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School Segregation and Native Flight: Evidence from School Catchment Area Borders

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Abstract:
Although extensively theorized, determining the mechanisms that produce ethnic or racial segregation in schools and neighborhoods has proven difficult. We investigate one potential mechanism behind ethnic segregation; native flight from schools. In contexts where school enrollment is determined primarily by geographic proximity to schools, Native or White parents with a preference for schools with low minority concentrations may choose to move away from schools with higher minority concentrations among students, contributing to both residential and school segregation. Using detailed, population-wide, geo-coded register data on families and school catchment areas for elementary schools in Oslo, Norway, we investigate whether native parents move away from schools with higher shares of students with non-Western immigrant backgrounds. We first show that native origin families systematically move away from schools with high shares of students with non-Western immigrant backgrounds. Employing a Geographic Regression Discontinuity design, exploiting the fact that catchment area borders sort neighboring children into different schools, our results indicate that such moves may be causally linked to local school characteristics, not just their neighborhoods. This may contribute to segregation in schools and neighborhoods. However, the results are ambiguous and sensitive to model specifications, and more research is needed to draw firm conclusions.

Key words: Ethnicity/race; school segregation; residential segregation; native/white flight

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Data Availability: The administrative register data used in this project were made available through the SEGREGATION project funded by the Research Council of Norway (RCN project 236793). These data are available from Statistics Norway to researchers with projects that satisfy the data owners' requirements. For information on how to gain access to Norwegian microdata and formal requirements, see https://www.ssb.no/en/data-til-forskning/utlan-av-data-til-forskere

Information on school catchment areas were provided by the Education Agency at the Municipality of Oslo, https://www.oslo.kommune.no/etater-foretak-og-ombud/utdanningsetaten/

Code for the preparation of geocoded data on catchment area boundaries (R) and analyses (Stata) are available at https://osf.io/5dwvk/

Ethics and Consent: The authors report no ethical issues. Necessary recommendations and approvals for the use of administrative register data and of the project were obtained from the National Research Ethical Committee, the Norwegian Data Protection Agency, and the Data Protection Official of the University of Oslo. The University of Oslo's Data Protection Official approved the data protection impact assessments for the project (ref: 222577) . Permissions to use register data without informed consent were based on the assessment that the issues related to lack of informed consent were outweighed by the societal relevance of the research.

Conflict of Interest: The authors declare that they have no conflict of interest.

Acknowledgements: The authors especially wish to thank Gunn Elisabeth Birkelund for excellent mentorship, assistance and project management, and Rannveig Kaldager Hart for invaluable feedback and advice. We also owe special thanks to our anonymous reviewers, and to Moris Triventi, Jan O. Jonsson, members of the Social Inequalities and Population Dynamics research unit at the Department of Sociology and Human Geography at the University of Oslo, members of the Work and Welfare research group at the Institute for Social Research, participants at the September 2019 PhD research seminar at the Department of Sociology and Human Geography at the University of Oslo, participants at the November 2019 Migration Seminar at the Department of Sociology and Human Geography at the University of Oslo, participants at Are Skeie Hermansen's Young CAS workshop at the Centre for Advanced Study in Oslo, August 2019, and participants at the Migration and education session at the European Consortium for Sociological Research conference in Lausanne, 2019 for very helpful comments and suggestions. We also wish to thank the municipality of Oslo, particularly John Erik Pope and Miriam Abildsnes at the Education Agency for providing catchment area data and helpful input. None mentioned here bear any responsibility for any errors. The register data was made available by Statistics Norway. This work was possible due to funding from the Norwegian Research Council (Grant No. 236793) to the project "Ethnic segregation in schools and neighbourhoods: consequences and dynamics".

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1 Introduction

Although school segregation is a well-known phenomenon around the world, we still have a limited understanding of the mechanisms that give rise to these patterns (Böhlmark, Holmlund, and Lindahl 2016). Free choice systems exacerbate both socioeconomic and ethnic school segregation (Wilson and Bridge 2019), but in systems where local catchment areas fully or in part determine school attendance, school segregation is closely linked to residential segregation. In such systems, your address matters for where your children go to school. If preferences for schools strongly impact parents' residential decisions, and if such preferences are related to the racial or ethnic student composition at schools, racial or ethnic majority families may systematically move away from neighborhoods and schools with high concentrations of minorities. Such patterns of 'flight' may be an important and self-reinforcing mechanism contributing to both school segregation and neighborhood segregation.

For policymakers who wish to reduce segregation, it is crucial to understand how and why such patterns emerge and persist. However, it is difficult to establish whether patterns of 'flight' are causally linked to school characteristics, as parents' moving patterns may be motivated by other factors. Life course transitions associated with having a first or second child might motivate young couples to move from urban to more suburban neighborhoods (Wessel and Nordvik 2019; Wessel and Lunke 2021), with what may be perceived as more child-friendly environments. Such a 'life course explanation' was a common narrative among out-movers from a disadvantaged urban neighborhood in Oslo (Kadasia, Andersen, and Dalseide 2020). Furthermore, housing prices, crime, pollution, or the socioeconomic composition of neighborhoods may motivate parents to move. In this article, we address whether schools might play a key role in producing patterns of flight, thus exploring the role of one potentially important mechanism behind segregation patterns.

Schools and neighborhoods may be segregated along a range of interrelated characteristics, such as socioeconomic status, culture, race, religion, or ethnicity, and several mechanisms may contribute to segregation. Empirically, this paper concerns the segregation of residents from native and immigrant origins in Oslo, Norway, and our focus is on whether 'native' families tend to move away from schools with a high share of students of non-Western immigrant origins[1].

To investigate whether 'native flight' is causally linked to school characteristics, we use highly detailed administrative register data linked to geographical coordinates for place of residence for the entire population of Oslo. We exploit discontinuous differences in the student composition of local schools at the catchment area borders, using a Geographic Regression Discontinuity (GRD) design. By comparing families that reside in the same neighborhood but within different school catchment areas, this approach allows us to study the effect of schools with different student compositions while accounting for neighborhood characteristics.

We study 'native flight' in a European context, where the largest minority groups consist of immigrants and their children. Nevertheless, our contribution is relevant for understanding the general mechanisms that produce racial or ethnic segregation in schools and neighborhoods, and we therefore relate closely to the broad US literature on racial segregation and 'White flight'.

[1] Racial categories are rarely used to characterize individuals in the Norwegian context (Andersson 2017)

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2 Flight and School Segregation

2.1 Neighborhood Preferences and Flight

A large US literature has documented that White families tend to move away from neighborhoods with large or growing shares of minorities ('flight'), or avoid moving into such neighborhoods ('avoidance'). One strand of this literature addresses people's expressed neighborhood preferences. Generally, these studies document preferences for neighborhoods dominated by the individuals' own racial or ethnic group, especially among US Whites, and preferences for mixed neighborhoods among minorities (Clark 2002; Clark and Coulter 2015; Clark and Fossett 2008; Emerson, Chai, and Yancey 2001; Fossett 2006; Krysan 2002; Krysan et al. 2009). Another strand of this literature addresses people's actual moving behavior. These studies have shown moving patterns that correspond with the notion of flight from, and avoidance of neighborhoods with high or increasing shares of racial or ethnic minorities (South and Crowder 1997; Crowder 2000; Crowder and South 2008; Crowder, Pais, and South 2012). Boustan (2010) also found the suburbanization of Whites in the postwar period to be in part caused by the urbanization of Blacks.

Related research in Europe has focused on natives' mobility patterns as a response to recently immigrated ethnic minority populations. Thus far, such studies have produced mixed results. Studies have found evidence of both native flight and avoidance in the Netherlands (Van Ham and Feijten 2008; Bolt, Van Kempen, and Van Ham 2008). In France, however, Rathelot and Safi (2014) found evidence of native avoidance, but no evidence of flight in Paris. McAvay (2017), on the other hand, found that natives are more likely to move out of immigrant-dense neighborhoods in France, while first- and second generation immigrants are more likely to retain in neighborhoods with higher shares of co-ethnics. In Britain, Simpson and Finney (2009) found that decisions to move out of neighborhoods seemed related to improvements in families' living conditions, and that flight behavior cannot explain the growth of segregated urban areas.

Studies from Nordic countries are particularly relevant comparisons for our study, but these results are also mixed. Bråmå (2006) found that native avoidance behavior, but not flight, was a major cause of residential segregation in Sweden. The importance of native avoidance in Stockholm was also supported by Andersson (2013). On the other hand, Aldén, Hammarstedt, and Neuman (2015) found that both native flight and native avoidance contribute to explaining why the native Swedish population growth drops when the share of non-European immigrants exceeds an observed tipping point. In Denmark, Andersen (2017) showed that native avoidance and, to a lesser degree, native flight, explain the neighborhood share of non-Western ethnic minorities, whereas Stonawski et al. (2021) found patterns of natives moving from areas with high or increasing shares of ethnic minorities in Copenhagen, especially among parents. In Norway, Wessel and Nordvik (2019) found that parents and parents-to-be are especially prone to exhibit flight behavior. These last two studies suggest that choice of school factors into natives' decisions to move.

