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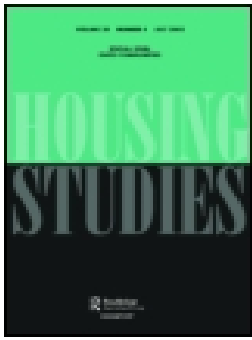
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Understanding the effects of school catchment areas and households with children in ethnic residential segregation

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ABSTRACT

Households with children have been suggested to play a key role in ethnic residential segregation. One possible mechanism is that school district boundaries affect their segregation patterns, but direct evidence on this is scarce. This study investigates the role of school catchment areas for ethnic residential segregation among different types of households in the city of Helsinki, Finland, using individual-level register-based data covering the complete population of the city between 2005 and 2014. The analyses consist of three steps: a description of ethnic segregation among different types of households with segregation indices, an analysis of mobility flows between school catchment areas, and a boundary discontinuity analysis of the causal effects of the boundaries of catchment areas on the mobility of different types of Finnish-origin households. The analyses show that ethnic segregation is stronger among households with children than among childless households and the residential mobility of higher-income Finnish-origin households with children is particularly affected by the school catchment area boundaries.

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Introduction

Ethnic residential segregation is commonly measured among the total population or among the adult population. However, recent studies in the USA have shown that it is more pronounced among children (Owens, 2017) and households with children (Iceland *et al.*, 2010) than among the general population. Similarly, Sabater & Catney (2019) found ethnic segregation in England and Wales to be more pronounced among children and among middle-aged and older persons. These findings suggest

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that families with children are a particularly important group regarding explanations of ethnic segregation.

One explanation for these findings may be that the residential choices of families with children are structured by school district or catchment area boundaries, as especially more affluent families are known to optimize the social and educational environment for their children (Ball, 2003; Benson *et al.*, 2015; Oria *et al.*, 2007; Wilson & Bridge, 2019). As a result, these families move to the school districts with the most prestigious schools, driving up property prices, which reinforces patterns of residential segregation by income and ethnicity. Recent studies have suggested that school district boundaries indeed affect residential segregation by both income and ethnicity in the USA (Owens, 2016, 2017). Such findings may not be limited to the US context, and European and other international research suggests schools to be a strong factor in the residential decision-making process for urban families (see e.g. Bernelius & Vaattovaara, 2016; Boterman, 2013; Butler & Hamnett, 2007; Oberti, 2007; Rowe & Lubieniski, 2017; Wilson & Bridge, 2019). However, none of these previous studies have applied strict causal designs.

Especially middle-class families have been demonstrated to be sensitive to perceived socio-economic and ethnic segregation in schools and neighbourhoods, leading to school choices on the basis of student composition rather than academic qualities of the schools (Butler & Hamnett, 2007; Harjunen *et al.*, 2018; Rowe & Lubieniski, 2017). If families with children have strong preferences regarding the neighbourhoods they want to live in, this should be visible in their residential mobility patterns. European studies have indicated that the intra-urban mobility of the native-origin population is *generally* an important demographic process increasing ethnic segregation (Bråmås, 2008; Kauppinen & van Ham, 2019; Musterd & de Vos, 2007), but there is not much evidence by type of household. However, a recent Norwegian study found the residential mobility of parents and upcoming parents to be particularly sensitive to concentrations of ethnic minorities (Wessel *et al.*, 2018).

This study contributes to the literature by assessing differences in segregation and residential mobility by the type of household in Helsinki, comparing especially households with children to childless households. It also contributes by explicitly investigating the causal role of school catchment areas in understanding ethnic segregation among different types of households. The Finnish city of Helsinki is a particularly relevant location for studying the relationships between school catchment areas, segregation and residential mobility, as the school intake is mostly based on the catchment areas of individual schools and the academic quality of schools is stable throughout the city. In this context, school choice can be exercised by residential moves and the choices can be expected to be related to socio-cultural considerations of the school context rather than the institutional qualities of schools.

In line with findings from other countries, ethnic segregation has been found to be stronger among children than among the working-age population in Helsinki (Saikkonen *et al.*, 2018). School catchment area boundaries have also been found to affect housing prices (Harjunen *et al.*, 2018), and the most disadvantaged catchment areas experience avoidance or loss of native Finnish families (Bernelius & Vilkkama, 2019).

Based on the literature we have formulated the following four research questions: (1) How does the residential segregation between Finnish-origin and immigrant-origin households in Helsinki differ by the household type?; (2) Are there differences in levels of ethnic segregation by household type after controlling for income?; (3) Are the migration flows of the Finnish-origin households with children below school-starting age particularly strongly directed towards school catchment areas with lower shares of immigrants?; and (4) Are the moves of Finnish-origin households with children affected by the catchment areas of elementary schools? We use individual-level longitudinal register-based data, covering the complete population of the city of Helsinki between 2005 and 2014. Central to our analytical approach, and our main contribution to research, is to isolate causal effects by conducting a boundary discontinuity analysis, taking advantage of detailed information on residential locations of the households.

Ethnic residential segregation and the role of schools

Residential segregation by type of household

Findings on segregation levels that are based on measuring segregation between individuals may be confounded by different segregation patterns among different types of households, such as among households with children as compared to segregation among single-adult households. Larger households also have more impact on the results, as they contribute more people to the analysis. One way to approach this is to analyze segregation between individuals by age. Owens (2017) argues that in the US context, only few studies have examined racial segregation separately among children and adults. This situation is not limited to the US context, and also Sabater & Catney (2019) see age as an overlooked aspect in most studies of residential segregation. Studies analyzing segregation by age have found pronounced ethnic segregation among children (Owens, 2017) or among children and middle-aged and older persons (Sabater & Catney, 2019). According to Sabater & Catney (2019), in England and Wales young adults in their 20s are the age group driving ethnic *mixing*, as in all ethnic groups they move to more diverse areas. However, when age cohorts are followed in time, their ethnic segregation increases afterwards, potentially related to family formation.

Instead of, or in addition to age, it may be fruitful to analyze segregation by type of household, as the residential locations of children are dependent on their parents. Taking the type of household into account, particularly making the distinction between households with and without children, can also provide clearer results concerning the adult population, as childless households may have different preferences and opportunities than households with children. Conducting such analysis at the household level instead of the level of individuals gives equal weight to each household, which may be preferable, as residential mobility outcomes are based on household level decisions. Ages of the household members may still matter, for example because younger and older childless households may have different future needs concerning the residential environment.

Iceland *et al.* (2010) called existing literature on residential segregation by the type of household ‘extraordinarily thin.’ Findings from the few existing studies suggest that in the USA, families with children are more segregated than either childless households or young adults in age groups typically preceding the establishment of families (Iceland *et al.*, 2010; Owens, 2017).

