1 - r_{ij} = 0\right)$ or all-non-Roma $r_{ij} = 0$. The maximum value of Roma exposure occurs when the fraction of non-Roma students in each school is equal to the fraction in the area: $1 - r_{ij} = 1 - r_j$ for all *i* in *j*. The two indices are intimately related:

$$ERN_j = \frac{1 - r_j}{r_j} ENR_j .$$

Despite their intuitive content, the exposure indices are rarely used. Their values depend on the overall fraction of minority students in the area, which poses a severe constraint on their use in comparing segregation across time or areas. The segregation index is intended to solve this problem. It is a normalized version of the exposure indices, and thus it retains their information content, albeit in a less intuitive way. The normalization amounts to comparing exposure to its attainable maximum; there is also a reversal of sign so that the higher levels of the index indicate higher levels of segregation (less exposure). Intuitively, the segregation index shows the fraction of contact possibilities that are made impossible by segregation. Formally,

$$S_j = \frac{r_j - ENR_j}{r_j} = \frac{\left(1 - r_j\right) - ERN_j}{1 - r_j}, \quad \text{so that} \quad 0 \le S_j \le 1 .$$

The maximum value of the index is one: segregation is at its maximum when the exposure is zero. The minimum value is zero: it is attained at maximum exposure, which is when the fraction of Roma students is the same in every school.

An alternative measure of segregation is the index of dissimilarity. Defined from the viewpoint of Roma students, and with many schools in mind, this index can be interpreted as the percentage of non-Roma students that would have to move to different schools to have schools with the same fraction of Roma students within the area. Formally, the index of dissimilarity is defined as

$$D_j = \frac{1}{2}\sum_{i=1}^{I_j}\left|\frac{R_{ij}}{R_j} - \frac{N_{ij}-R_{ij}}{N_j - R_j}\right|, \quad \text{so that} \quad 0 \le D_j \le 1.$$

Similar to the index of segregation defined formerly, a value of 1 would denote complete segregation, and a value of 0 would denote equal distribution across schools. In any other case, the index of dissimilarity is, in general, not equal to the index of segregation. The index of dissimilarity is a more traditional measure than the index of segregation, but it lacks the latter's theoretical relationship to exposure. For that reason, the index of segregation is a more useful measure that is used in the new literature on school segregation (*Clotfelter* [1999]).

4. Trends in school segregation in Hungary between 1980 and 2011

We measure the ethnic composition of primary schools and segregation between schools in years 1980, 1989, 1992 and yearly between 2006 and 2011. Recall that the data in 1980, 1989 and 1992 are high quality, that there are no data from between 1992 and 2006, and that the data starting with 2006 are of lower quality, characterized by many schools without information on the fraction of Roma students. For that reason, from 2006 onwards, we show the conservative lower and upper bound estimates of both the overall share of Roma students and the index of segregation in addition to our best estimates. We define segregation within three geographic areas: catchment areas, micro-regions, and municipalities. Naturally, between-school segregation is defined for the areas with two schools or more. We restricted the analysis to areas that had two schools or more in each year of observation. This criterion was fulfilled by 175 out of the 1 055 catchment areas and 140 towns or cities of the over 3 000 municipalities.

Table 3 shows the averages of the segregation indices in 1980 and 2011 in the three geographic areas. The averages shown in the table are weighted by the distribution of students.

Table 3

Ethnic composition and ethnic segregation of primary schools in catchment areas as well as in micro-regions and larger municipalities (towns and cities) in 1980 and 2011

Average values	Larger catchment areas		Micro-regions		Towns and cities	
	1980	2011	1980	2011	1980	2011
Average number of students	5 153	3 324	6 668	4 235	4 723	3 139
Fraction of Roma students	0.05	0.11	0.06	0.13	0.03	0.08
Exposure of non-Roma students to Roma students	0.04	0.08	0.05	0.10	0.03	0.07
Exposure of Roma students to non-Roma students	0.86	0.69	0.85	0.68	0.90	0.75
Index of segregation	0.09	0.22	0.09	0.22	0.07	0.19
Index of dissimilarity	0.48	0.53	0.47	0.53	0.47	0.51
Number of observations	175	175	174	174	140	140

Note. Average values (using the benchmark imputations from 2006 onwards) weighted by the number of students (except for the average number of students, which is unweighted).

The first row of Table 3 shows the number of students. The most important information here is the uniform decline in the number of students by about 35 percent. The second row presents the fraction of Roma students. The figures show a strong increase: the fraction of Roma students in Hungarian primary schools more than doubled between 1980 and 2011. A small part of their growing share is due to the greater participation of Roma students in primary school education, but a large part is due to demographics.

The catchment areas shown in this table refer to areas that had two or more schools during the 1980 to 2011 period and thus do not cover the smallest catchment areas, which have only one school. In the part of Hungary that is covered by these two-or-more-school catchment areas, the share of Roma students was 5 percent in 1980 and increased to 11 percent by 2011. The micro-regions cover the entire country, and thus the figures in the corresponding columns refer to the overall fraction of Roma students in Hungary. From a 6 percent level in 1980, the share of Roma students in primary schools (grades 1 through 8) increased to 13 percent by 2011. The corresponding figures in the larger municipalities (towns and cities with two or more schools) are 3 percent in 1980 and 8 percent in 2011. The lower levels in the larger catchment areas and the even lower levels in the larger municipalities show that the Roma population is overrepresented in the smaller villages and that the degree of overrepresentation did not decrease over time.