2.2 School Preferences and Flight

There may be several reasons why native parents would avoid or 'flee' schools with high minority concentrations. Explanations have revolved around two dominant theoretical positions (Billingham and Hunt 2016). The first is the '*pure race'* explanation, whereby a racial group's preferences for schools are primarily motivated by stereotypes, prejudice, ethnocentric or racist attitudes towards out-groups. In Norway, Morken and Theie (2015) have found that minority concentrations matter for parents' evaluation of schools, and Andersson et al. (2017) show that although a large proportion of Oslo residents prefer ethnically mixed neighborhoods, many do not. We find it plausible that some parents may be motivated by stereotypes, prejudice etc., but note that families residing near schools with high minority concentrations are likely a relatively tolerant segment of the native population.

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The other explanation is the '*racial proxy'* explanation, whereby people use the racial or ethnic composition of a school as a proxy for other, salient characteristics, such as crime rates, safety, school quality, or socioeconomic composition (see for instance Harris 2001). In Norway, such proxying might have limited explanatory power, as parents can access information on schools' average test results, schools' cohort sizes, and teacher/student ratio and – with some effort – align this with information on the share of minority language students (Udir n.d.; Berge and Lepperød 2018; Kjelstrup 2019; Oslo Kommune n.d.-a). However, families might vary in whether they seek out information on schools, and whether they act on this information by moving out (Crowder and Krysan 2016). Further, information about the learning environment, the quality of teachers or school facilities are not easily accessible to parents, which may make them resort to assumptions of such school characteristics based on the school's ethnic composition.

Additionally, Hailey (2020) proposes the '*racialized prism*' explanation, suggesting that parents may make biased judgements of known information about schools depending on their racial demographics. For instance, parents may view a majority-dense school as safer than a minority-dense school even when they have comparable safety levels. Lastly, we would add *concern over potentially adverse peer effects* as a fourth plausible explanation. Internationally, and in Norway, the research literature reveals modest, if any, effects of both ethnic- and the socioeconomic composition of school peers on student outcomes (see for instance Van Ewijk and Sleegers 2010; Brunello and De Paola 2017; Borgen, 2023b; Carbonaro et al 2023). Nevertheless, high minority concentrations in schools are frequently described as problematic in media reports (examples include Fremstad 2017; Stavrum 2019; Zahid 2018), and a belief among native parents that their child will fare worse by attending such schools may be enough to produce patterns of flight.

Later, we will return to a discussion about these possible explanations in light of our findings. Notably, however, we are unable to differentiate empirically between the explanations, as we do not observe preferences or motivations, but rather actual behavior patterns.

Empirical evidence on school-related White or native flight is limited compared to the literature on neighborhoods. Some US studies have shown that White parents tend to prefer sending their children to majority-White schools, often resorting to private or charter schools (Betts and Fairlie 2003; Renzulli and Evans 2005; Fairlie and Resch 2002; but see a counterpoint by Rapp and Eckes 2007). Further, free school choice has been shown to contribute to school segregation in the U.S (Bischoff and Tack 2020), and these patterns are also confirmed across a range of country settings in a systematic review by Wilson and Bridge (2019).

A few US studies have used vignette experiments to investigate preferences for schools with different racial compositions among parents and students (Billingham and Hunt 2016; Hailey 2020; Bielamowicz 2019). Such studies have consistently found preferences for own-group majority schools among Whites, and, in a recent study, more flexible racial preferences among other racial groups, particularly Blacks (Hailey 2020). Similar patters were found in a survey-based study in the Netherlands, where the ethnic composition of the school was highly influential on parents' school choices, and parents tended to reject predominantly non-White schools (Karsten et. al. 2003). In the German city of Essen, however, ethnic segregation across schools seems related mainly to Turkish origin parents' preferences, who – due to unfamiliarity with the school system – tend to opt for the school with the highest share of foreign nationals (Kristen 2008). Few studies have investigated parents' school choices or preferences in Nordic countries. Two studies, addressing the Swedish system of free school choice, indicated that parents' choice of school is related to neighborhood characteristics (Malmberg, Andersson, and Bergsten 2014), and that the generalized choice reform resulted in small increases in socioeconomic and ethnic school segregation (Böhlmark, Holmlund, and Lindahl 2016). A Finnish study also found that the ethnic and socioeconomic composition of the school mattered for school choice and avoidance behavior among middle-class residents in Helsinki (Bernelius and Vaattovaara 2016). Recently, Bjerre-Nielsen and Gandil (2020) found that parents opted out of schools where a high share of students had low socioeconomic status or non-Western immigrant origins

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in Denmark, and often either sent their children to another public school, to a private school, or moved to a different area. A similar conclusion was drawn by Kauppinen, van Ham, and Bernelius (2020), who studied the impact of school catchment area boundaries in Helsinki, Finland, using a GRD design. They found clear evidence of avoidance behavior among affluent native families with young children.

2.4 Our Contribution

Previous research on White or native flight and school segregation generally falls into one of two categories. First, several studies document associations between school characteristics and White or native flight. While these results are important, it is difficult to give them a causal interpretation as the observed flight behavior may be confounded by neighborhood-level characteristics such as the neighborhoods' socio-economic or ethnic composition. Kauppinen, van Ham, and Bernelius (2020) have used a research design suitable for causal inference, but studied avoidance behavior, which could impact spatial segregation patterns, but reflects a less active choice than flight behavior.

In the second category we find studies that document preferences for own-group majority schools and show that such preferences are causally linked to their ethnic or racial composition. While equally important, they cannot directly show whether such preferences translate into actual school choices or flight (Billingham and Hunt 2016; Hailey 2020; Bielamowicz 2019). The main contribution of this paper is our ability to address whether observed patterns of native flight are causally related to characteristics of schools, over and above the effects of neighborhoods.

Our study also complements a previous study by Bjerre-Nielsen and Gandil (2020), which exploited the exogeneous shocks of catchment area redrawings to document flight behavior from schools in Denmark. Their focus was on socioeconomic school composition, which is strongly correlated with ethnic composition, while our study provides evidence on a similar mechanism in a different national context.

3 Oslo and the School System

Oslo is the capital of Norway, a Nordic social-democratic welfare state. It is also the municipality with the highest share of immigrant origin minorities in the country. As of January 1st 2023, the municipality of Oslo had a total population of 709 037 (Statistics Norway 2023a), a population that increased steadily from 507 467 at the turn of the century. Approximately 26% of the total population of Oslo are immigrants (born abroad with two parents born abroad), while 8.4% are Norwegian-born children of two immigrants (Statistics Norway 2023b).

Oslo is also a segregated city. Whereas the western and south-western parts of the city are relatively affluent and dominated by the native ethnic majority, central, southern, and eastern city districts are less affluent and more ethnically diverse (Wessel 2015, 2017; Toft 2018; Haandrikman et al. 2021). This division has evolved as a consequence of long historical processes, such as industrialization, urbanization, and building regulations, as well as more recent developments, such as the settlement of newly arrived, relatively disadvantaged immigrants in neighborhoods in the central, eastern and southern parts of the city (Myhre 2017). Approximately 14 % of individuals in Oslo move internally every year in the period studied here – a rate that has fluctuated between 11.9 % and 14.2 % over the last two decades (Statistics Norway 2024a), while nearly 5 % move out of the city every year (Statistics Norway 2024b).

Admission in the compulsory public school system in Oslo is based on the principle that children attend their local school, as defined by the catchment areas drawn by the municipality. These encompass a given geographical area surrounding the school. The municipality may redefine the catchment areas of schools in

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response to capacity constraints, but not as a tool for affecting the compositions of students (The Norwegian Directorate for Education and Training 2014)[2]. Thus, public schools in Oslo differ greatly in their student composition mainly due to residential segregation. In the school year 2016/2017 the proportion of minority language students in public elementary schools varied between 0% and 98.3% (Oslo Kommune n.d.-a). A full, updated map of the school catchment area borders are available at Oslo Municipality's web page (Oslo kommune n.d.-b).