Why do household types matter for understanding segregation?

Two main reasons have been proposed for why ethnic segregation is stronger among children (Iceland *et al.*, 2010; Owens, 2017). The first relates to *economic resources*. Income is a key characteristic influencing neighbourhood sorting (e.g. Clark & Rivers, 2012; Hedman *et al.*, 2011). If the disparity in economic resources by ethnicity is larger among households with children than among childless households, this can be expected to lead to stronger residential segregation. In that situation, the ability to pay for housing in more expensive neighbourhoods is limited more strongly among minority families. In the US context, particularly the higher prevalence of single-parent families among black and Hispanic families might be an important driver of segregation. In contexts such as Finland, the low level of employment particularly among non-Western immigrant women could be a similar explanation.

The second potential explanation is related to variation in *residential preferences*. Families with children have different preferences than childless households. They are commonly attracted by suburban environments, presence of other children, access to schools and playgrounds, and availability of dwellings suitable for families (Hedman *et al.*, 2011). They may also be more sensitive to the ethnic composition of the neighbourhood population, as concerns for the circumstances of their children may add to the parents’ personal preferences. Parents of young children may therefore put more weight on the population composition in their residential choices than other types of households (see e.g. Boterman, 2013), particularly higher-income majority ethnic parents (Owens, 2016, 2017). Such preferences might not be directly related to the actual neighbours, but the ethnic composition may act as a signal for other neighbourhood characteristics such as perceived school quality or safety (Iceland *et al.*, 2010). This is called the *racial proxy hypothesis* (e.g. Swaroop & Krysan, 2011). Assumed school characteristics may directly affect residential decisions when schools have catchment areas. Among childless households, such concerns may be less relevant.

These two potential explanations lead to different expected outcomes. If economic resources are the decisive factor, there should not be stronger ethnic segregation among households with children when the economic resources are controlled for. If households with children are more strongly segregated even after controlling for economic resources, this could be a sign of differential residential preferences (or discrimination).

In this framework, economic resources and preferences should be seen as ‘proximate’ causes of residential outcomes that may mediate the effects of more distal factors. For example, social class and education and their interplay with the local context (e.g. Maloutas, 2007) also matter. Their effects can be expected to be realized

through both economic resources and residential preferences – and via utilization of social and cultural capital, whereby the apparent significance of economic resources may reflect non-economic effects as well (see Oberti, 2020). The ultimate causes may lie still further in the structural inequalities and discrimination within the society (e.g. Wilson, 2010). Due to this complexity, conclusions regarding these more distal factors cannot be based solely on the analysis of economic resources and residential preferences.

After stratifying the measurement of ethnic segregation by the poverty status of households, Iceland *et al.* (2010) concluded that differences in poverty status do *not* explain why ethnic segregation is stronger among families with children than among non-family households. Neither Owens (2017) nor Sabater & Catney (2019) used information on income in their analyses. Therefore, the significance of economic resources for the differences in ethnic segregation by type of household is not clear, but in the US context, the difference seems to be related to other factors besides poverty status.

Studies analyzing residential mobility out from or into ethnic minority concentrations have not typically addressed differences by household type. According to Owens (2017), evidence from existing studies has been mixed on whether households with children are more sensitive to the ethnic composition. Recently, a Norwegian study (Wessel *et al.*, 2018) found the out-mobility of native-born parents and upcoming parents to be more sensitive to neighbourhood's share of ethnic minorities than the out-mobility of childless native-born adults even after controlling for income and other socio-demographic characteristics. This finding was interpreted from the point of view of the racial proxy hypothesis, as indication of fear of neighbourhood decline.

School choices and residential mobility

Research from several countries demonstrates that especially parents with a higher socio-economic status actively choose schools which they expect to benefit their children most (Ball, 2003; Byrne, 2009; Raveaud & van Zanten, 2007). The families' ability and motivation to navigate the school markets are linked to questions of class, and school choices are typically seen as one of the key middle-class strategies for social reproduction through education, where parents seek to optimize both the academic quality and the 'right' kind of peer group for their children (Ball, 2003; Wilson & Bridge, 2019). Therefore, the characteristics of local schools may be important particularly for middle-class families with children in neighbourhood selection, especially when the children are below the school-starting age or in the beginning of their school years. On the other hand, the population composition of neighbourhoods affects the composition of school populations and school reputations (see e.g. Bernelius, 2013; Boterman, 2013). A growing body of research has highlighted this link between residential and school segregation, where the socio-economic structure of the neighbourhood affects the schools' student base and educational attainment, which may affect further school and residential choices made by families with children (Andersson *et al.*, 2010; Boterman, 2013; Cheshire & Sheppard, 2004; Nieuwenhuis & Hooimeijer, 2016; Oberti, 2007; Riedel *et al.*, 2010).

This interaction between schools and urban residential segregation is strong especially when school allocation is regulated through school catchment areas. In these circumstances, residential mobility is an important way of exercising school choice, as it is the central way of ensuring access to the desired schools (Boterman, 2013; Reay *et al.*, 2011). This is reflected in housing prices (e.g. Cheshire & Sheppard, 2004; Gibbons *et al.*, 2013; Harjunen *et al.*, 2018), increasing the importance of economic resources. As Oberti (2020) notes, this strategy of school choice has the most direct connection with economic resources, particularly in contexts with high housing prices (such as Helsinki). In many countries, parents can additionally navigate the system by opting out of the public-school system and applying for private education. In Finland, however, private education plays a minor role, and the majority of schools belong to the local network of public school with address-based allocation policies. Parents' selective choice strategies thus focus predominantly on public school alternatives and can be expected to be partly exercised through residential mobility behaviour.

School choices are strongly linked to the social and ethnic composition of schools (Boterman, 2013; Vowden, 2012). In addition to parents' concerns about the social or ethnic mix and associated ethos in schools, parents appear to associate the schools' composition with the quality of education (Bathmaker *et al.*, 2013; Butler & Hamnett, 2007; Kosunen, 2014; Rowe & Lubienski, 2017). There are thus multiple links between the parents' views on school quality, school composition and neighbourhood qualities, and the choice of neighbourhood may represent a simultaneous choice for a desirable neighbourhood and access to a certain school.