The exposure of non-Roma students to Roma students increased, but at a slower pace than the growth in the share of Roma students, the theoretical maximum of the exposure index. Mirroring this trend, the exposure of Roma students to non-Roma students declined significantly, more than the decreasing share of non-Roma students would imply. Taken together, the trends in the indices indicate a growing trend in the segregation index.

Between-school segregation increased substantially in Hungary between 1980 and 2011. Taking the average of the catchment areas, the relevant geographic units in the system of free school choice in Hungary, the index of segregation raised from 9 percent to 22 percent. The intuitive content of these figures is that the chance of contact between Roma students with non-Roma schoolmates decreased from 91 percent of its theoretical maximum in 1980 to 78 percent of the maximum level by 2011.

Table 4

Ethnic composition and ethnic segregation of the primary schools in the catchment areas around the largest Hungarian cities in 1989 and 2011

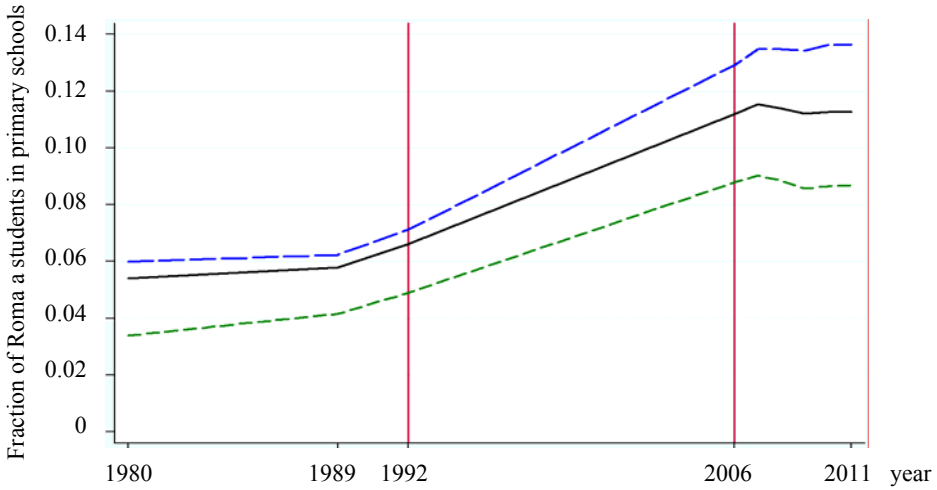
Year	Indicator			
	Number of students	Fraction of Roma students	Index of segregation	Number of municipalities
		Budapest		
1980	237 896	0.02	0.06	71
2011	165 931	0.07	0.26	
		Miskolc		
1980	35 255	0.09	0.13	33
2011	20 818	0.20	0.36	
		Debrecen		
1980	28 280	0.02	0.09	7
2011	20 361	0.04	0.26	
		Pécs		
1980	24 020	0.04	0.13	55
2011	15 489	0.08	0.16	
		Szeged		
1980	20 178	0.02	0.16	12
2011	14 311	0.03	0.05	
		Gyõr		
1980	19 736	0.02	0.06	37
2011	13 316	0.04	0.13	

Table 4 shows the number of students, the share of Roma students and the index of segregation for the catchment areas around the six largest Hungarian cities in 1980 and 2011. Similar to the national trends, these areas experienced a large drop of 30 to 40 percent in the number of students. Again, similar to the national trends, the share of Roma students got higher substantially in each area. The levels differ considerably, but the trends are rather similar except for the catchment area of Budapest where the increase was more than three-fold, from 2 percent to 7 percent. The highest share, both in 1980 and in 2011, was in the catchment area of the northern city Miskolc, while the lowest one was in the catchment area of the southern city Szeged.

Ethnic segregation strengthened considerably in most but not all of the catchment areas. The index of segregation grew almost threefold in the areas of Budapest, Miskolc and Debrecen. Segregation increased by a smaller amount in the Pécs and Győr areas, and it decreased substantially in the Szeged area.

The level of segregation in 1980 could be considered to be low; the level in 2011 is moderate. The US metropolitan areas that are characterized by the school segregation of African Americans and whites similar to the levels documented for large Hungarian areas include San Diego (0.28), Phoenix (0.31) or Los Angeles (0.33). These are not among the most segregated US cities: the segregation index is 0.45 in New York City, 0.57 in Chicago; while the most segregated metropolitan area is that of Detroit (0.71, see *Clotfelter* [1999] p. 494.).