Parents may opt out of their local schools by either moving (the mechanism we study), applying for their child to attend another nearby school, or through private schools. The vast majority of children in Oslo attend public schools. As of 2019, only 8 percent of school-aged children in Oslo were not registered at a public school[3]. Out of 118 elementary schools (including 14 combined elementary and secondary schools) in Oslo in 2019, only 13 were private schools (Abildsnes 2020). The private schools are primarily religious schools, providers of education with alternative pedagogical approaches, or providers of education in other languages, and most are not regarded as of higher quality than public schools (Lauglo 2010).

Children start school in August the year that they turn 6 years old. In December the year before the child starts school, the parents receive a letter from the local school informing them of the child's enrollment. This initial enrollment is based on the registered place of residence as of November 1st. Final enrollment is in April. Parents may appeal the decision on what school should be considered their local school to the County Governor. For the school years 2012/2013-2015/2016, the municipal Education Agency reported 124 such appeals out of nearly 30,000 enrollments. In the vast majority of such appeals, the decision was not changed (Education Agency of Oslo 2019; e-mail correspondence).[4] We therefore consider this to be a minor issue.

Applications to change schools are prioritized based on the capacity at schools, based on geographical distance, siblings at the school, traffic and safety, social and/or medical considerations, the views of the applicant, and other practical considerations, such as distance to parents' place of work or siblings' kindergarten etc. (Oslo Kommune n.d.-c). The application will be granted if the school they apply to has capacity to take more children (Education Agency of Oslo na)[5],

According to Abildsnes (2020), more than 90 % of students attend their local school, but some schools are more (less) popular than others, attracting more (fewer) students than would be expected based on their catchment areas. The least popular schools tend to be those that have a higher minority concentration than their neighboring schools, suggesting patterns of local school selectivity based on native avoidance.

While parents may not know the exact student compositions at schools, they likely have, or can gain, some general idea about whether the local school has a relatively high or low share of immigrant origin students. School compositions generally reflect neighborhood compositions, and some information on the student

[2] We have also had a meeting with representatives from the municipality where the procedures for the drawing of catchment area borders were explained to us.

[3] They either attended private schools, attended schools with special needs education, had private home schooling, were erroneously registered as resident in Oslo, did not attend school at all (despite legal requirements) or were not registered at a school in Oslo for some other reason.

[4] 2 appeals were rejected by the Education Agency (EA); in 3 appeals, the County Governor (CG) partially ruled in favor of the plaintiff; in 19 cases, the child was assigned to another school due to changes in the capacity, so that the case was not considered by the CG; 90 appeals were rejected by the CG; in 5 appeals, the decision was changed by the EA; 5 appeals were withdrawn by the parents (Education Agency of Oslo 2019e-mail correspondence).

[5] In an attempt to collect information on the volume of such applications and the share of such applications that are approved, we sent out e-mails to all elementary schools in Oslo, asking them to supply us with information on this. Unfortunately, only one school replied with this information.

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composition is publicly available (Oslo Kommune n.d.-a). We aim to assess whether local schools with varying student compositions impact families' moving behavior.

4 Data and Methods

4.1 Data

In our main analysis, we rely on administrative register data covering all residents in Oslo over the years 2012 to 2014, provided by Statistics Norway. We also use information from 2011 for lagged characteristics and data from 2015 to identify movers in 2014. Unique personal identifiers allow us to link data form different administrative registers, including population registers, tax records, educational registers, etc. Additionally, we have access to geocoded data on place of residence on a 100x100m grid allowing us to locate the place of residence of each individual or family with great precision – a prerequisite for our research design.

We have further obtained data from the municipal Education Agency on local school catchment area boundaries that affected children who started in elementary school in the years 2013-2015. These came in the form of lists of addresses that we separately geocoded onto a 100x100m grid using publicly available geocodes (Norwegian Mapping Authority/Geonorge 2018), allowing us to link school catchment areas to grid cells. No sensitive or identifiable information was ever linked to addresses. Additionally, we assigned a pseudonym to each school before linking catchment areas to register data to preserve the anonymity of the schools.

4.2 Sample and Variables

Our main interest is in whether ethnic majority families respond to local schools with high proportions of ethnic minority students by moving out. Since we do not have register data on ethnicity, we use immigrant background and country of origin as a proxy for ethnic minority/majority categorization. In our main specification we define the ethnic majority families as families where at least one parent is born in Norway by two Norwegian-born parents, and none of the parents originate from a non-Western country. Although somewhat arbitrary, this classification is both relatively simple and ensures a reasonable sample size. We define the minority student group as immigrants (born abroad to two foreign-born parents) and children of immigrants (born in Norway to two foreign-born parents) originating from non-Western countries[6]. This choice is based on an assumption that individuals originating form non-Western countries are especially likely to be subject to prejudice and avoidance behavior from the native origin population. However, we test the sensitivity of our estimates to the classification of both majority families and minority students.

We do not have access to data on actual school enrollment, so to calculate the share of non-Western origin pupils at each local school, we use the share of children in elementary school age (aged 6-12 years) among children residing in the school catchment area each year. Although some children attend other schools than their local school, as clarified above and discussed below, we believe this measure is a good proxy for the share of non-Western origin pupils in schools.

In an alternative model specification, we use information on the proportion of minority language students to measure the school composition. This information is only available for the years 2013 and 2014, which limits the sample size for this analysis. We also specify alternative models where we use measures of other

[6] Western countries include EU/EEA countries, USA, Canada, Australia and New Zealand. If immigrant parents have different countries of origin, the mother's country of origin is used.

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school characteristics, including the proportion of parents with higher education, the schools' average standardized test scores, and a value added indicator for school quality.

We take families as our units of analysis, as we believe the decision to move will usually be taken at the family level. Families are defined according to Statistics Norway's definition as "persons resident in the same dwelling and related to each other as spouse, registered partner, cohabitant, and/or parent and child (regardless of the child's age)" (Statistics Norway n.d.). We further limit our main analysis sample to include only native families where the oldest child is older than 2 and younger than 6 years old on January 1st in the given year. This is because we assume that, while other concerns (space constraints, kindergarten availability etc.) are likely more important to families with very young children, school characteristics matter more for decisions to move as the oldest child approaches school starting age[7]. We test the sensitivity of our estimates to this specification.

At the family level, we include information on several indicators of demographic/housing characteristics (family size, age of the oldest family member, parents' marital status, and the family's type of dwelling, measured by a dummy for living in an apartment building) and socioeconomic characteristics (parents' total income, total gross wealth and debt, and highest attained level of education, in addition to a measure of the share of parents currently enrolled in education). We lag income and education (level and enrollment) by one year. Unfortunately, we do not have data on housing prices.

In our data, some grid cells contain residents on both sides of a catchment area border. We omit these residents from the analyses because we cannot with certainty identify which catchment area they belong to. This reduces our effective sample size by 10 percent. While dropping observations close to the border is problematic, we are forced to do so because they cannot be clearly assigned to the treatment or control group.

4.3 Challenges to Causal Identification

There are some major hurdles to overcome when studying whether parents selectively move in accordance with preferences for their school's ethnic composition.

The first is **neighborhood-level confounding**. School characteristics systematically correlate with neighborhood characteristics. Such characteristics may include the ethnic or socioeconomic composition of neighborhoods, crime rates, pollution, geographical features, dwelling types etc. Estimates will likely be biased upwards if neighborhood-level characteristics affect natives' propensity to move. We employ a geographical regression discontinuity (GRD) approach to circumvent neighborhood-level confounding. In effect, our design compares similar families that reside in the same neighborhood, but in different catchment areas. Neighborhood-level characteristics are assumed to be a continuous function of distance to the catchment area border, and, to the extent that these are not extremely local and sharply differ along these borders, they are thus controlled for in our models. This assumption may be violated for instance if the borders are not arbitrarily drawn (e.g., rental or public housing apartments systematically cluster on one side of the border). Catchment area borders are somewhat, but not entirely arbitrarily drawn. The Municipality of Oslo draws up catchment areas primarily based on geographical distance to schools, but other factors, such as ensuring safe school routes and considerations for tight local communities may also weigh in (Education Agency of Oslo na). Such considerations in boundary drawing may be a source of bias.

[7] The importance of taking the oldest child's age into account is underlined by Goyette, Iceland, and Weininger (2014), who showed that parent's decision to move based on neighborhood racial composition is conditional on the age of the oldest child.

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The second is **school-level confounding**. Characteristics of schools correlate with the share of immigrant origin students. Schools with a high minority concentration may for instance have lower socioeconomic status among the students (Hermansen and Birkelund 2015) or struggle with teacher attrition (OECD 2010; Bonesrønning, Falch, and Strøm 2005). Such factors may confound the effect of the share of immigrant origin students. Although the quality differences between Norwegian schools are likely to be modest (Oftedal Telhaug, Mediås, and Aasen 2006), school-level characteristics that correlate with the student composition are an integral part of the potential consequences of school segregation (Borgen 2023a). Thus, controlling for school characteristics in an attempt to estimate the net effect of the share of immigrant origin students may introduce overcontrol bias[8]. School characteristics that induce school-level confounding will thus not be netted out in our design. In sum, this is a matter of interpretation. Our estimates do not represent the isolated effect of minority concentrations at schools, but the total effect of schools characterized by (among other things) a higher minority concentration.

