

The Impact of School Racial Compositions on Neighborhood Racial Compositions: Evidence from School Redistricting*

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Abstract

I use data surrounding public school redistricting to study how school racial compositions affect neighborhood racial compositions. This redistricting followed from the end of court-ordered busing for racial desegregation, significantly changing the racial composition of the assigned school for many neighborhoods. Over a five-year period, I find that the impact of an increase in the percent black of the assigned elementary school on the percent black of the neighborhood was positive. The effects increased over time, consistent with predictions from a simple model of short-run neighborhood racial dynamics. These results have implications for the potential effects of school racial desegregation policy changes on neighborhood racial compositions.

Keywords: Public School Redistricting, Racial Desegregation, Neighborhood Racial Sorting

JEL Classification Numbers: H75, I28, R23

1 Introduction

The 1954 United States Supreme Court case *Brown v. Board of Education of Topeka* and subsequent decisions ended the "separate but equal" doctrine applied to public schools and led to implementation of court-ordered racial desegregation plans for school districts across the country.¹ Various desegregation techniques have been used, including public school choice, the creation of magnet schools, and busing of students in one part of the district to a school located in another (Rivkin and Welch (2006)).

The 1991 *Board of Education of Oklahoma City v. Dowell* decision stipulated how a school district could be declared unitary, managing a single educational system for students of all races (as opposed to a dual system), after it has "taken all 'practicable' steps to eliminate the legacy of segregation" (Rivkin

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¹See Table 1 of Rivkin and Welch (2006) for a summary of landmark school desegregation Supreme Court cases.

and Welch (2006), p. 1023). Once a district has achieved unitary status, it is no longer subject to court-ordered racial desegregation and cannot use race as a factor in assigning students to schools, even if the new, race-neutral student assignment plan causes an increase in school racial segregation. This and consequent Supreme Court decisions have made it easier for school districts to be released from court-ordered racial desegregation. As a result of the dismissal, a student may be reassigned to a school closer to residence with possibly very different characteristics than the school previously attended.

I investigate neighborhood racial sorting in response to changes in school assignments that resulted from the termination of court-ordered racial desegregation in a large, urban public school district. Tiebout (1956) motivated neighborhood sorting with the idea that households "vote with their feet" by choosing residential locations with the most desired package of local public goods (e.g., public schools). Subsequent theoretical work developed general equilibrium models of public goods provision, taxation, voting, and residential location decisions to study the relationship between public goods provision, household sorting, and housing market equilibrium.² In addition, there is empirical evidence that neighborhood racial or ethnic compositions or neighborhood segregation matters for individual outcomes, at least for certain subgroups of the population. Such neighborhood effects have been found in labor market activity, education, and health.³ Studying neighborhood racial sorting is thus valuable for understanding how individual outcomes may vary as neighborhood racial compositions change.

I use administrative data surrounding extensive school redistricting in the Charlotte-Mecklenburg Public School District (CMS) to examine the impact of large changes in school racial characteristics on neighborhood racial characteristics. CMS is one of the largest school districts in North Carolina, serving all of Mecklenburg County, which includes the city of Charlotte and six neighboring suburbs. In Fall 2001, CMS was ordered to dismantle the race-based student assignment plan that had been in effect for 30 years. Under this plan, school assignment zones were typically drawn to capture non-contiguous areas with vastly different racial compositions to achieve racial balance in schools. A district-wide public school choice plan was approved for the 2002-2003 school year, with school assignment zones dramatically redrawn to give each student a guaranteed seat at a school close to her residence, typically the closest (students could gain admission to other schools in the district through a lottery process). Approximately half of families were reassigned to different schools, causing large changes in school racial compositions across the district. These extensive shocks to school racial compositions make CMS an ideal place to

²Examples include Epple, Filimon, and Romer (1984), Fernandez and Rogerson (1996), and Nechyba (1997).

³Examples include Borjas (1995), O'Regan and Quigley (1996), Cutler and Glaeser (1997), O'Regan and Quigley (1998), Weinberg (2000), Clark and Drinkwater (2002), Durlauf (2004), Card and Rothstein (2007), and Ananat (2011).

identify the impact of school racial characteristics on neighborhood racial characteristics.

Several related studies have used data surrounding school desegregation programs to examine the effect of school racial compositions or school desegregation on neighborhood racial sorting or housing prices. Findings include a negative relationship between the percent black of the assigned school and housing prices (Clotfelter (1975)), slower increases in housing prices in cities expected to undergo school desegregation relative to their neighboring suburbs (Gill (1983)), decreases in housing prices in neighborhoods subject to redistricting but mixed evidence that school racial compositions affected housing values (Bogart and Cromwell (2000)), and increases in black populations mostly in non-southern central city school districts and declines in white populations mostly in southern central city school districts due to school desegregation (Baum-Snow and Lutz (forthcoming)).