Figure 1. Time series of the fraction of Roma students in primary schools in larger catchment areas, micro-regions and larger municipalities (towns and cities) from 1980 to 2011

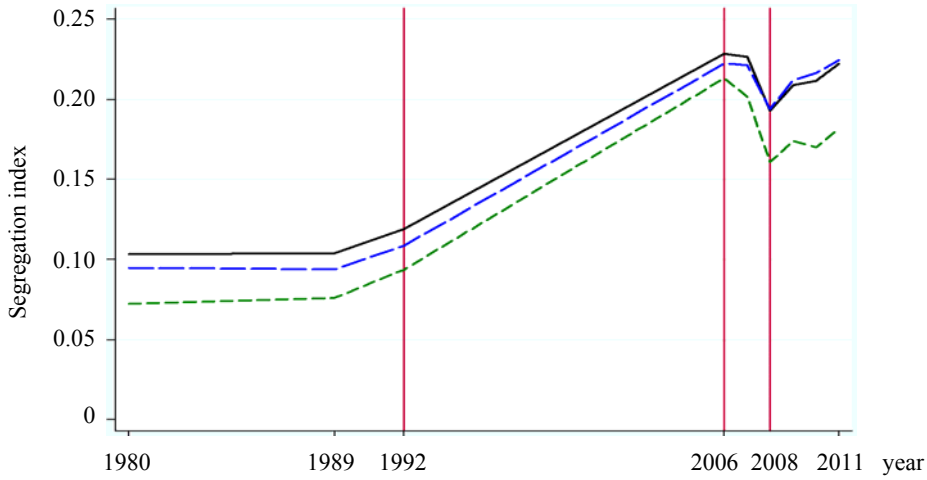


Note. The fraction of Roma students after 2006 is based using our benchmark imputations for missing data. The solid line indicates larger catchment areas, while the long dashed line is for micro-regions and the dashed line is for larger municipalities (towns and cities).

Figure 1 shows the times series of the fraction of Roma students as estimated using the benchmark imputation procedure. Figure A1 in Appendix shows the same time series together with the conservative lower and upper bounds. Recall that the bounds represent the most conservative imputations for the missing data. While we cannot rule out any figure within the bounds, our benchmark estimates use available information in a careful way and are thus likely to be close to the true figures. The post-2006 data are also noisier, although that noise is unlikely to have a significant effect on the aggregate figures. According to the benchmark results, the increase in the fraction of Roma students was concentrated in the 1989 to 2007 period, and it stopped afterwards. When one looks at the intervals between the lower and upper bounds in Figure A1, the apparent trend break is lost in the overall degree of uncertainty.

Figure 2 shows the time series for the index of segregation, and Figure A2 presents the uncertainty interval for our calculations using the lower and upper bound imputations for the missing data in 2006–2011. The figures show the time series of the index of segregation from 1980 to 2011 averaged over the geographic areas (catchment areas, micro-regions, and larger municipalities).

Figure 2. Time series of the average of the index of ethnic segregation between primary schools in larger catchment areas, micro-regions and larger municipalities (towns and cities) from 1980 to 2011



Note. The index after 2006 is based using our benchmark imputations for the missing data. The average of the index is weighted by the number of students. The solid line indicates larger catchment areas, while the long dashed line is for micro-regions and the dashed line is for larger municipalities (towns and cities).

According to Figure 2, between-school segregation by ethnic lines stayed constant between 1980 and 1989 but began to increase afterwards. By 2006, it reached a value that is more than double the 1989 level. This growth is large and is also robust

to the imputation method that we chose for the missing data. Our best estimate for the index shows a significant decline in between-school segregation in the 2006–2008 period that appears to be driven by the larger municipalities. The slope of the decreasing trend is comparable to that of the previous increase, resulting in a small drop because of the short time interval.

The trend breaks in the time series coincide with trends in the desegregation initiatives of the government of Hungary. A law introduced in 2004 banned segregation based on race, ethnicity and social background and divided the burden of proof between the plaintiffs and the defendants. In the following years, advocacies and offices of the central government pressured some of the towns and cities to close down segregated schools. By anecdotal evidence, these central government activities came to a halt after 2008. The link between desegregation in larger municipalities and the observed patterns of segregation is further supported by the fact that the trend breaks are largest for the largest municipalities, from 0.21 to 0.16. The drop was smaller, from 0.23 to 0.19 in the catchment areas that included not only the towns and cities but also some of the surrounding villages. This finding is consistent with the larger municipalities implementing desegregation within their administrative boundaries without the other parts of their catchment area following suit. Furthermore, some of the largest drops between 2006 and 2008 are observed in the cities that carried out changes in the composition of their schools as a result of desegregation plans (including, for example, Szeged, shown in Table 4). This evidence suggests that the observed trend breaks could be real.