The Finnish context

The city of Helsinki had a population of 635,000 by the end of 2016. In that year 14 per cent of them had a foreign background, which was an increase from 6 per cent in 2000 (Hiekkavuo, 2017). Larger-scale immigration to Finland began in the 1990s, and between 1990 and 2016, the population with a foreign background grew from 10,000 to 95,000 in Helsinki. Levels of ethnic segregation are not very high in Helsinki compared to other Nordic capitals (Skifter Andersen *et al.*, 2016). Many immigrants have settled in socioeconomically deprived neighbourhoods (Kortteinen & Vaattovaara, 2015; Saikkonen *et al.*, 2018; Vilkama, 2011), which reflects their low socio-economic status, and their over-representation in social rental housing (Kauppinen & Vilkama, 2016).

Residents with a foreign background are still a minority in all neighbourhoods in Helsinki, but the differences are more marked among children. In the beginning of 2019, 16 per cent of total population and 20 per cent of children aged 0–15 years had a foreign mother tongue. The shares vary between neighbourhoods from a few per cent to over a third among the total population and to over 50 percent among children (City of Helsinki, 2019).

The school system in Helsinki reflects the egalitarian Nordic educational policies. The network of schools largely consists of local public schools, where the education is based on a national curriculum. The existing private schools are also publicly

controlled, free of tuition fees and tied to the national curriculum. The institutional quality of schools is thus fairly uniform: all schools follow the same curriculum, teachers are required a Master's qualification and the funding for schools comes from national sources. The school choices reflect this pattern, as very few parents note distrust in institutional qualities as a significant factor (Kosunen, 2016). Catchment area effects on housing prices have also been shown to be related mainly to pupil composition (Harjunen *et al.*, 2018).

School enrolment is organized through geographical catchment areas. Each child is assigned a 'local home school' based on their home address. Since the mid-1990s, families have had the right to express a choice of a school outside their catchment area, which has led to stronger ethnic segregation between schools than between neighbourhoods (Bernelius, 2013). However, the possibility to attend another school depends on the availability of free places in each school as well as possible admission criteria, such as ability testing in music or languages in the case of specialized classes. The only way to ensure a place in a certain school is to have a home address within the catchment area. Currently 80 percent of the children starting primary school attend the school within their own catchment area.

The direct link between socio-spatial patterns and pupil composition in schools combined with high overall institutional quality makes Helsinki an interesting location to study the links between catchment areas and residential segregation (see also Bernelius & Vilkkama, 2019). When the vast majority of pupils attend their nearest school, residential segregation has a direct effect on pupil composition, which is further reflected in the educational attainment (Bernelius, 2013). The pupil composition and attainment, in turn, affect the school reputation, which further affects school choices (Kosunen, 2014) and potentially also residential segregation. As the institutional qualities of the schools are fairly constant through the city, the parental choices are mostly related to social composition and neighbourhood qualities instead of varying academic qualities in schools.

Study design

In this study, we aim to demonstrate the differences between household types in ethnic residential segregation, while taking into account income differences. Additionally, we illustrate differences between household types in residential mobility flows, and we test for one potential mechanism in bringing about these differences: the effect of school catchment areas on residential mobility. Next, we describe the data and the analytical steps and methods of this analysis.

Data

We use individual-level register-based data covering the full population of Helsinki annually between 2005 and 2014 (Statistics Finland contract number TK-52-1417-16). We have aggregated the data on the household level and we measure socio-demographic characteristics of households: ethnic background, income, number and ages of children (those below the age of 25 in a child's position in the family according to

Statistics Finland), and age of the youngest adult (the reference person or his/her spouse). While we focus on the distinction between households with and without children, we use information on age and income to measure more detailed types of household. Residential locations are known with the precision of $250\text{ m} \times 250\text{ m}$ grid cells.

Ethnic categorization was based on the ‘background country’ and the mother tongue. Background country refers to parents’ countries of birth, if known, prioritizing the foreign-born parent. By native-origin households, we mean those households in which the background country for all members was Finland and the mother tongue was Finnish. The information on mother tongue was used because there are separate Swedish-language schools with different catchment areas (around six percent of the population of Helsinki belong to the Swedish-speaking minority). In the case of foreign-origin households, we focus on the ethnic group whose presence might influence the residential mobility decisions of Finnish-origin households the most: those with a ‘non-Western’ immigrant origin. By non-Western-origin households we refer to households with all members having a non-Western background country. The ‘non-Western’ category refers to non-European countries except the USA, Canada, Australia and New Zealand.

Household income was measured as the income decile of the household based on equivalized disposable money income. The deciles were based on the income distribution of the total population of the city of Helsinki. In segregation index calculation, the income is from the current year, and in the migration analyses it is from the calendar year before the move. As we use income as a stratifying variable, we dichotomize it to have enough observations, with the categories low (deciles 1–4) and high (deciles 5–10) income.

In addition to the grid cells, we used the catchment areas of the municipal Finnish-language elementary schools ($N = 85\text{--}89$, depending on the year). In 2010, the catchment areas had on average 6600 residents (standard deviation = 4100) and 3500 households (standard deviation = 2600). We measured the catchment areas by combining annually the grid cells belonging to the same catchment area. Since the school year 2011–2012, some catchment areas (15 since the school year 2012–2013) were combined into larger districts in the school intake, decreasing the potential importance of catchment areas for moving decisions on average. The catchment areas still remained, so we use them as units in the analysis even when the school intake was not based on them.

In the migration analyses we used control variables mainly referring to the housing stock of the areas. These variables are listed in the description of the analyses. They were measured from our individual-level dataset and the information on the housing stock was based on inhabited dwellings.

Analytical steps and methods

The analysis consists of three steps, each linked to the research questions (RQs) as formulated in the introduction. In the first step we analyze segregation levels by household types (RQ 1 and 2). In the second step we investigate residential mobility

flows (RQ 3) and in step three we analyze the potential causal effects of catchment area boundaries on intra-urban residential mobility (RQ 4).

First step of analysis: segregation levels

The first step is to measure ethnic segregation with segregation indices, comparing the residential distributions of different types of native-origin households to the distributions of similar types of non-Western-origin households (RQ 1). This is done for the year 2010, before the creation of several larger school intake districts. We primarily used the index of systematic dissimilarity (Carrington & Troske, 1997), and we also refer to findings applying the index of dissimilarity (e.g. White, 1983).

The index of systematic dissimilarity takes into account that when the population groups or the spatial units are small, even random allocation can lead to high values of the index of dissimilarity. It compares the observed index of dissimilarity to values that could be expected under random allocation (for the calculation of expected values, see Carrington & Troske, 1997 and Åslund & Nordström Skans, 2009). Its values tell the extent of excess segregation as compared to random allocation, as a fraction of the maximum possible amount. When the group and unit sizes are sufficiently large, the values are very close to the regular index of dissimilarity.