Kane, Staiger, and Riegg (2005) investigated the relationship between school compositions and housing prices using data on multiple smaller-scale episodes of redistricting in CMS from 1994 to 2001, which were needed to maintain racial balance in schools while CMS was under court-ordered busing.⁴ They found that housing prices responded gradually to changes in school racial compositions, suggesting that part of the effect was due to neighborhood racial sorting as a result of changed school assignments. Examining changes in block group racial compositions over the 1990s using Decennial Census data, the authors found more direct evidence of sorting: a 10 percentage point increase in the percent black of the assigned school was associated with a two to four percentage point increase in the percent black of the block group over the 1990s. I look more closely at neighborhood racial sorting in response to a much larger episode of redistricting in CMS, studying annual changes versus a 10-year change in neighborhood racial compositions. That is, my data allow me to analyze neighborhood racial dynamics, testing whether the estimated effects of school racial compositions on neighborhood racial compositions are in line with predictions from a simple model of short-run neighborhood racial dynamics.⁵

I study the impact of changes in school racial compositions on neighborhood racial compositions, constructed using average student characteristics by neighborhood, from 2001, the final year of busing, to 2006. I show that the effect of an increase in the percent black of the assigned elementary school on the percent black of the neighborhood was positive and statistically significant over the five-year period. A 10 percentage point increase in the percent black of the assigned elementary school led to an approximately

⁴See Section 2 for more information about redistricting in CMS prior to 2002.

⁵I analyzed one- to five-year effects of changes in school racial compositions on neighborhood racial compositions, while Kane, Staiger, and Riegg (2005) studied 10-year effects. Also, I used only public school students to construct neighborhood racial characteristics (see Section 3), while Kane, Staiger, and Riegg (2005) used all residents (Decennial Census data). For these reasons, it is difficult to draw meaningful comparisons of the estimated impacts across the two studies.

1.2 percentage point increase (relative to a mean of 53.6 percent) in the percent black of the neighborhood five years after the dismissal of busing. The impacts increased over time, consistent with predictions from a simple model of short-run neighborhood racial dynamics, where the change in neighborhood racial composition is a function of lagged school and neighborhood racial compositions.

Because I have student-level administrative data from CMS, including exact residential locations for all enrolled students in each year, I also examine student-level attrition from and decisions to change residences within CMS to shed more light on which racial groups drove the changes in neighborhood racial compositions. These results indicate that the estimated responses of neighborhood racial compositions to changes in assigned elementary school racial compositions (at least for the longer time horizons) were consistent with non-black residents' moving from neighborhoods with increases in assigned elementary school percent black to neighborhoods with decreases in assigned elementary school percent black, while black residents did not change residential locations in response to the school reassignments.

This paper proceeds as follows. Section 2 gives details on school redistricting in CMS, and Section 3 discusses the data and empirical strategy. Section 4 outlines a simple model of neighborhood racial dynamics to understand how changes in school assignments can affect short-run neighborhood racial compositions. Section 5 contains the empirical results for neighborhood racial dynamics, and Section 6 presents the empirical findings for student-level attrition and moving decisions. Section 7 discusses how the results are useful for understanding the potential effects of school racial desegregation policy changes on neighborhood racial compositions and provides implications for future research.

2 School Redistricting in CMS

The 1971 United States Supreme Court decision *Swann v. Charlotte-Mecklenburg Board of Education* required CMS to create racially integrated schools by redrawing school boundaries and employing race-based busing (Kane, Staiger, and Riegg (2005)). As a result, school assignment zones were typically drawn to capture non-contiguous areas with vastly different racial compositions to achieve racial balance in schools. A 1980 court order mandated that CMS make reasonable attempts at keeping each school's percent black within 15 percentage points of the district-wide percent black, so CMS needed to redraw assignment boundaries at various times to have schools remain desegregated.⁶ Students could also apply to magnet programs, with admission determined by lottery. Each student was required to attend the

⁶Some schools, typically in the more remote parts of Mecklenburg County, did not have racial compositions within this band, likely because very long bus rides would have been required for some students (Kane, Staiger, and Riegg (2005)).

(non-magnet) school assigned to her residence if she did not gain admission to a magnet program.

In September 1997, CMS was sued for its magnet program assignment policy, leading to the reactivation of the *Swann* ruling to determine if CMS had achieved unitary status. In September 2001, the United States Fourth Circuit Court of Appeals declared CMS to be unitary and ordered the district to dismantle the race-based student assignment plan. In December 2001, the school board voted to approve a race-neutral, district-wide public school choice plan for the 2002-2003 school year. In the spring of 2002, parents were asked to submit their top three choices of school programs for each of their children. Each student was assigned a home school, typically her closest school, and was guaranteed a seat at this school. Admission of students to non-home choices was limited by grade-specific capacities set by the district, with lotteries used to determine admission to over-subscribed schools.⁷ As most of the data I use was compiled near the beginning of a school year, I characterize a school year by the calendar year in which it starts; for example, the 2001-2002 school year (last year of busing) is denoted as 2001, and the 2002-2003 school year (first year of choice plan) is denoted as 2002.

The end of court-ordered busing led to a large redistricting of home school assignments in 2002. Before 2002, many school assignment zones were satellite zones: a school located in an area with a large percentage of students from one race drew students from this area, as well as students from another area (possibly located many miles from the school) where a large percentage were of another race.⁸ Beginning in 2002, all school assignment zones were connected areas. In addition, due to population growth in CMS, four new elementary, one new middle, and one new high school opened in 2002.