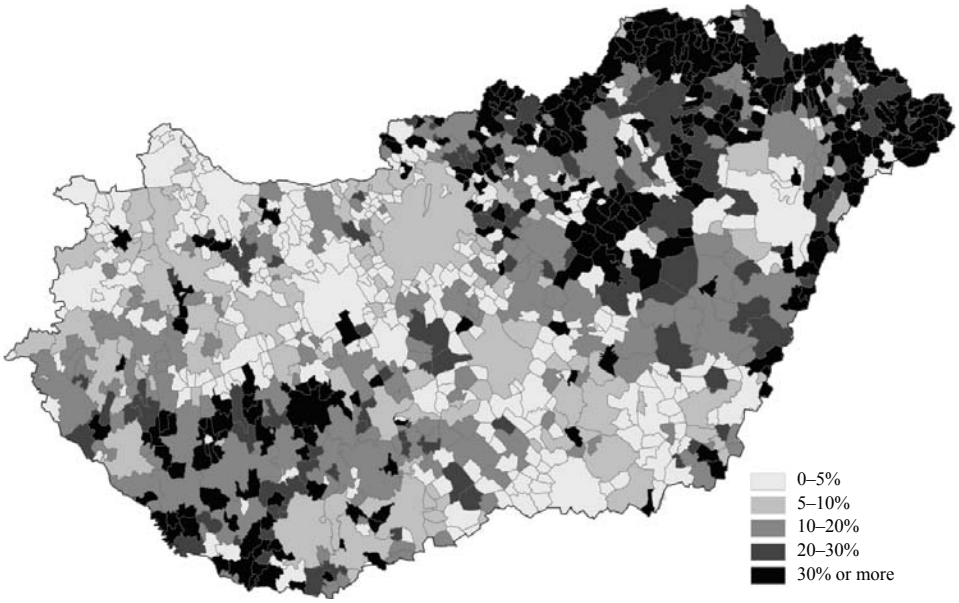
However, they also coincide with the apparent breaks in the time series of the share of Roma students, which is harder to understand. This trend implies that the estimated breaks in the segregation indices could be spurious. Indeed, while the large increase between 1992 and 2006 is robust to the imputation method used after 2006, the trend breaks after 2006 are not robust at all. Similar to the Roma share series, the benchmark estimates are surrounded by a very wide interval of possible values between the conservative lower and upper bounds, shown in Figure A2. As a result, the coincidence of the trend breaks with the desegregation activities could be completely spurious. Evidently, the missing information in the NABC data simply prevents us from identifying trends after 2006.

5. The geographic distribution of school segregation

The Roma population is distributed unevenly in Hungary. Using all data available up to 1993, *Kertesi–Kézdi* [1998] presented detailed maps on the geographic distri-

bution of the Roma population in Hungary. Using school-level information in a system characterized by school choice and the widespread commuting of students, we can present analogous maps at the level of the catchment areas for the 2000s. Figure 3 shows a map of Hungary divided into catchment areas (1 055 clusters of villages, towns and cities) with the fraction of Roma students for all areas in 2011.

Figure 3. The share of Roma students in primary schools in all catchment areas of Hungary in 2011



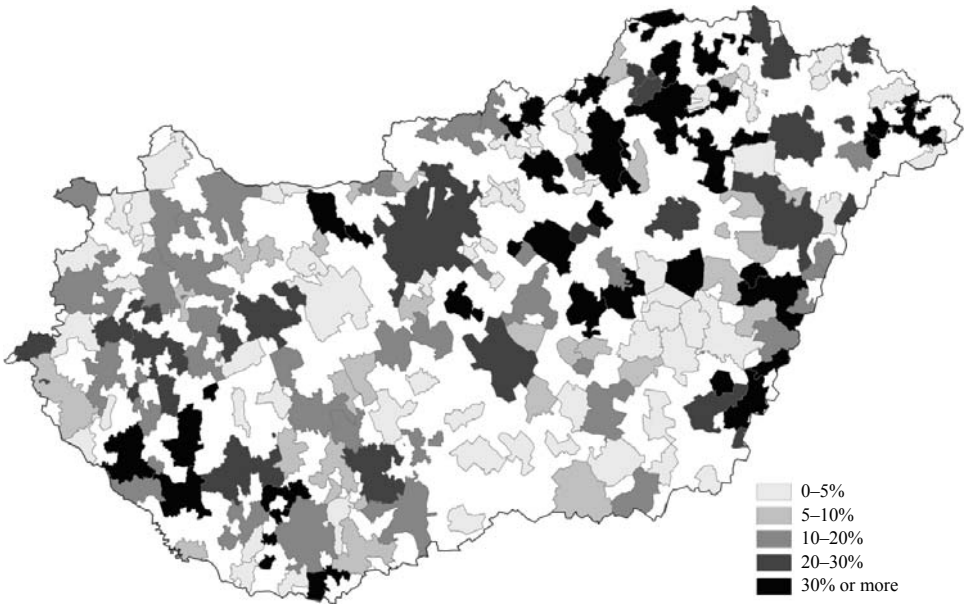
Note. Catchment areas are clusters of villages, towns and cities that are close in terms of student commuting. We defined these areas using the observed commuting patterns. The calculations are based on our benchmark imputations for the missing data.

As we presented formerly, between-school segregation is defined for the larger catchment areas. Figure 4 shows the map of the 175 largest catchment areas and presents the index of segregation in these areas.

Comparing the two maps suggests two patterns. The geographic distribution of school segregation is quite alike to the geographic distribution of the Roma students. This similarity indicates a positive and potentially quite strong relationship between the share of Roma students in the area and the level of ethnic segregation as regards primary schools. However, this correspondence is far from being perfect. The areas around Budapest, Pécs and Győr, for example, are characterized by relatively strong segregation but a low fraction of Roma students. This finding suggests that other mechanisms can also be important and that the size of the area

is likely to be related to these mechanisms. In the following section, we present regression results that show some more systematic evidence for these types of associations.

Figure 4. Ethnic segregation between primary schools in the larger catchment areas of Hungary in 2011



Note. Catchment areas are clusters of villages, towns and cities that are close in terms of student commuting. We defined these areas using the observed commuting patterns. The calculations are based on our benchmark imputations for the missing data.