The index of systematic dissimilarity can be extended by controlling for another dimension of segregation. This is achieved by calculating a *conditional* index of systematic dissimilarity (Åslund & Nordström Skans, 2009). It takes into account one or more systematic sources of segregation in addition to random allocation when calculating the expected values. Here it is used to control for the effects of income. The conditional index shows how much the observed index of dissimilarity differs from segregation that could be expected if only income differences and random allocation affected the residential patterns. When compared to the unconditional index, we can see what share of ethnic segregation is related to income differences (RQ 2).

Second step of analysis: mobility flows

In the second step we analyze migration flows between the school catchment areas. The primary aim is to describe the association between the share of non-Western-origin children in the school-age populations of the catchment areas and the migration of different types of Finnish-origin households with children (RQ 3). Their migration is compared to other household types. We apply ‘gravity’ models of migration at this phase, similarly to Bakens *et al.* (2018).

The migration flow analysis is done separately for each type of household and for the periods 2006–2010 and 2011–2014. In the case of foreign-origin households, we are only able to analyze coarse groups as there are too few mover households. As a moving household, we define a group of persons who lived together in the previous year in Helsinki and moved to a new dwelling in another catchment area.

The analysis is done using aggregated data with a cell for each combination of an origin area and a destination area, including those combinations without any movers (total number of combinations: 7308 in 2006–2010 and 6806 in 2011–2014). The outcome is the number of mover households from the origin area to the destination area. The difference in standardized shares of non-Western-origin children in 7–15-

years-old population of the catchment area is measured in the end of 2005 or 2010, depending on the period.¹ The mean values of the unstandardized variable were 9,5% in 2005 and 13,1% in 2010 (standard deviations were 6,6% and 9,1%, respectively). By the end of 2013, the mean had reached 14,9% and the standard deviation was 10,0%. We use a standardized variable in the analyses, as the shares have increased steadily, and we expect households to base their comparisons of areas mainly on relative instead of absolute differences.

Other variables central for the gravity model are the (log) distance between the catchment area centerpoints, the (log) number of dwellings in the destination area (in 2005 or 2010), the (log) increase of dwellings in the destination area during the period, and to take the population at risk of moving into account, the (log) household-years of the given type in the origin area during the period as an offset term.² We also control for the differences between the areas in (log) distance to the city centre, the percentage of dwellings in apartment buildings, the percentage of social rental dwellings, and the percentage of dwellings having at least two bedrooms. When analyzing households with children, the variables related to the numbers of dwellings and shares of social rental dwellings refer to dwellings with at least two bedrooms.

Our model for the number of movers from area i to area j (λ_{ij}) is

$$\ln \lambda_{ij} = \beta_0 + \beta_1 \Delta s_{ij} + \beta_2 d_{ij} + \beta_3 x_{1j} + \beta_4 x_{2j} + \Delta x'_{ij} \beta_5 + \ln P_i + \varepsilon_{ij} \quad (1).$$

where

Δs_{ij} = difference between the catchment areas in the share of non-Western-origin children in 7–15-years-old population

d_{ij} = log distance between the catchment area centerpoints in kilometers

x_{1j} = log number of dwellings in the destination area

x_{2j} = log increase of dwellings in the destination area (zero if no increase)

$\Delta x'_{ij}$ = differences between the catchment areas in housing and distance characteristics

P_i = exposure: population at risk of moving (coefficient of the log transformation constrained to 1)

ε_{ij} = unit-specific error allowing for overdispersion (gamma distribution, mean = 1)

We estimate this model with negative binomial regression (Stata command nbreg).

Third step of analysis: boundary discontinuity analysis

The third step is an attempt to assess the *causality* of the association between catchment area characteristics and residential mobility (RQ 4). We analyze in-migration to vacated dwellings and ask whether it is causally affected by the catchment-area characteristics. For this purpose, we conduct a boundary discontinuity analysis.

In the migration flow analyses, the associations between catchment area characteristics and residential mobility might have been caused by unobserved factors. The central idea of the boundary discontinuity analysis is that within a small enough area, many of these unobserved factors may be expected to be shared within the whole area (Gibbons *et al.*, 2013; Young *et al.*, 2016). Therefore, if outcomes are different on the different sides of a geographical boundary crossing through this area (which

we call a boundary region), in absence of other coinciding significant boundaries, the boundary might be the cause for the difference. Study designs employing either fixed effects for the boundary regions or differencing across the boundary allow for controlling for the shared unobserved factors.

We look at households moving to dwellings that are vacated in the 250 m × 250 m grid cells along catchment area boundaries. This includes households moving within the same grid cell or catchment area but not households moving (completely) from other municipalities or countries to Helsinki, as we expect intra-urban migration to be particularly affected by the catchment areas. A vacated dwelling means here a dwelling that has completely different inhabitants in the end of the year as compared to the previous year, or a new dwelling. A mover household includes all persons who live in such a dwelling.

The boundary regions were constructed using information on the catchment area boundaries for the 2014–2015 school year. Detailed information on their construction is given in [Appendix A](#). We ended up on 41 boundary regions. Several particularly disadvantaged or affluent neighbourhoods were left out due to their clear physical separation from surrounding neighbourhoods.

We conduct the boundary discontinuity analysis by applying a hybrid negative binomial regression model (Stata command `xthybrid`).³ The unit of analysis is a group of grid cells on one side of a catchment-area boundary, which we call a boundary region side. We pool all the years when the boundary existed together, in order to have enough mover households. We do the analysis separately for different types of household.⁴ For each type, the outcome is the number of households moving to vacated dwellings. The (log) number of vacated dwellings is in the model as an offset variable. The initial explanatory variable is the standardized share of non-Western-origin children in the 7–15-years-old population of the catchment area, using the value from the year preceding the first year when the boundary existed. This is calculated from those grid cells in each catchment area that did not belong to any of the boundary regions in order to keep it more independent from the moves under analysis. However, we ultimately use a housing-stock related explanatory variable, due to endogeneity concerns (see below).

The other observed predictors measure characteristics of the boundary region side. These include distance measures aiming to capture some spatial trends in amenities: the (log) distance to the sea shore and to the nearest metro or railway station. Additionally, differences in housing characteristics are measured: the percentage of dwellings in apartment buildings and in social rental housing and the percentage of vacated dwellings having at least two bedrooms.