The third challenge is **geographic self-selection**, meaning that natives who move to a neighborhood and school with a high share of residents and students of immigrant origin may differ systematically from people who don't. In our main analytical approach, the generalizability of our findings relies on the implicit assumption that no such self-selection occurs. We test wether this assumption holds for observed family characteristics in our register data (please see section 5). However, we cannot test whether our assumption holds for unobserved characteristics such as tolerance, values, and preferences. Thus, those who choose to reside close to school catchment area borders where there is a high contrast in the schools' minority concentration – who make up our main analytical sample – may be a fairly tolerant segment of the population. Importantly, such geographical self-selection would mean that our estimates represent the average treatment effect for relatively tolerant families – families who are less likely to respond to the immigrant share at the school compared to a random family. Machin and Salvanes (2016) found that families' moving patterns reveal a substantial preference for better-preforming upper-secondary schools, which may be correlated with the schools' immigrant share, suggesting that such self-selection is likely. The process we study is itself such a selection process, entailing that this population is in part endogenously conditioned on previous moves; if the share of minority students at a school causes some families to move, the families remaining the next year will consist of a relatively tolerant subsample, plus new families. All in all, this implies that the self-selection would make our estimates of native flight downwardly biased, in the sense that it would be a conservative indication of the flight patterns that would occur if families were randomly assigned to either side of the border.

In addition, there are **other ways to avoid the local school than by moving**. The school enrollment process is not entirely deterministic, and subject to exceptions. As discussed above, parents have some opportunities to opt out of their local schools. The most important option is to apply to another school (or send their children to one of the few private schools in Oslo). Such applications likely represent a more common and less costly avenue of avoidance, as shown by Bjerre-Nielsen and Gandil (2020). Schools with high shares of minority language students experience significantly more of this type of student flight (Abildsnes 2020). This indicates that among those who do not respond to the local schools' minority concentration by moving, many submit a transfer application. By studying only one of the ways parents might select schools for their children, i.e., by moving, we essentially study those who do not transfer their children, are unaware of this option, or are not willing to take the risk of a rejected application. We also note that parents may move or apply to have their children attend another school after school has started. The possibility of transferring to private schools or neighboring schools may bias our estimates downward,

[8] An exception may be permanent features of schools, such as location, size or playground quality. Unfortunately we have limited data on such features.

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especially for families residing near borders, since applicants residing nearer to the school they apply to are prioritized.

In sum, our empirical strategy mainly reduces the potential upward bias from neighborhood-level confounding. Biases and attenuation due to other factors primarily suggest that our estimates should be seen as a lower bound of the impact of local schools with high minority concentration on native flight.

4.5 Model Specifications

We use the border discontinuities to study the effect of belonging to a school characterized by – among other things – a higher share of students from non-Western immigrant backgrounds. Our running variable is not strictly distance to the border, but rather, distance to the nearest grid cell where all valid addresses belong to another school catchment area. A map of distances to the school borders is shown in **Figure 1**. Due to the discrete nature of the distance between grid cells, the lowest (absolute) value on this variable is 100 meters. We therefore subtract 50 meters from the absolute value of our running variable on either side of the border in our main specifications. We also limit our bandwidth to 600 meters from the nearest populated grid cell in a different catchment area (that is, on average, 550 meters from the border), as there are few observations beyond this distance. We assess the sensitivity of our estimates to these specifications.

[FIGURE 1]

We pool data for the years 2012-2014. In our data, we have 306 borders that are shared by pairs of schools (hereafter: dyads), along which we can compare families on either side of the border. We use a nearest neighboring school-approach, where each family is assigned to the school whose catchment area they reside inside, and one neighboring school, which is always the school where the distance between the family's place of residence to the catchment area border is shortest. Each family is only included once. Ideally, we would study each dyad separately and only compare families that live in the same neighborhood but belong to different schools. However, only a limited number of people live on either side of the border in each dyad. Our analytical interest is in comparing neighboring schools with large contrasts in terms of their minority composition, where we would expect to see an effect on out-mobility. We therefore sample the 25 % of school dyads with the largest difference in the share of students with non-Western immigrant background, between the two schools. In this quartile of dyads, this difference is on average 33 percentage points (compared to 2, 6, and 14 percentage points in quartiles 1-3, respectively). Estimates for the lowest quartile is used as a placebo test.

We present results from both parametric and non-parametric specifications. In the non-parametric specifications, families are considered treated if they reside on the side of the border that has the school with the highest concentration of non-Western immigrant background pupils. Here, we also limit the bandwidth to 400 and 200 meters (350 and 150 meters with the abovementioned border correction) on either side of the border. The running variable takes negative values in the school catchment area with the lowest share of students with non-Western immigrant background (untreated), and positive values for the school with highest share of students from non-Western immigrant backgrounds (treated) within each dyad. It is zero at the border by construction. Thus, our running variable, x_i, takes the following values:

$$x_i = \begin{cases} distance_i - 50 \; if \; SL_i \geq SN_i, and \; distance_i \leq 600 \\ -1 \times distance_i + 50 \; if \; SL_i < SN_i, and \; distance_i \leq 600 \end{cases}$$

where $SL_i$is the share of non-Western immigrant background students at the local school of family *i*, while SN_i is the same share at the nearest neighboring school. Our treatment indicator, D_i takes the values 1 if x_i is greater than zero, and 0 otherwise.

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Our outcome variable, hereafter denoted *moved*, is a dummy variable that takes the value 0 if the family did not move to a different school catchment area in a given year (i.e. that they either lived in the same 100x100m grid cell or another grid cell within the same school catchment area). It takes the value 1 if they moved to a grid cell not within the same school catchment area that year, regardless of where that catchment area is located, thus including moves to locations outside the city. Our dichotomous specification can be written as

$$moved_i = \alpha + \rho \times D_i + \varepsilon_i, \qquad (1$$

This specification simply represents a comparison of the (conditional) mean out-mobility on either side of the border. Parametric (linear or polynomial) specifications further account for unobserved characteristics of families and neighborhoods that are a continuous function of distance to the border. Our main linear specification can be written as

$$moved_i = \alpha + \beta_1 \times x_i + \rho \times D_i + \beta_2 \times D_i \times x_i + \varepsilon_i, \qquad (2$$

where, α is the constant term, β_1 is the coefficient for the running variable, and β_2 is the coefficient for the running variable interacted with the treatment indicator D_i. ε_i is the residual. In both equations, ρ captures the parameter of interest; the difference in out-mobility at the border. The units are families.

According to Gelman and Imbens (2019), there are good reasons not to include high-order polynomials in RD designs as these are highly sensitive and may produce misleading results. However, for the sake of transparency, we also present results using 2nd through 4th degree polynomials. Model 2) can be expanded to include higher-order polynomials, indicated by p:

$$moved_i = \alpha + \beta_1 \times x_i + \rho \times D_i + \beta_2 \times x_i^2 + \cdots + \beta_p \times x_i^p + \beta_1^* \times D_i \times x_i + \beta_2^* \times D_i \times x_i^2 + \cdots + \beta_p^* \times D_i \times x_i^p + \varepsilon_i \qquad (3$$

We also expand our models to include control variables measured at the family level. All models are estimated with triangular kernel weights, giving more weight to observations closer to the border, and a heteroskedasticity-robust nearest neighbor variance estimator.

5 Descriptive Statistics and Balance Tests

Table 1 shows descriptive statistics for our analysis sample, separately for schools with high (treated) and low (untreated) shares of non-Western origin students. The share of native origin families that moved is substantially higher (11 percentage points) in treated catchment areas, in line with theoretical expectations. Regarding the other variables, there are marked differences, but the important question is whether these come in the form of a discontinuous jump at the border. To assess whether there are discontinuities at the borders for observable potential confounders, we have run the models presented in Equations 1-3, but using variables listed in Table 1 as outcomes. **Table 2** presents the main results from this exercise, using a linear specification with a 600 m bandwidth. Overall, the results from these balance tests are satisfactory. None of the estimates indicate sharp discontinuities. However, we nevertheless present models that control for these variables to reduce potential bias. Density tests are provided in the supplementary material (S1).