6. School segregation and the size of the educational market, schools and the Roma population

In our final analysis, we show regression results with the index of segregation being the left hand-side variable and the size of the area (number of schools), the average size of the schools and the size of the Roma minority (fraction of Roma students) on the right hand-side. We first present the results from the cross-sectional regressions for 1980 and 2011. They show cross-sectional associations: whether, in a given point in time, the areas that are larger, have bigger schools or have a greater fraction

of Roma students in the schools are characterized by higher or lower levels of school segregation.[10, 11]

The results are shown in Table 5, and the summary statistics are in Table A1. The number of schools in the area was positively associated with school segregation in 2011, while the association was substantially weaker in 1980. The change is also statistically significant. In 2011, the standard deviation of the log number of schools was between 0.8 and 1.0 depending on the geographic area definition (see Table A1); the areas that are larger by one standard deviation were characterized by a one-tenth of a standard deviation higher index of segregation on average, holding ethnic composition and average school size constant. The average size of the schools is negatively, albeit weakly, correlated with the segregation between schools, with no clear pattern across years or definitions of the geographic area.

Table 5

School segregation and the sizes of the educational market, schools and the Roma population

Dependent variable – index of segregation	Larger catchment areas		Micro-regions		Larger municipalities	
	1980	2011	1980	2011	1980	2011
Log number of schools	0.022 [2.45]*	0.055 [4.98]**	0.020 [1.81]	0.066 [7.10]**	0.021 [2.06]*	0.062 [8.84]**
Log average school size	–0.024 [1.51]	–0.022 [0.58]	–0.032 [2.19]*	–0.067 [2.17]*	–0.056 [2.09]*	–0.036 [0.84]
Fraction of Roma students	0.439 [4.27]**	0.661 [6.86]**	0.247 [3.00]**	0.563 [8.40]**	0.624 [2.53]*	0.747 [6.06]**
Constant	0.142 [1.41]	0.076 [0.36]	0.200 [2.23]*	0.288 [1.80]	0.343 [2.02]*	0.121 [0.49]
Number of observations	175	175	174	174	140	140
R-squared	0.12	0.30	0.10	0.35	0.11	0.42

Note. Cross-sectional regressions for selected years. Robust *t*-statistics in brackets. * significant at the 5 percent level; ** significant at the 1 percent level. Observations are weighted by the square root of the number of students in the area.

[10] Apart from the missing information from some schools after 2006, our data represent the population of schools. We sew standard errors nevertheless, because we interpret our regressions as models that try to uncover more general tendencies in educational markets, characterized by the properties of the Hungarian educational markets in the observed years.

[11] Note that the Budapest agglomeration is an outlier in terms of size, and it experienced larger than average increase in both the share of Roma students and the index of segregation. Nevertheless, the estimated coefficients are very similar when we exclude Budapest.

The fraction of Roma students in the area is the strongest predictor of school segregation, with increasing magnitude over time and across geographic units (being the strongest predictor within towns and cities). Towns and cities that had a one percentage point greater fraction of Roma students in their schools were characterized by a 0.75 percentage point higher index of segregation. In terms of standardized coefficients, the towns and cities with a fraction of Roma students that is greater by one standard deviation (0.1) were characterized by a half of a standard deviation (0.14) higher index of segregation on average, holding the number of schools and the average school size constant.[12]

Table A2 shows the regression results for all years for the larger catchment areas. They suggest that the large increase in the coefficients took place between 1992 and 2006, and the years after 2006 are characterized by further increases, with ups and downs without any clear pattern.

Table 6

Changes in school segregation and in the sizes of the educational market, schools and the Roma population from 1980 to 2011

Dependent variable – change in index of segregation	Larger catchment areas	Micro-regions	Larger municipalities
Log change in number of schools	0.170 [3.23]**	0.116 [2.43]*	0.018 [0.42]
Log change in average school size	0.068 [1.30]	–0.01 [0.19]	–0.059 [1.08]
Change in fraction of Roma students	0.605 [4.31]**	0.792 [7.39]**	0.839 [3.84]**
Constant	0.098 [3.01]**	0.057 [2.05]*	–0.016 [0.56]
Number of observations	175	174	140
R-squared	0.17	0.23	0.14

Note. Regression results. Robust t-statistics in brackets. * significant at the 5 percent level; ** significant at the 1 percent level. Observations are weighted by the square root of the number of students in the area.

After the cross-sectional regressions, we turn to the regressions estimated in long differences: changes between 1980 and 2011. Table 6 shows the results, and Table

[12] These results are similar to the regression results of *Clotfelter* ([1999] p. 501.). In particular, the magnitudes of all three partial correlations are similar to our estimates. His regression has the log number of students as opposed to that of schools and the log average size of the school districts as opposed to that of the schools. Of course, his measure of segregation is between African American and white students. Our results are very similar if we include the log number of students instead of the log number of schools.

A3 has the appropriate summary statistics. Table A4 and A5 show the corresponding results separately for the communist period (1980 to 1989) and the post-communist period (1989 to 2011).

The results from these regressions show the extent to which the areas that experienced larger-than-average increases in the number of schools, school size or the fraction of Roma students tend to be characterized by larger-than-average growth in school segregation. When interpreting the results, one must keep in mind that, typically, school segregation strengthened, the number of schools decreased (except in the larger municipalities), the average school size became smaller (especially in the larger municipalities) and the fraction of Roma students grew during the observed period. These trends were the most pronounced during the post-communist period (1989 to 2011). On average, there were no significant shifts before 1989, but the variation in changes was substantial even then, so that interesting associations can be identified.