Our model for the number of movers to the side j of the boundary region i (λ_{ij}) is

$$\ln \lambda_{ij} = \beta_0 + \beta_1(s_{ij} - \bar{s}_i) + ((x_{1ij} - \bar{x}_{1i})\beta_2 + \dots + (x_{5ij} - \bar{x}_{5i})\beta_6) + \beta_7\bar{s}_i + (\beta_8\bar{x}_{1i} + \dots + \beta_{12}\bar{x}_{5i}) + \ln V_{ij} + u_i + \varepsilon_{ij} \quad (2)$$

where

s_{ij} = catchment-area characteristic, e.g. % non-Western-origin children in 7–15-years-old population

$x_{1ij}..x_{5ij}$ = housing and distance characteristics of the side j of the boundary region i

\bar{s}_i, \bar{x}_{1i} etc. = boundary-region averages of the variables

V_{ij} = exposure: number of vacated dwellings (coefficient of the log transformation constrained to 1)

u_i = random effect of the boundary region

ε_{ij} = unit-specific error allowing for overdispersion (gamma distribution, mean = 1)

The parameter β_1 is intended to capture the causal effect of the catchment area characteristic. However, there is still a risk of an endogenous relationship between the population characteristics of the catchment areas and the moves we explain. The migration flows shaping the population might earlier have been influenced similarly as the present moves, so the population characteristics are not independent from the moves, even though we exclude the grid cells of the boundary regions from their measurement. The factors influencing migration to the boundary regions may have influenced the population characteristics of the non-boundary-region areas as well. Therefore, we use the percentage of state-subsidized rental dwellings in the housing stock of the catchment area (excluding the boundary region cells) as an alternative explanatory variable. It cannot be easily or quickly affected by the phenomenon studied.

As we analyze the total population instead of a random sample, we mostly base our interpretations on the point estimates. However, we still show information on statistical significance, because the individual life histories can be seen as realizations of stochastic processes that are subject to random variation (Hoem, 2008).

Findings

Segregation levels

We begin by investigating how ethnic segregation differs for different household types (RQ 1). Table 1 shows the level of segregation between the Finnish-origin and non-Western-origin households in 2010, by household type.⁵

The index of dissimilarity was higher among households with children, as expected. For more detailed comparisons, we use the index of systematic dissimilarity. The unconditional estimates show that ethnic segregation is stronger among households with children than in any of the categories among the childless households. Younger two-adult households are the most strongly segregated among the childless households.

The index values conditional on income show how much segregation remains after controlling for income differences between the ethnic groups (RQ 2). This decreases the estimates especially among households with children. Most – but not all – of the excess segregation among households with children seems to be related to income differences between Finnish-origin and non-Western-origin households. In contrast, income does not explain much of the low segregation among childless households.

Comparison of these results to similar results in 2006 and 2014 shows that segregation was stronger among households with children in all years. Except for younger

Table 1. Catchment-area level segregation between Finnish-origin and non-Western-origin households, by the type of household, 2010.

	Index of dissimilarity	Index of systematic dissimilarity		Number of households	
		Unconditional	Conditional on income	Finnish origin	Non-Western origin
All households	25.5	22.4	18.8	240,983	7448
Households with children, all	35.4	31.0	21.6	44,255	3303
Households with children, <40	35.1	29.4	20.8	17,690	2123
Households with children, ≥40	37.5	30.1	23.1	26,565	1180
Households without children, all	18.2	13.6	11.5	196,728	4145
Single-person households	13.6	7.8	7.0	129,039	2853
Single-person households <40	21.0	14.6	14.3	45,305	1825
Single-person households ≥40	16.3	6.4	5.2	83,734	1028
Two adults' households	29.4	20.2	16.8	63,457	926
Two adults' households <40	34.3	25.0	23.6	25,408	739

households with children, the segregation levels have increased to some extent. Income differences have explained an increasing share of ethnic segregation, particularly among younger households with children.

Residential mobility flows

Selective intra-urban residential mobility can be expected to be the main mechanism producing the segregation outcomes in [Table 1](#), particularly the mobility of households with children. Therefore we analyze the patterns of residential mobility flows between catchment areas by type of household, focussing on households with children (RQ 3). We stratify the analysis by the age of the oldest child, as we expect schools to have the greatest impact on residential mobility decisions in those households in which all children are below the school-starting age of seven. After that phase, the residential flows to other areas decrease (Bernelius & Vilkama, 2019).

[Table 2](#) shows the results. They indicate how the share of the 7–15-years-old non-Western origin population predicts the migration flows of different types of households, when several other characteristics of the catchment areas are controlled for. The values are incidence rate ratios (IRR) showing the predicted ratio of movers to a destination area with a one standard deviation higher share than the origin area, as compared to the migration rate between areas with identical shares.

Among Finnish-origin households with children, the migration flows are smaller when the destination area has a higher proportion of non-Western-origin school-age children. The association is clearest in the case of households in which the oldest child is 4–7 years old, i.e. just below the school-starting age. In the 2006–2010 analysis, the predicted migration rate of these households – adjusted for the other measured differences between the areas – was 11.5 per cent lower (IRR = 0.885) when the destination area had one standard deviation higher proportion of non-Western-origin school-age children than the origin area. In contrast, migration flows of households without children are only weakly related to the shares of non-Western-origin children. Among foreign-origin households, a higher share of non-Western-origin

Table 2. Incidence rate ratios (IRR) of residential mobility between catchment areas, by period and the type of household.

Household type	Effect of one standard deviation higher % of non-Western origin in the 7–15-years-old population in the destination area as compared to the origin area					Number of mover households	
	2006–2010		2011–2014		95% C.I.	2006–2010	2011–2014
	IRR	95% C.I.	IRR	95% C.I.			
All movers	0.995	(0.957 – 1.033)	1.001	(0.967 – 1.036)		150,264	132,021
All Finnish-origin movers	0.981	(0.949 – 1.014)	0.990	(0.959 – 1.022)		121,281	102,216
Finnish-origin households without children	0.987	(0.954 – 1.020)	0.991	(0.961 – 1.022)		107,211	90,226
Finnish-origin households with children	0.888	(0.851 – 0.927)	0.921	(0.880 – 0.965)		14,070	11,990
Finnish origin, oldest child 1–3 years	0.928	(0.877 – 0.981)	0.949	(0.888 – 1.013)		3384	2874
Finnish origin, oldest child 4–7 years	0.885	(0.834 – 0.939)	0.914	(0.858 – 0.974)		2483	2408
Finnish origin, oldest child 8–11 years	0.913	(0.845 – 0.986)	0.903	(0.850 – 0.960)		1556	1372
Finnish origin, oldest child 12–15 years	0.940	(0.872 – 1.012)	0.934	(0.873 – 0.999)		2158	1540
Finnish origin, oldest child 1–7 years, low income	0.941	(0.884 – 1.003)	0.987	(0.930 – 1.049)		2608	2234
Finnish origin, oldest child 1–7 years, high income	0.886	(0.837 – 0.938)	0.901	(0.846 – 0.959)		3259	3048
Finnish origin, oldest child 8–15 years, low income	0.928	(0.872 – 0.987)	0.924	(0.841 – 1.015)		3007	2380
Finnish origin, oldest child 8–15 years, high income	0.867	(0.809 – 0.930)	0.865	(0.814 – 0.919)		2431	1962
All foreign-origin movers	1.128	(1.064 – 1.196)	1.105	(1.055 – 1.157)		16,053	17,433
Foreign-origin households with children	1.148	(1.083 – 1.218)	1.120	(1.055 – 1.189)		2770	3132
Foreign-origin households without children	1.115	(1.053 – 1.180)	1.089	(1.041 – 1.139)		13,283	14,301
Foreign origin, oldest child 1–7 years	1.139	(1.049 – 1.237)	1.065	(0.971 – 1.168)		1094	1339

Note: Separate model for each household type, control variables of the gravity model controlled for.

children in the catchment area predicts a higher rate of migration to the catchment area. This is clearest in the case of households with children.