[TABLE 1] [TABLE 2]

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6 Main Results

6.1 Ethnic School Segregation and Out-Mobility

While Wessel and Nordvik (2019) have shown that parents with pre-school children have a strong tendency to move out of *neighborhoods* with high concentrations of immigrants in Oslo, **Figure 2** shows that this is also the case for *school catchment areas*. Here, circles in the left, blue panel represent school-by-year-level out-mobility among native families where the oldest child is aged between 2 and 5 years old. The line is a Lowess smoother. The middle (red) panel shows the same for native families where the oldest child is aged between 14 and 17. This comparison group is likely unaffected by the student composition at local elementary schools. The right (green) panel shows the same for immigrant origin families where the oldest child is aged between 2 and 5. If these tend to 'flee' schools with high minority concentrations, this would put into question whether 'native flight' is a relevant mechanism. Among natives with pre-school children, there is a strong, positive relationship between out-mobility and the share of students with non-Western immigrant backgrounds at the local school. Among parents with older children, and immigrant-origin families, we find much weaker associations between school composition and out-mobility. In other words, native-origin parents with young children do systematically move away from schools with high shares of students with non-Western immigrant backgrounds. In the remainder of this article, we assess whether this pattern is driven solely by neighborhood-level characteristics, or if local schools also play a causal role.

[FIGURE 2]

6.2 GRD Estimates of the Effect of Local School Affiliation on Native Out-Mobility

In **Table 3**, we present GRD estimates of the effect of the local school affiliation on out-mobility in school dyads with large differences in the minority concentration. All model specifications are presented both with and without control variables. Results from models without controls are also plotted in **Figure 3**.

There are two important features to note. First, the results using dichotomous specifications are consistent with our expectations and suggest that school borders have a large effect on native parents' out-mobility. The point estimates range between 0.056 and 0.111, depending on the bandwidth and inclusion of control variables. This suggests that residing in a school catchment area with, on average, a 33 percentage points higher concentration of non-western minority students increases yearly out-mobility among native families by around 5.6 to 11.1 percentage points. This is a quite substantial effect, given that the out-mobility rate in the sample is around 19 %. Estimates are somewhat smaller when control variables are included. This may also indicate that the estimates may be sensitive to other unobserved characteristics relevant to relocation decisions. Prime candidates for such unobserved factors are families' tolerance and preferences, as well as characteristics of their residence and neighborhood. Such factors may be better accounted for with a parametric specification, to the extent that they are a continuous function of distance to the border.

Second, these results are highly sensitive to the choice of functional form. In our linear specification, the point estimates are smaller and (barely) not statistically significant at the 5 % level. When we use 2nd to 4th degree polynomials, the point estimates change substantially, turn from positive to negative, and lose statistical significance. It is worth reiterating that higher-order polynomial estimates are very sensitive and may produce noisy estimates (Gelman and Imbens 2019). However, these estimates make our results difficult to interpret. On the one hand, they clearly indicate that out-mobility is considerably higher in school catchment areas with higher minority concentrations, and that these differences are large even between very close neighbors. On the other hand, we cannot rule out that our GRD results may be driven by nonlinear patterns rather than discontinuities.

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However, since families residing nearest a border are likely to be prioritized in applications to change schools (as applications are in part prioritized based on geographical distance) we could also expect lower out-mobility for families residing in catchment areas with high minority concentrations but very close to borders to schools with lower concentrations. This could bias our estimates downwards, especially with higher-order polynomials. A visual inspection of Figure 3 suggests that the strongly negative estimates obtained with higher-order polynomials are driven by a few families residing very close to the border in catchment areas with high minority concentrations. There is also a potential for bias due to measurement error if, for instance, a building located within meters from a grid cell border, or intersected by it, is erroneously coded to the neighboring grid cell. To assess this, we also estimate alternative specifications (below) where we exclude the families residing nearest the border. In these specifications, we drop observations within 50 meters of the border (a 'donut hole') to test for endogenous sorting and measurement error around the threshold.

[TABLE 3] [FIGURE 3]

6.3 Placebo tests

We run three types of placebo regressions, all shown in Table 4, using the same model specifications as we do in Table 3, to assess whether other factors besides school characteristics may be driving our results. In the first set of placebo regressions, we include only families where at least one parent is an immigrant originating from a non-western country. If this group exhibits similar out-mobility patterns as native families, it would suggest that our positive results are driven by general out-mobility, not native flight. We find no statistically significant effects in this group. Second, we study families whose oldest child is aged 14-17 years, as explained above. If differences in out-mobility at the border are driven by school catchment areas and not other, unobserved factors, we should expect estimates for this group to be small and non-significant. This is also what we find. Third, we present results for the 1st quartile. Here, the proportion of non-Western students is practically identical within each dyad, so if differences in families' out-mobility is driven by differences in this proportion or correlated school characteristics, we should expect small and non-significant coefficients. That is what we find in the majority of model specifications. In one specification, the estimate is (barely) significant at the 5 % level. All in all, these placebo tests are mostly in line with the notion that out-mobility patterns are partly driven by school-related preferences among native families with small children.

[TABLE 4]

6.4 Sensitivity Analyses

To assess the sensitivity of our results to various model specifications, we present results where we vary the following characteristics of our models on by one, compared to our main specifications; First, we change the target quantile (the school dyads we study) from the 25 % of schools with the largest contrasts, to the 40 % and 10 % of schools with the largest contrasts, respectively. Second, we include families where the oldest child is aged between 0 and 5 years. Third, we include only families where both parents are native (or the one parent, in cases of single-parent families). Fourth, we define the minority group as immigrants and children of immigrants from either non-European or non-Norwegian origins. Fifth, we characterize schools by the proportion minority-language students (Oslo Kommune n.d.-a), the proportion of parents whose oldest child is in school age that have higher education (estimated from our data), and the mean scores on national tests and a value added indicator from 2010-2011 (Steffensen et al. 2017). Sixth, we

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contract 99 meters instead of 50 meters on either side of the border, to reduce the gap in observations near the threshold. Finally, we exclude the families residing closest to the border (creating a 'donut hole') as these may be more likely to apply to nearby schools. The results are plotted in Figure 4. Overall, these estimates are quite similar to our main specifications. Notably, however, we see less tendencies of out-mobility when characterizing schools by their quality. The results remain highly sensitive to the use of higher-order polynomial specifications, but our 'donut hole' specification - where all estimates are positive - indicates that this sensitivity stems from a few observations residing nearest the border that have a strong impact on the higher-order polynomial results. Subgroup analyses stratified by parents' education also produce similar results as our main specifications (Supplementary material, S2).

Since our GRD design is sensitive to residential self-selection around the border, we have made attempts at employing a second identification strategy as a robustness check; a two-way fixed effects Difference-in-Differences (DiD) estimation where we exploit plausibly exogenous variation in the local schools' concentration of minority students arising from the redrawing of school catchment area borders. This approach effectively removes bias due to both neighborhood-level confounding and geographic self-selection. However, due to the low number of border redrawings between schools with a substantial difference in student composition, the number of 'treated' families in these analyses was low, resulting in limited statistical power and unstable, non-parallel pre-treatment trends. We therefore do not include these results.

[FIGURE 4]

6.5 Destination schools

Ideally, we would also leverage information on the destination schools of movers to assess whether out-mobility from schools represents 'flight' to schools with lower minority concentrations. There are two issues with this. First, compared to schools with high minority concentrations, most other schools have lower concentrations. Thus, even random moves would generate patterns of flight from schools with high minority concentrations to schools with lower concentrations. Second, we only have data on school catchment areas in the municipality of Oslo. Thus, families moving out of the city to other municipalities (or even families that move abroad) would be excluded from such an analysis. Most other municipalities have low minority concentrations relative to catchment areas in Oslo with high concentrations, meaning that we would underestimate patterns of 'flight'.

We do, however, provide a descriptive analysis of the minority concentration of origin schools and destination schools for movers who move within Oslo as a supplementary analysis. As expected, these analyses reveal that families moving out of catchment areas with high minority concentrations on average tend to move to schools with lower minority concentrations, avoiding schools with high concentrations. Details are provided in S3.

7 Limitations

Our study has several limitations. First, we cannot rule out the possibility of selection along the border between schools. We have attempted to compensate for this by exploiting the redrawing of such borders. While these results generally suggested patterns of native flight, they were not particularly robust, and future studies with access to more years of mobility data may be able to draw stronger conclusions. Relatedly, we cannot rule out the possibility that unobserved characteristics of families differ along the borders, although our balance tests revealed no such discontinuities for the variables we included. It is also worth noting that

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if the out-mobility of some native families affects families across the borders, this would violate the stable unit treatment value assumption.