The results are qualitatively similar to the cross-sectional associations measured in 2011. Growth (drop) in the number of schools by 10 percent is associated with an increase (decline) in the index of school segregation by one to two percentage points in the larger catchment areas and the micro-regions. These magnitudes are actually stronger than the cross-sectional estimates in 2011: a one standard deviation (0.35 to 0.42) higher rise in the log number of schools is associated with an approximately one third of a standard deviation (0.14 to 0.16) increase in segregation. No association is present within the larger municipalities. The changes in the average school size are not associated with changes in segregation, holding the number of schools and the ethnic composition constant. Similar to the cross-sectional results, the change in the fraction of Roma students is the strongest predictor of changes in school segregation. The magnitudes are similar to the cross-sectional associations (a one standard deviation growth in the fraction of Roma students is associated with a half of a standard deviation increase in segregation).

7. Conclusions

In this paper, we documented the degree of between-school segregation of Roma versus non-Roma students between 1980 and 2011. We showed the long-run trends and geographic distributions as well as the regression estimates of some robust associations.

An important contribution of our paper was the definition of school catchment areas: clusters of villages, towns, and cities that are closed in terms of student commuting in the 2000s. This geographic aggregation allows school segregation to be ana-

lyzed at the level of the smallest and most relevant geographic area. The use of the catchment areas also allows school-level information to be used to estimate figures for the people living in those areas, such as the share of the Roma minority.

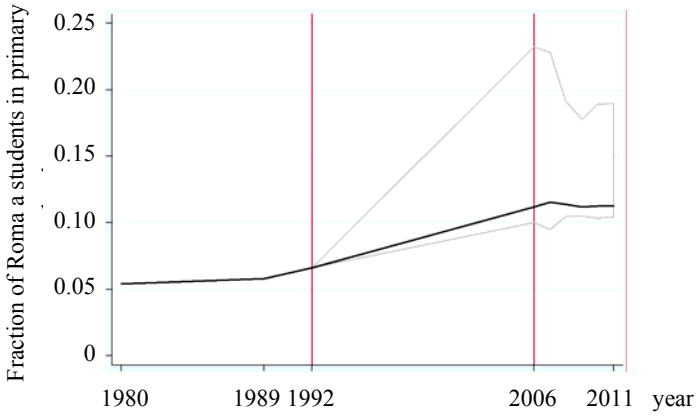
From a theoretical point of view, our most interesting results are the regression estimates. They show that the size of the educational markets (defined as the number of schools) is strongly and positively associated with between-school segregation. This association is consistent with the notion that school choice and selective commuting are among the most important mechanisms behind segregation, and the size of the market increases differentiation between schools, therefore providing a higher incentive to commute. This explanation is, however, not the only possible one. The fraction of Roma students in the area is an even stronger predictor of segregation. Explaining this association could be even harder. However, both associations are robust in the sense that they are identified from the cross-section as well as from the long differences, and analogous results for both are found in the US as well.

From a policy perspective, another interesting finding is the coincidence of an apparent trend break in segregation between 2006 and 2008, correspondent to the timing of the most intensive desegregation campaigns. Unfortunately, the quality of the data does not allow for a robust analysis here. Improving the data quality by implementing the full coverage of schools is necessary for fine analysis of the effects of desegregation policies and other aspects of school segregation in Hungary.

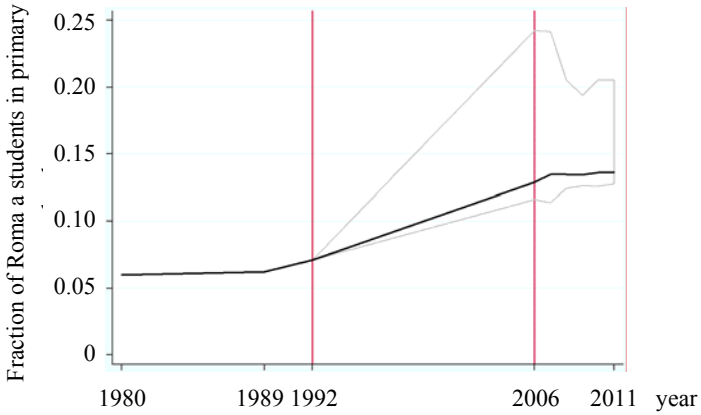
Appendix

Figure A1. Time series of the fraction of Roma students primary schools in larger catchment areas (panel A), micro-regions (panel B) and larger municipalities (towns and cities; panel C) between 1980 and 2011