When we stratify the analysis by the income of the household, we see that among the Finnish-origin households with the oldest child between 1–7 years, particularly the migration of higher-income households is related to the ethnic compositions. A one standard deviation higher share of non-Western-origin school-age children predicts an 11.4 per cent lower rate of residential mobility, whereas among the low-income households a similar difference predicts a 5.9 per cent lower rate. Differences by income are similar when the oldest child is 8–15 years old.

The results for the 2011–2014 period indicate mostly weaker associations than in the 2006–2010 analysis. This was expected, as some schools based their pupil intake on larger school districts since 2011. The point estimates also suggest that differences by the age of the oldest child became smaller. Otherwise the results are similar to those for 2006–2010.

When the difference between the catchment areas in the percentage of the 7–15-years-old children living in low-income households was used as an alternative explanatory variable, the results were similar to those presented above. Therefore, we cannot determine, whether the ethnic composition – instead of something else correlating with it – is the characteristic that matters. Additionally, although we have shown the predictive power of the ethnic composition, the analyses have not shown any evidence of causal effects. In the next section we use boundary discontinuity analysis to get more insight into causal relationships.

Causal effects of catchment area boundaries on intra-urban residential mobility

In the last step of the analysis, we analyzed the potential causal effects of catchment area boundaries on intra-urban residential mobility (RQ 4). We used data on intra-urban moves to vacated dwellings in the boundary regions along the boundaries of catchment areas (Figure 1).

Figure 2 shows for each type of household how the share of non-Western-origin children among the school-age population of the catchment area predicts migration of Finnish-origin households to vacated dwellings when the unobserved boundary-region effects and observed boundary-region-side characteristics are controlled for. The values are calculated from incidence rate ratios of the hybrid negative binomial regression models and they show how much higher in-migration rate of the given type of household is predicted by a one standard deviation higher share of non-Western-origin children (see Appendix B for the exact values).

A higher share of non-Western-origin children predicts lower rate of in-migration especially among higher-income households with children and higher-income households of two over-40-years-old persons. However, these results may be biased due to residential mobility patterns under analysis having affected the explanatory variable. As a stricter test for causal effects, we obtained results with the share of state-subsidized rental dwellings as the catchment-area-level explanatory variable (see *Analytical steps and methods*). The types of household are ordered in the figure on the basis of this effect. These results suggest that the catchment-area effect is the strongest among

higher-income households with children at or below the school-starting age of seven: a one standard deviation higher share of state-subsidized rental dwellings predicts a 14.8 per cent lower rate of in-migration. If confidence intervals are used as a criterion (although we analyze the complete population), a statistically significant effect is observed only among these households. Effects of all variables in this model are shown in [Appendix C](#) and similar results for all types of household are shown in the online [supplementary material](#).

Apparent effects among childless high-income households could reflect the effect of high demand for housing increasing the housing prices on the catchment areas with less state-subsidized rental housing, and therefore making it more difficult for lower-income households to move to these areas. This mechanism could be expected to have a particularly strong relationship with the income level. We found some support for this interpretation when we replicated the analysis for two more detailed higher-income groups (deciles 5–7 and 8–10): among older singles or two-adult households an effect was only observed in income deciles 8–10, whereas in both income groups the strongest effect was observed among the households with seven-years-old or younger children. The confidence intervals are wide, however, suggesting caution with making generalizations.

Sensitivity analyses

We checked whether the results change if education is used as the socio-economic variable and East-European-origin households are used as the immigrant-origin group.

Education could not be used in the segregation index analysis, as it is not measured reliably for immigrants. The results of the mobility flow analyses do not change with the educational variable. In the boundary discontinuity analysis, the results differ in that we find statistically significant effects of the share of state-subsidized rental dwellings also among highly educated older two-adult households and among highly educated families with older children. This might indicate a general awareness among higher-educated households of the importance of the catchment areas for housing price development of family-size dwellings.

There are some differences in the results when East-European-origin households are used as the immigrant-origin group. The type of household is less strongly related to segregation and income explains less among the households with children. Results of the migration flow analyses do not change, but in the boundary discontinuity analysis the effects are clearly weaker and not statistically significant. These results show that our main analyses focus on the most relevant category of immigrant-origin households regarding the segregation-increasing residential mobility tendencies among the Finnish-origin households.

Discussion

The main aim of this study was to contribute to literature on ethnic residential segregation by explicitly investigating the role of school catchment areas in ethnic