Second, actually moving to a different school is only one avenue of 'flight' for native parents. Parents may apply for attendance at another nearby or private school, and those who move may be those least willing to take the risk of a rejected application or are unaware of this option. In this sense, our results are likely downward biased – particularly for residents close to the border, a notion supported by our 'donut hole' specification. Unfortunately, our attempt to survey the extent of applications to nearby schools was unsuccessful. Related to this, we do not use data on where families move to in the main analysis due to the issues discussed above, but we provide supplementary descriptive analyses of these patterns.

Third, our study is limited in time and space, to the Oslo context in the period 2012-2014. The effect we estimate pertains to native families with small children residing near catchment area borders where schools differ substantially, who have not already moved. The external validity of our findings depends on whether the mechanisms that produce these patterns generalize to other contexts. Given the progressive resource allocation of the Norwegian school system, and that Norwegians on average have relatively tolerant attitudes towards minorities (Blom 2011), we find it likely that patterns of flight will be stronger in less egalitarian or tolerant contexts. Our results also support the notion that theories of school-related flight can be applied to non-US contexts and immigrant origin minorities.

Finally, we cannot say for sure what characteristic of the local school parents might flee. While the share of immigrant origin students is a likely suspect, this share is also strongly correlated with the socioeconomic composition of the school and other potentially salient factors that immigrant origin composition may proxy for. These factors are difficult to disentangle, as suggested by our sensitivity analyses where schools are characterized by parents' education.

8 Discussion and Conclusions

A large research literature has documented that native or White households tend to move out of neighborhoods with high concentrations of ethnic or racial minorities. The main objective of this study was to explore one of the potential mechanisms that might contribute to such moving patterns; moves away from local schools with high concentrations of minorities. We found indications that native families with pre-school children systematically tend to move away from schools with higher shares of students with non-Western immigrant backgrounds in Oslo, Norway, and that such moves may in part be related to characteristics of their local school, not just their neighborhood. However, it is important to stress that our results are ambiguous and not clear-cut. They are sensitive to model specifications, and more research is needed to provide conclusive answers. Future studies could attempt to study the impact of changes over time in the ethnic composition of schools or, using data covering more years, fully exploit the redrawing of catchment area boundaries and employ a differece-in-differences estimation that exploits exogeneous variation in the concentration of minority students at the local school.

Patterns of native flight from schools may have many explanations. Our results suggest that life course explanations, whereby young, native, urban couples with young children suburbanize because they want larger dwellings in a child-friendly neighborhood, may be insufficient as they cannot explain why similar families, living in the same neighborhood, but on either side of the catchment area border, move out at different rates. Nevertheless, neighborhood and individual-level characteristics may also play important roles in contributing to native out-mobility.

We cannot with our data assess what aspects of schools parents might consider when deciding whether to relocate. The research literature has pointed to preferences for the ethic/racial composition as an important

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factor, and our results, to the extent that they reflect patterns of native flight, are in line with such an interpretation. Notably, our results show that non-Western immigrant families and families with older children do not display patterns of out mobility from schools with high minority concentrations, and that there were hardly any differences in out-mobility between neighboring schools with similar minority concentrations.

Preferences for schools may be motivated in several different ways, ranging from prejudiced or racist views of minorities, parents viewing a high share of immigrant origin students as an indicator of other, more salient issues at the school, (such as teacher quality, the socioeconomic composition of the students, etc). Parents may also interpret information about schools differently, depending on the composition of the students, or worry that their children will fare worse academically or socially from having peers of immigrant background (despite empirical evidence to the contrary). We cannot isolate characteristics of schools, as these are strongly correlated with the minority concentration. In fact, we found similar patterns when characterizing schools based on the concentration of non-Norwegian or non-European minorities or minority language students, and the proportion of parents with higher education. Interestingly, however the moving patterns we find are less related to the schools' average test scores. This suggests that the out-mobility indicated by our main analyses is not solely explained by immigrant concentration serving as a proxy for lower-quality schools. Meanwhile, null findings for immigrant-origin families support the notion that ethnicity is a relevant factor. While our analyses shed light on the relationship between school preferences and segregation in schools and neighborhoods, endeavors to further disentangle the motivation for these school preferences are needed.

Thus, we find it pertinent to stress that, to the extent that our results suggest patterns of native flight, we cannot rule out that moves may be motivated by other characteristics of schools that correlate with the concentration of ethnic minorities that may also be important to parents and families. Further, motivations are likely heterogeneous, so that no single explanation is universally valid. Disentangling the motivations of parents is a potentially important avenue for future research, requiring different methods and data than we have available, namely qualitative, survey-based and experimental approaches.

With regard to policy implications, we believe several efforts may be relevant to consider for policymakers interested in reducing ethnic segregation in schools and neighborhoods. First, communicating clearly the main research findings regarding immigrant-origin peer effects may reduce patterns of flight, as these primarily show small or even positive impacts of more diverse classrooms, and may counteract negative perceptions, concerns, or stereotypes. Second, both theory (Allport 1954/1979) and experimental evidence (Finseraas and Kotsadam 2017; Finseraas et al. 2019) suggest that contact and cooperation with ethnic or racial minorities reduces prejudice and negative attitudes towards minorities. Thus, if flight is primarily motivated by prejudice, the most effective long-term approach to reduce it may be to increase contact and integration in arenas such as workplaces, neighborhoods, and schools. Third, policies that allocate more resources to schools with more disadvantaged students and equalize school contexts may also reduce parents' propensity to flee if they are clearly communicated. In Norway, several such policies already exist (Taguma et al. 2009) and may explain why low-achieving students get better test scores from attending schools with high shares of immigrant origin students (Borgen 2023b). Finally, the main reason why schools are segregated is that neighborhoods are segregated. If policymakers wish to reduce school segregation, reducing residential segregation is likely the most effective means. As Bjerre-Nielsen and Gandil (2020) suggests, attempting to reduce school segregation through, for instance, the redrawing of school catchment area boundaries may not be effective if parents respond by moving or opting out in other ways.

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Tables

Table 1: Descriptive statistics for the main GRD sample.

	Lowest	Highest
Count	2,298	1,838
Share of non-Western immigrants and descendants at the school (mean)	0.22	0.53
Share of non-Western immigrants and descendants at the school (min)	0.00	0.22
Share of non-Western immigrants and descendants at the school (max)	0.57	0.84
Moved in year t	0.17	0.29
Share of parents in families with higher education in year t-1	0.83	0.79
Share of parents in families enrolled in education in year t-1	0.09	0.12
Share of families living in an apartment building in year t	0.50	0.74
Age of the oldest family member (mean) in year t	37.36	35.90
Number of persons in family (mean) in year t	3.43	3.31
Total income among parents in the family (mean) in year t-1	785,287	683,209
Total debt among parents in the family (mean) in year t	2,651,274	2,242,170
Total gross wealth among parents in the family (mean) in year t	1,920,275	1,343,569
Share of families with married parents in year t	0.46	0.39

Note: The main GRD sample is the quarter of school dyads with the largest contrast in the share of non-Western immigrant origin students at the schools (by percentage points). Descriptive statistics are shown separately for native families residing within the catchment area of schools with the highest and the lowest share of non-Western immigrant origin students. Income, wealth and debt are in 2014 NOK.

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Table 2: GRD balance tests

	Higher education	Enrolled in education	Apartment building	Age, oldest family member	
GRD estimate	0.031	-0.018	-0.002	-0.437	
Robust SE	(0.028)	(0.017)	(0.034)	(0.383)	
N	4134	4134	4136	4136	
	Number of persons in family	Total income	Total debt	Total gross wealth	Married
GRD estimate	0.023	12087.051	2.04e+05	-1.27e+05	0.041
Robust SE	(0.054)	(23117.284)	(1.25e+05)	(1.61e+05)	(0.036)
N	4136	4136	4136	4136	4136

Note: GRD estimates, using a linear (1st degree polynomial) specification, where the outcome variables are a set of potential confounders. Heteroscedasticity robust standard errors (SE) in parentheses.

No estimates are significant at the 5 % level. Two-tailed tests.