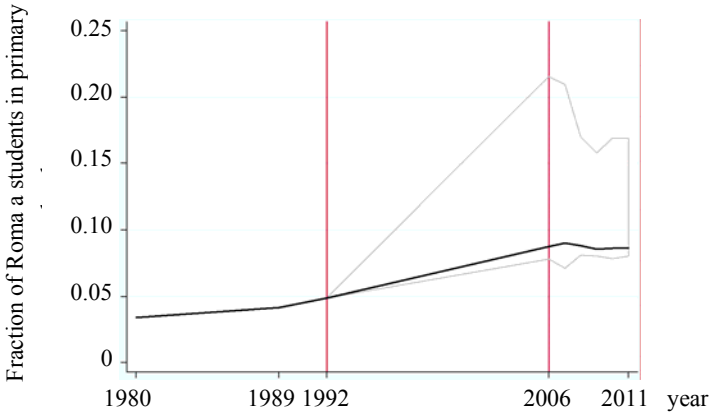
Panel A. Larger catchment areas



Panel B. Micro-regions



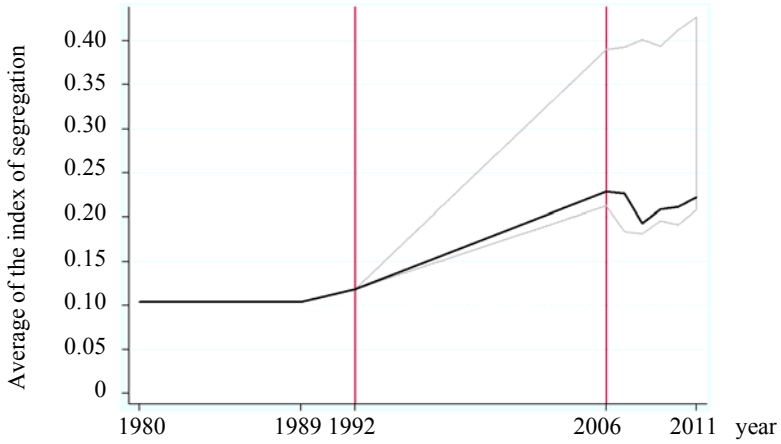
Panel C. Larger municipalities (towns and cities)



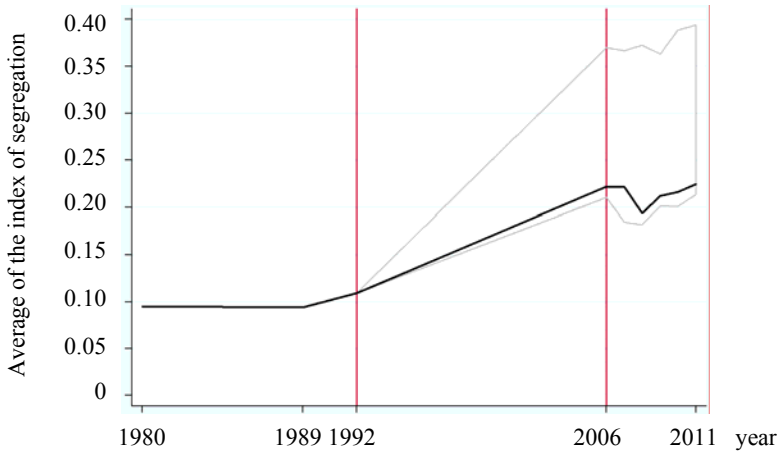
Note. The lines are based on our benchmark imputations for missing data after 2006. Grey area shows conservative lower and upper bounds using alternative imputations.

Figure A2. Time series of the average of the index of ethnic segregation between primary schools in micro-regions (panel A), catchment areas (panel B) and larger municipalities (towns and cities; panel C) between 1980 and 2011

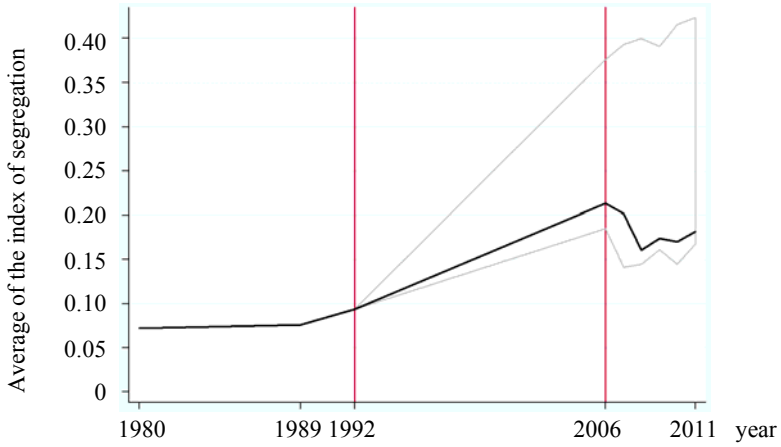
Panel A. Micro-regions



Panel B. Catchment areas



Panel C. Larger municipalities (towns and cities)



Note. The lines are based on our benchmark imputations for missing data after 2006. Grey area shows conservative lower and upper bounds using alternative imputations. Average of the index is weighted by number of students.