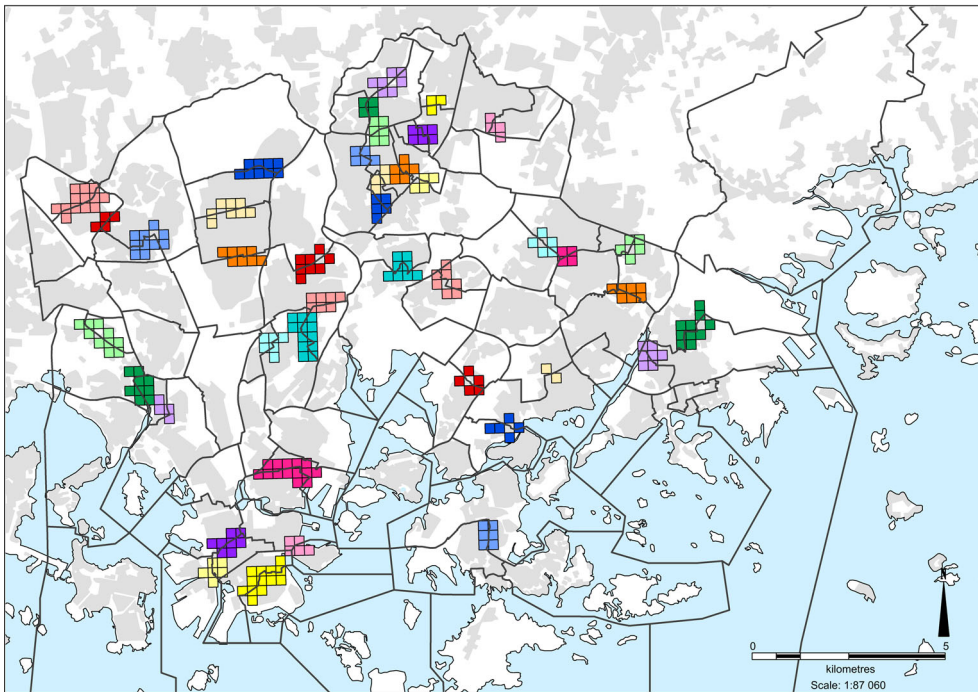


Figure 1. The catchment areas of the schools in 2014 and the boundary regions used in the boundary discontinuity analysis.

segregation among different types of households. Using data from Helsinki, we found that segregation between Finnish-origin and non-Western origin households is stronger among households with children than among childless households, similarly to previous studies in other contexts (Iceland *et al.*, 2010; Owens 2017; see also Sabater & Catney, 2019). We also found that the stronger segregation among households with children seems to be related to a large extent but not totally to the higher incomes of Finnish-origin households, and that particularly higher-income Finnish-origin households with children contribute to reproduction of ethnic segregation through intra-urban mobility flows between catchment areas. These findings could be expected on the basis of the established finding that especially more affluent families optimize the social and educational environment for their children (Ball, 2003; Benson *et al.*, 2015; Oria *et al.*, 2007; Wilson & Bridge, 2019), but they also lead to the conclusion that income does not explain everything, similarly to Iceland *et al.* (2010). There seem to be both resource- and preference-based explanations for the stronger segregation among households with children.

The net effect of intra-urban residential mobility on ethnic segregation depends also on the stock of different types of households in different kinds of neighbourhoods (Kauppinen & van Ham, 2019) and on the extent of within-neighbourhood mobility, but we showed that those moves of higher-income Finnish-origin households with children that occur between the catchment areas tend to increase ethnic segregation. This refines the previous finding of the significance of the intra-urban residential mobility of the native-origin population as a segregation-increasing process

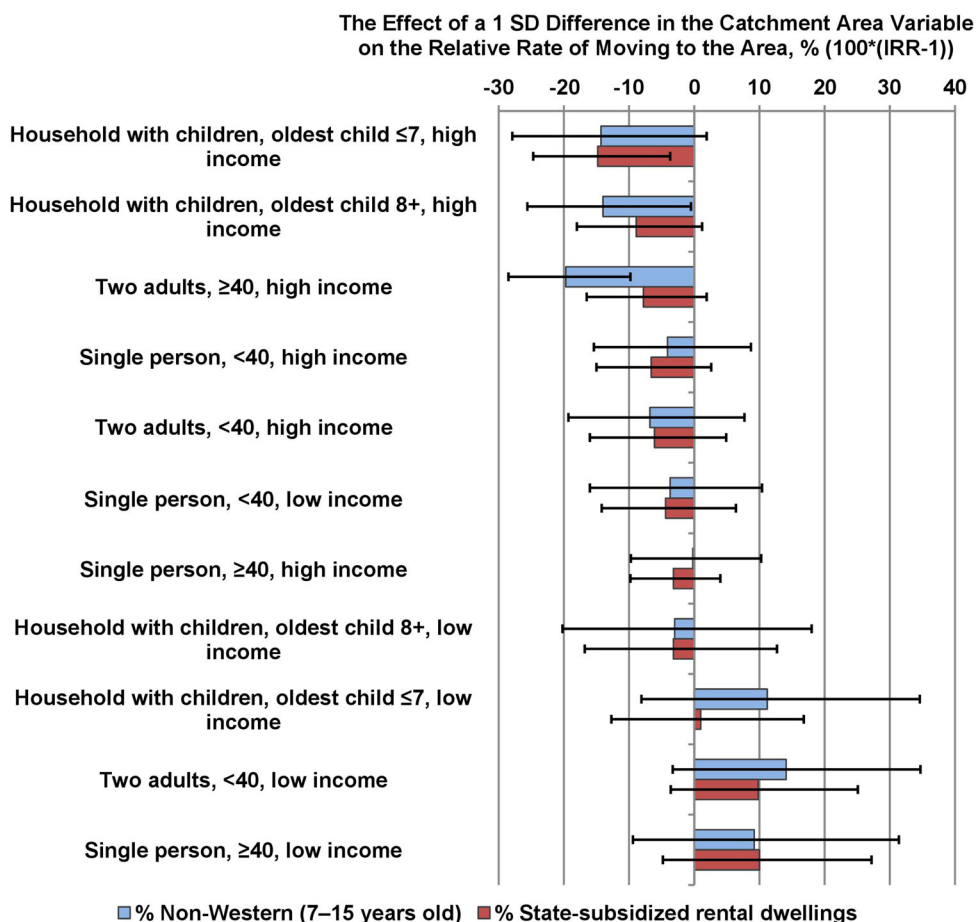


Figure 2. The effects of catchment area characteristics on intra-urban mobility of different types of Finnish-origin households to vacated dwellings in the boundary regions of selected catchment areas, results from hybrid negative binomial regression analyses.

(Bråmås, 2008; Kauppinen & van Ham, 2019; Musterd & de Vos, 2007), by showing which kind of households particularly contribute to this process, corroborating the findings of Wessel *et al.* (2018) from Norway.

Our main new contribution was to demonstrate that the catchment-area boundaries have causal effects on intra-urban residential mobility. This was clearest in the case of higher-income Finnish-origin households with children below the school-starting age. As the catchment-area boundaries matter, it follows that schools matter. School catchment area boundaries influence the development of residential segregation through mediating access to certain schools and influencing the residential decisions of families. Although previous studies (e.g. Owens, 2017) have arrived to similar conclusions, they have not had strict causal designs and they did not directly observe residential mobility.

Regarding the limitations of our study, we had to rely on a housing-stock related variable to get stricter causal estimates of the catchment-area effects. Our design could not determine the actual catchment area characteristic affecting residential

mobility. However, we expect the share of social rental housing to matter by influencing and perhaps also signalling the social and ethnic composition of the population. Our findings suggest that in addition to determining housing opportunities, differences in housing stock also affect the desirability of the areas, i.e. the effects of housing and land-use policies are not limited to determining the opportunity structure. Another limitation is that we were not able to account for the complexity of the potential effects of various socio-economic characteristics of households on the residential moves. We used income as the stratifying variable, but the findings may partly reflect the significance of education or social class, for example, and some potential mechanisms – such as using specialized classes as a way of school choice (cf. Oberti, 2020) or diversity-seeking behaviour instead of ‘flight’ (e.g. Boterman, 2013) – could be related to particular combinations of these factors.