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Table 3: GRD estimates

Dichotomous						
Bandwidth	600 meters		400 meters		200 meters	
	no controls	controls	no controls	controls	no controls	controls
GRD estimate	0.114***	0.077***	0.107***	0.076***	0.079***	0.052*
Robust SE	(0.014)	(0.014)	(0.015)	(0.015)	(0.023)	(0.022)
Mean below cutoff	0.173	0.173	0.175	0.175	0.200	0.200
N	4136	4134	3779	3778	2147	2147

Parametric								
Polynomial order	1st		2nd		3rd		4th	
	no controls	controls	no controls	controls	no controls	controls	no controls	controls
GRD estimate	0.061	0.058	-0.016	-0.041	-0.078	-0.119	-0.203	-0.231
Robust SE	(0.032)	(0.031)	(0.057)	(0.055)	(0.092)	(0.088)	(0.151)	(0.146)
Mean below cutoff	0.173	0.173	0.173	0.173	0.173	0.173	0.173	0.173
N	4136	4134	4136	4134	4136	4134	4136	4134

Note: GRD estimates of out-mobility in the 25 % of school dyads with the largest contrasts in the minority concentration. Models with "no controls" include no controls except the given polynomial specification of the running variable. Models with "all controls" include family-level controls for the share of parents with higher education and enrolled in education (t-1), a dummy for living in an apartment building (t), the age of the oldest family member (t), the number of persons in the family (t), the total income among parents in the family (t-1), the total debt and gross wealth among parents in the family (t) and a dummy for whether the parents are married (t). Heteroscedasticity robust standard errors (SE) in parentheses. Minor differences in sample sizes here and in Tables 1 and 2 are due to families with missing information on parents' education.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Two-tailed tests.

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Table 4: Placebo estimates

Immigrant origin families						
Dichotomous						
Bandwidth	600 meters		400 meters		200 meters	
	no controls	controls	no controls	controls	no controls	controls
GRD estimate	-0.009	-0.003	-0.009	-0.002	-0.015	-0.002
Robust SE	(0.014)	(0.014)	(0.015)	(0.015)	(0.020)	(0.020)
N	3823	3558	3619	3365	2204	2041

Parametric								
Polynomial order	1st		2nd		3rd		4th	
	no controls	controls	no controls	controls	no controls	controls	no controls	controls
GRD estimate	-0.021	-0.013	-0.031	-0.011	-0.089	-0.071	-0.098	-0.122
Robust SE	(0.027)	(0.028)	(0.045)	(0.046)	(0.071)	(0.073)	(0.122)	(0.125)
N	3823	3558	3823	3558	3823	3558	3823	3558

Families with older children						
Dichotomous						
Bandwidth	600 meters		400 meters		200 meters	
	no controls	controls	no controls	controls	no controls	controls
GRD estimate	0.018	0.004	0.017	0.004	0.014	0.008
Robust SE	(0.010)	(0.010)	(0.012)	(0.011)	(0.018)	(0.017)
N	3215	3214	2943	2942	1454	1454

Parametric								
Polynomial order	1st		2nd		3rd		4th	
	no controls	controls	no controls	controls	no controls	controls	no controls	controls
GRD estimate	0.012	0.004	0.012	0.014	0.057	0.068	0.151	0.144
Robust SE	(0.024)	(0.023)	(0.044)	(0.043)	(0.073)	(0.072)	(0.123)	(0.120)
N	3215	3214	3215	3214	3215	3214	3215	3214

Lowest quartile						
Dichotomous						
Bandwidth	600 meters		400 meters		200 meters	
	no controls	controls	no controls	controls	no controls	controls
GRD estimate	0.016	0.010	0.018	0.012	0.033*	0.026
Robust SE	(0.010)	(0.009)	(0.011)	(0.011)	(0.016)	(0.016)
N	6692	6689	6085	6082	3118	3115

Parametric								
Polynomial order	1st		2nd		3rd		4th	
	no controls	controls	no controls	controls	no controls	controls	no controls	controls
GRD estimate	0.039	0.033	0.073	0.066	0.117	0.109	0.115	0.110
Robust SE	(0.021)	(0.021)	(0.038)	(0.038)	(0.061)	(0.060)	(0.099)	(0.098)
N	6692	6689	6692	6689	6692	6689	6692	6689

Note: GRD estimates of out-mobility. Model specifications as in Table 3, except that the top panel includes only immigrant origin families, the middle panel includes only families where the oldest child is aged 14-17, and the bottom panel includes only the 25 % of school dyads with the lowest contrasts in the minority concentration. Heteroscedasticity robust standard errors (SE) in parentheses.

* $p < 0.05$, Two-tailed tests.

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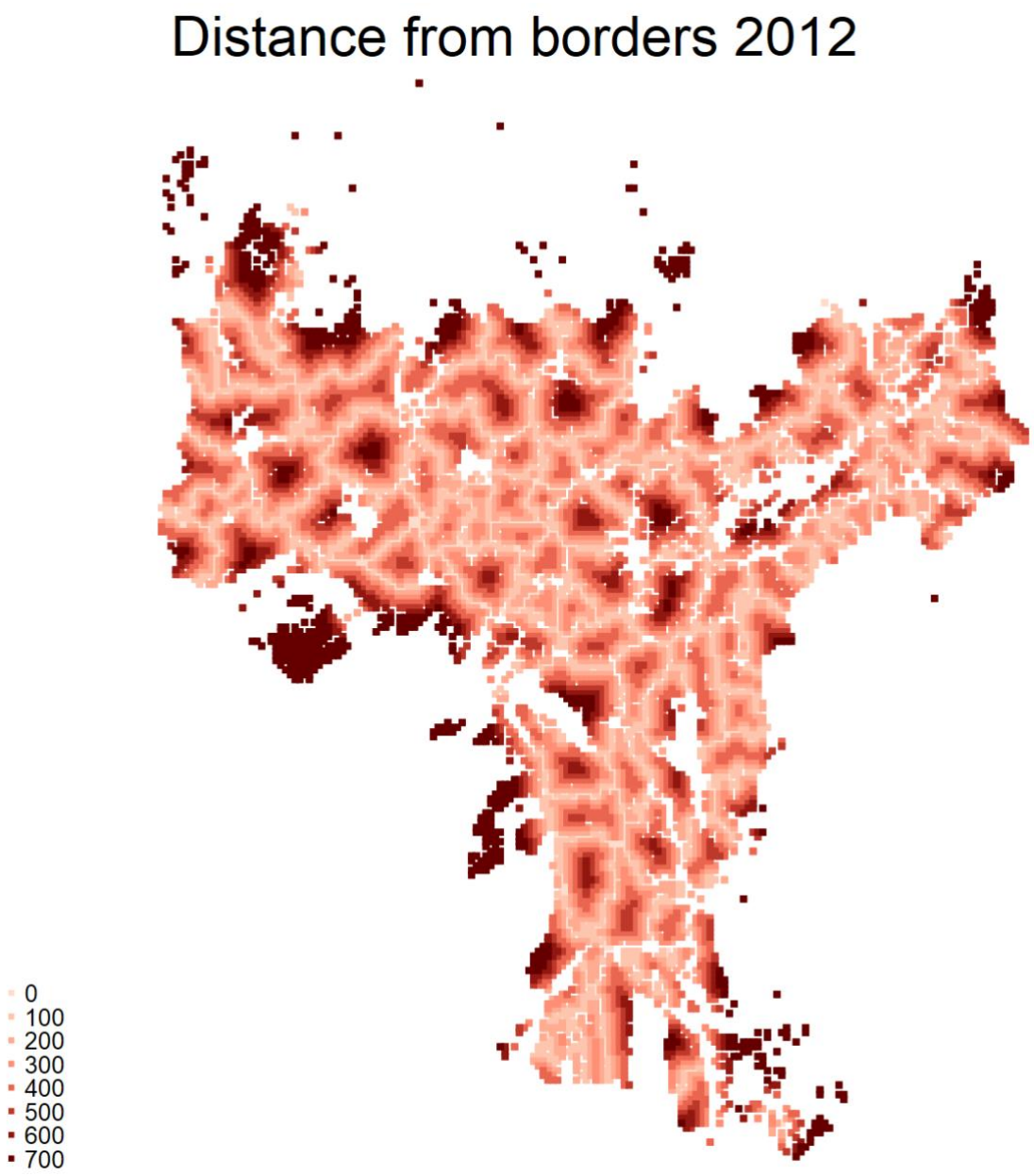
Figures

Figure 1: Map of distances to the school border



Note: The map shows all populated 100x100m grid cells in Oslo in 2012, colored by the distance to the nearest occupied grid cell in another school catchment area. Numbers in the legend represent the lowest value of each 100m bin ("100" means "100-199" etc.). Grid cells with distances over 700 are top-coded to 700. Populated grid cells are included regardless of whether they are inhabited by families that meet our sample restrictions.