Table A1

Summary statistics for school segregation and for the sizes of the educational market, schools and the Roma population (corresponding to the regressions in Table 5 of the article)

Summary statistics	Larger catchment areas		Micro-regions		Larger municipalities	
	1980	2011	1980	2011	1980	2011
Mean (index of segregation)	0.08	0.17	0.10	0.20	0.06	0.12
Log number of schools	2.05	1.83	8.43	7.93	7.81	7.41
Log average school size	5.71	5.41	5.60	5.33	6.15	5.60
Fraction of Roma students	0.08	0.18	0.08	0.17	0.06	0.12
Standard deviation (index of segregation)	0.09	0.17	0.08	0.14	0.11	0.14
Log number of schools	0.91	0.93	0.72	0.80	0.90	0.89
Log average school size	0.44	0.31	0.41	0.27	0.39	0.28
Fraction of Roma students	0.06	0.14	0.06	0.14	0.05	0.10
Number of observations	175	175	174	174	140	140

Table A2

School segregation and the sizes of the educational market, schools and the Roma population

Dependent variable – index of segregation	Larger catchment areas								
	1980	1989	1992	2006	2007	2008	2009	2010	2011
Log number of schools	0.022	0.022	0.025	0.039	0.041	0.038	0.038	0.042	0.055
	[2.45]*	[3.00]**	[3.47]**	[3.38]**	[3.37]**	[4.05]**	[4.30]**	[3.89]**	[4.98]**
Log average school size	–0.024	–0.010	–0.006	0.073	0.065	0.051	0.050	0.027	–0.022
	[1.51]	[0.75]	[0.39]	[2.87]**	[2.46]*	[1.66]	[0.99]	[0.57]	[0.58]
Fraction of Roma students	0.439	0.464	0.511	0.555	0.620	0.635	0.595	0.617	0.661
	[4.27]**	[4.54]**	[5.36]**	[6.12]**	[6.45]**	[6.15]**	[5.52]**	[5.66]**	[6.86]**
Constant	0.142	0.055	0.019	–0.379	–0.354	–0.296	–0.274	–0.156	0.076
	[1.41]	[0.62]	[0.22]	[2.95]**	[2.53]*	[1.75]	[1.01]	[0.60]	[0.36]
Number of observations	175	175	175	175	175	175	175	175	175
R-squared	0.12	0.19	0.22	0.24	0.26	0.27	0.20	0.23	0.30

Note. Cross-sectional regressions for all years for the larger catchment areas. Robust t-statistics in brackets. * significant at 5 percent, ** significant at 1 percent. Observations are weighted by the square root of the number of students in the area.

Table A3

Summary statistics of the changes in school segregation and in the sizes of the educational market, schools and the Roma population from 1980 to 2011
(corresponding to the regressions in Table 6 of the article)

Summary statistics	Larger catchment areas	Micro-regions	Larger municipalities
		Mean	
Log change in index of segregation	0.09	0.10	0.06
Log change in number of schools	–0.22	–0.23	0.15
Log change in average school size	–0.30	–0.27	–0.55
Change in fraction of Roma students	0.10	0.09	0.06
		Standard deviation	
Log change in index of segregation	0.16	0.14	0.16
Log change in number of schools	0.42	0.35	0.35
Log change in average school size	0.41	0.30	0.39
Change in fraction of Roma students	0.10	0.09	0.07
Number of observations	175	174	140

Table A4

Changes in school segregation and in the sizes of the educational market, schools and the Roma population from 1980 to 1989 and from 1989 to 2011

Dependent variable – change in index of segregation	From 1980 to 1989			From 1989 to 2011		
	Larger catchment areas	Micro-regions	Larger municipalities	Larger catchment areas	Micro-regions	Larger municipalities
Log change in number of schools	0.085	0.002	0.112	0.171	0.095	–0.013
	[2.30]*	[0.05]	[1.24]	[2.84]**	[2.28]*	[0.26]
Log change in average school size	–0.001	–0.068	–0.022	0.061	–0.028	–0.072
	[0.02]	[1.86]	[0.26]	[1.04]	[0.56]	[1.30]
Change in fraction of Roma students	0.612	1.194	1.708	0.564	0.69	0.759
	[1.29]	[2.16]*	[1.73]	[4.24]**	[7.22]**	[4.27]**
Constant	–0.009	–0.007	–0.019	0.109	0.06	–0.005
	[1.42]	[1.05]	[1.33]	[3.32]**	[2.51]*	[0.17]
Number of observations	175	174	140	175	174	140
R-squared	0.06	0.08	0.13	0.19	0.25	0.19

Note. Regression results. Robust *t*-statistics in brackets. * significant at 5 percent; ** significant at 1 percent. Observations are weighted by the square root of the number of students in the area.

Table A5

Summary statistics of the changes in school segregation and in the sizes of the educational market, schools and the Roma population from 1980 to 1989 and from 1989 to 2011

Summary statistics	From 1980 to 1989			From 1989 to 2011		
	Larger catchment areas	Micro-regions	Larger municipalities	Larger catchment areas	Micro-regions	Larger municipalities
	Mean					
Log change in index of segregation	–0.01	–0.01	–0.01	0.10	0.11	0.07
Log change in number of schools	–0.03	–0.06	0.03	–0.19	–0.17	0.12
Log change in average school size	0.02	0.04	0.04	–0.32	–0.31	–0.59
Change in fraction of Roma students	0.00	0.00	0.00	0.10	0.09	0.06
	Standard deviation					
Log change in index of segregation	0.07	0.07	0.10	0.15	0.11	0.12
Log change in number of schools	0.19	0.15	0.22	0.38	0.30	0.32
Log change in average school size	0.18	0.14	0.23	0.41	0.28	0.34
Change in fraction of Roma students	0.02	0.01	0.03	0.09	0.09	0.07
Number of observations	175	174	140	175	174	140

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