Assumed pupil composition and related socio-cultural considerations seems to be a more important determinant of school choice and associated residential choice in the Finnish context than the assumed quality of teaching (Harjunen *et al.*, 2018; see also Bernelius & Vilkkama, 2019). This is related to the fairly constant institutional or academic qualities of Finnish schools in an international comparison. Therefore, our findings show that ensuring high institutional quality in education across the board is not enough to prevent effects of school choice on residential segregation. The socio-economic and ethnic divisions can still drive school-related residential mobility and reproduce and increase segregation as an emergent consequence of sensitivity to social or ethnic compositions of neighbourhoods and schools (cf. Sampson & Sharkey, 2008). The link between residential segregation and school segregation can lead to vicious circles (van Ham *et al.*, 2018), where the existing segregation, working partly through school, acts as a driver of further segregation (see also Boterman *et al.*, 2019). Schools’ role in the residential patterns in the city underlies the need for integrated educational and urban policies.

Notes

1. In this variable, we count also those children who have both a Finnish-born and a non-Western-born parent as having a non-Western origin.
2. The risk population was not easy to define for the childless households, as persons could split from all types of households and form new childless households. Therefore we focus more on households with children and use the total number of households of the given ethnicity as the risk population for childless movers. Essentially the same results were obtained when using only the same household type as the risk population.
3. The available fixed-effects procedures for negative binomial regression do not control for unobserved cluster-level i.e. boundary-region-level characteristics (Allison, 2012; Schunck & Perales, 2017). The hybrid model can be used to approximate a fixed-effects design as it decomposes the effects of level-one covariates into within-cluster and between-cluster components (Schunck & Perales, 2017). Fixed-effects Poisson regression analysis with the Stata command `xtpoisson` produces very similar point estimates with some differences in statistical significance.
4. Here we use a more coarse age classification for children to get enough cases.
5. The age limits refer to the adults in the household. See *Data* for our definition of an adult.

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Appendix A: Details of the boundary discontinuity design

A boundary region means here a group of grid cells on both sides of a particular boundary between two school catchment areas. We first identified grid cells with at least a part of the cell within 250 metres from a catchment area boundary. Only those boundaries between catchment areas were selected which did not coincide with another major border such as a railroad, highway, water body, forest, field, or an industrial area. For each boundary region, only those consecutive years were used in the analysis during which the boundary existed (unchanged) and the catchment areas were used as the basis for pupil intake. If there were major changes in the boundaries elsewhere in either catchment area, the boundary region was not used any more after those changes. Grid cells clearly separated from the other cells of the boundary region by borders listed above (railroads etc.) were not included. In the case of the catchment area boundary crossing across a grid cell, we used auxiliary information on the locations of residential buildings and their numbers of residents and included only those grid cells in which at least 75% of the residents lived on one side of the boundary. When a grid cell would otherwise have belonged to two or more boundary regions, it was allocated to the region to which its residential area most clearly belonged to as a continuation of the region's residential area, or removed if this was not clear.

Appendix B: Effects of the catchment-area variables in the boundary discontinuity analyses

Household type	Effect of one standard deviation higher value of the catchment area variable on the relative rate of moving to the boundary-region side				Number of mover households
	% Non-Western (7–15 years old)		% State-subsidized rental dwellings		
	IRR	95% C.I.	IRR	95% C.I.	
Single person, <40, low income	0.963	(0.840 – 1.104)	0.956	(0.858 – 1.064)	10,938
Single person, <40, high income	0.959	(0.846 – 1.087)	0.934	(0.850 – 1.026)	7394
Single person, ≥40, low income	1.092	(0.906 – 1.314)	1.100	(0.952 – 1.272)	2970
Single person, ≥40, high income	0.998	(0.903 – 1.103)	0.968	(0.902 – 1.040)	3512
Two adults, <40, low income	1.141	(0.967 – 1.347)	1.098	(0.964 – 1.251)	3733
Two adults, <40, high income	0.932	(0.807 – 1.077)	0.939	(0.840 – 1.049)	6143
Two adults, ≥40, high income	0.803	(0.715 – 0.902)	0.923	(0.836 – 1.019)	1530
Household with children, oldest child ≤7, low income	1.112	(0.919 – 1.346)	1.010	(0.873 – 1.168)	1311
Household with children, oldest child ≤7, high income	0.857	(0.721 – 1.019)	0.852	(0.753 – 0.963)	1838
Household with children, oldest child 8+, low income	0.970	(0.798 – 1.180)	0.968	(0.832 – 1.127)	1415
Household with children, oldest child 8+, high income	0.860	(0.744 – 0.995)	0.911	(0.820 – 1.012)	1684

Note: Separate model for each combination of a household type and catchment area variable, housing and distance characteristics of the boundary-region side controlled for. The category 'Two adults, ≥40, low income' is omitted due to small number of mover households (324).

Appendix C: Effects of all explanatory variables in the boundary discontinuity model explaining moves of higher-income households with seven years old or younger children, incidence rate ratios (IRR)

	IRR	95% C.I.			p
Within-boundary-region effects					
Standardized share of social rental dwellings in the catchment area	0.852	(0.753	–	0.963)	.011
Ln (distance to the nearest railway or metro station, m)	1.024	(0.799	–	1.312)	.850
Ln (distance to the sea, m)	0.819	(0.698	–	0.961)	.014
% of dwellings in the boundary-region side in apartment buildings	1.003	(0.993	–	1.013)	.582
% social rental dwellings in the boundary-region side	0.991	(0.985	–	0.997)	.003
% of dwellings with at least 2 bedrooms among vacated dwellings	1.023	(1.009	–	1.036)	.001
Between-boundary-region effects					
Standardized share of social rental dwellings in the catchment area	0.952	(0.750	–	1.209)	.687
Ln (distance to the nearest railway or metro station, m)	1.184	(1.014	–	1.383)	.033
Ln (distance to the sea, m)	0.960	(0.861	–	1.070)	.458
% of dwellings in the boundary-region side in apartment buildings	0.988	(0.976	–	1.001)	.063
% social rental dwellings in the boundary-region side	1.001	(0.989	–	1.013)	.825
% of dwellings with at least 2 bedrooms among vacated dwellings	1.016	(0.998	–	1.033)	.083