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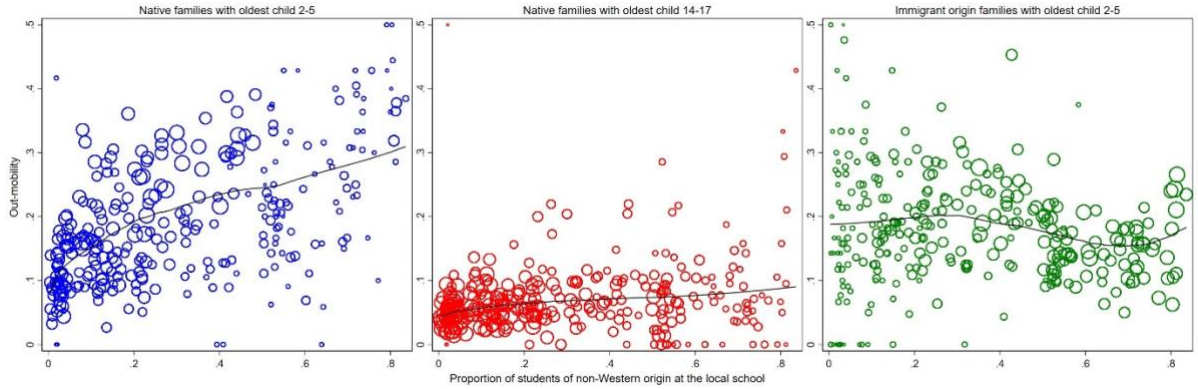
Figure 2: Out-mobility and school segregation



Note: The lines are lowess smoothers drawn based on the underlying family-level data. Circles represent school-by-year estimates of out-mobility by the share of non-Western immigrant origin students at the school, weighted by the number of families.

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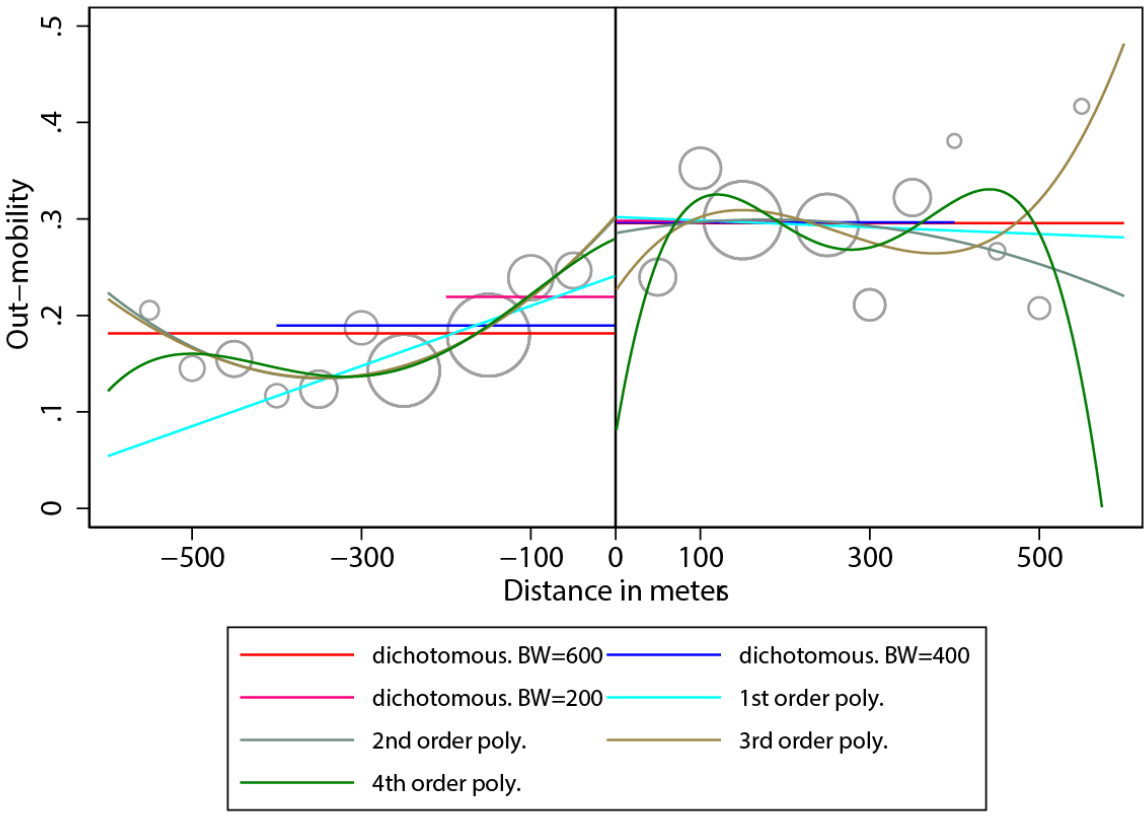
Figure 3: GRD plot



Note: Lines represent the GRD estimates from the model specifications in Table 3. Circles represent binned, unadjusted out-mobility among native families, by the distance to the nearest catchment area border, weighted by the number of families. Positive values on the x-axis represent schools with relatively higher shares of non-Western immigrant origin students.

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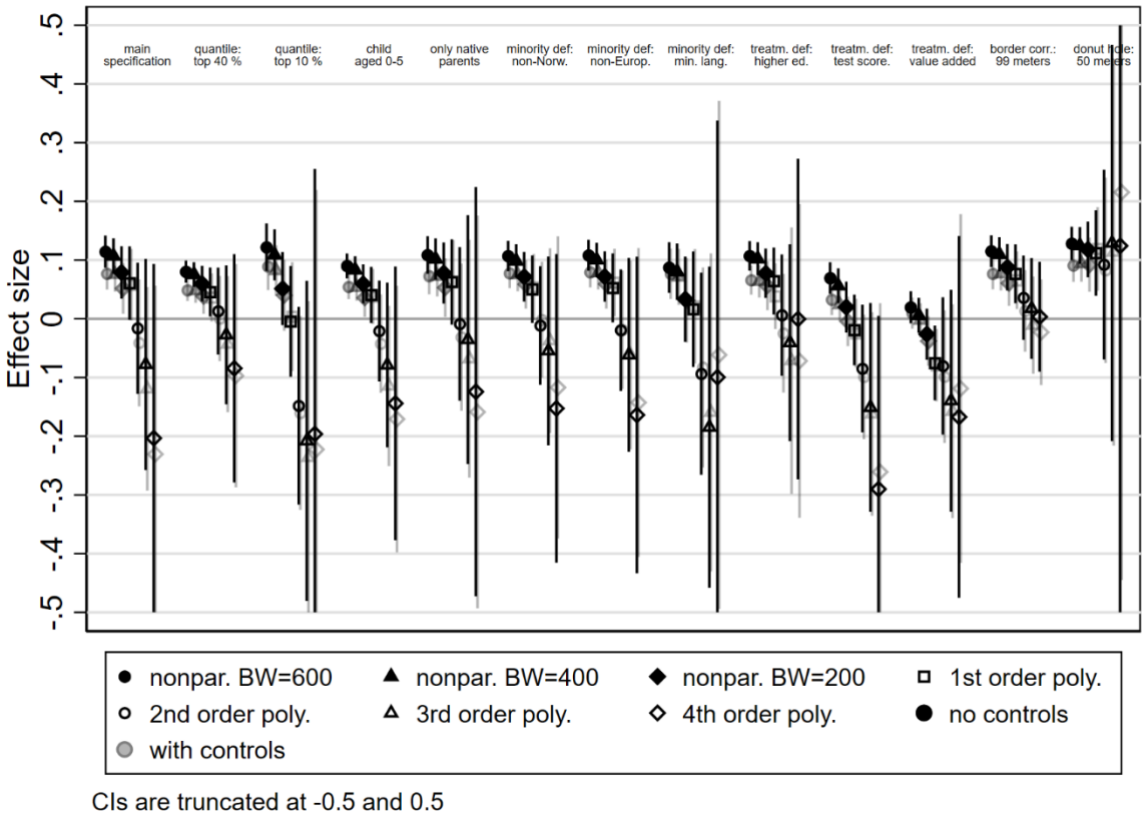
Figure 4: Sensitivity analyses and alternative specifications



Note: GRD estimates of out-mobility. Model specifications as in Table 3, except that each set of models varies one model specification: 'quantile: top 40 %' and 'quantile: top 10 %', includes the 40 % and 10 %, respectively, of school dyads with the largest contrasts in the minority concentration; 'child aged 0-5' includes families where the youngest child is between 0 and 5 years old; 'only native parents' includes only families where no parent has any immigrant background; 'minority def: non-Norw.' and 'minority def: non-Europ.' defines the minority group as immigrants and children of immigrants from any country of origin, and non-European origin, respectively; 'border corr.: 99 meters' subtracts 99 meters (instead of 50) on either side of the border so that families that live, on average, 100 meters away from each other, across a border, are treated as though they are very close neighbors; 'donut hole: 50 meters' excludes observations residing 50 meters from the border, as these may have a higher likelihood of selecting schools through applications. Heteroscedasticity robust standard errors (SE) in parentheses.

[NOTE TO THE EDITOR/REVIEWERS: the legend text that reads 'nonpar.' should read 'dichotomous'. We apologize. This error will be fixed. – the authors]

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