Forty-five percent of student residences were reassigned to different elementary schools due to the redistricting.⁹ This number was 53 percent and 39 percent at the middle and high school levels, respectively. Nineteen percent were reassigned at all three school levels, 25 percent were reassigned at exactly two levels, 30 percent were reassigned at exactly one level, and 26 percent were not reassigned at all.

After 2002, there were additional changes in school assignment zones as new schools opened due to continued population growth in CMS. Relative to the district-wide changes in school assignments in 2002, episodes of redistricting after 2002 affected far fewer students. Moreover, the post-2002 episodes of redistricting likely led to much smaller changes in school compositions than the 2002 redistricting:

⁷See Hastings, Kane, Staiger, and Weinstein (2007) and Hastings, Kane, and Staiger (2009) for more information.

⁸See Kane, Staiger, and Riegg (2005) for a discussion of other racial desegregation strategies used in CMS.

⁹This number was computed using student residential locations around the end of September 2001. I also calculated the driving distance from each student's 2001 residence to her pre- and post-redistricting assigned school. Students, on average, were reassigned to schools closer to their residences. The average decline in distance was larger for black versus non-black students, reflecting the fact that busing typically assigned students living in areas with higher concentrations of black students to schools in areas with higher concentrations of non-black students.

after 2002, students were transferred from nearby schools to other nearby schools (within areas of similar demographics), while in 2002, students were possibly moved from schools distant from residence to schools close to residence (areas with different demographics). As a result, I focus on how neighborhood compositions changed due to the 2002 redistricting, ignoring subsequent smaller-scale redistricting.

3 CMS Data and Empirical Strategy

3.1 Data

I have secured access to annual administrative records from CMS for 2001 to 2006. The main sources of demographic and geographic data are 20th day CMS student censuses, collected around the end of September of each year to determine official enrollment figures for funding purposes. These data include the exact residential location, the school attended, ethnicity, free- or reduced-lunch status, and gender for each student enrolled in CMS. I also have end-of-year data on the number of absences and suspensions and, for students in grades 3 through 9, scores on North Carolina standardized tests. In addition, I know the exact location of every school and school assignment zone for 2001 and 2002.

3.2 Construction of Neighborhoods

I define a neighborhood at the level of the intersection of 2001 (pre-dismissal) and 2002 (post-dismissal) elementary school assignment zones. This implies that the entire neighborhood was assigned to exactly one elementary school in 2001 and exactly one elementary school in 2002. These elementary schools might or might not have been the same, but even neighborhoods assigned to the same elementary school in both years might have experienced changes in elementary school racial characteristics due to reassignment elsewhere. Constructing neighborhoods in this way implies that the "shock" to school assignment was constant within a neighborhood (ignoring changes in middle and high school assignments).

I focus on elementary school assignment zones because they were, on average, much smaller and thus more numerous than middle or high school assignment zones. There were 68 elementary versus 21 middle and 14 high school assignment zones in 2001, implying a far larger sample of neighborhoods when using elementary school assignment zones.¹⁰ In addition, I will show that constructing neighborhoods using elementary versus middle or high school assignment zones gives better matches on student baseline characteristics across students who were and were not reassigned due to the redistricting.

¹⁰Constructing neighborhoods using middle or high school assignment zones gives 104 or 69 neighborhoods, respectively, while constructing neighborhoods using elementary school assignment zones gives 249 neighborhoods (discussed below).

Figure 1 is a visual representation of neighborhood construction from a hypothetical 2001 elementary school assignment zone. Notice that this assignment zone consisted of two unconnected areas (Triangles I and II). This was typical, as many elementary school assignment zones were satellite zones in 2001, whereby a school located in an area with a large percentage of students from one race drew students from this area, as well as students from another area where a large percentage were of another race. In what follows, I call each of these unconnected areas a polygon, implying that a 2001 elementary school assignment zone possibly consisted of two or more polygons. By contrast, every elementary school assignment zone in 2002 was a single connected area because there was no busing, so that the three rectangles in Figure 1 were precisely the assignment zones for three different elementary schools in 2002. Given how I defined neighborhoods, a polygon assigned to n different elementary schools in 2002 consisted of n neighborhoods, and each of these n neighborhoods was fully contained in the polygon.

The final sample is 249 neighborhoods.¹¹ Each neighborhood had, on average, 427 students in 2001 (standard deviation of 449) and 538 students in 2006 (standard deviation of 636). These neighborhoods are in 102 polygons, so each polygon has, on average, 2.44 neighborhoods (standard deviation of 1.20).

3.3 Main Empirical Specification

In Section 5.1, I provide estimates of the following system of neighborhood-level equations:

$$bneigh_{2001+k}^j - bneigh_{2001}^j = \alpha_{FE} + \beta \Delta bschl_shock^j + \delta bneigh_{2001}^j + \varepsilon_{2001+k}^j \quad k = 1, \dots, 5, \quad (3.1)$$

where

$$\begin{aligned} k &= \text{Number of years since dismissal of busing in 2001} \\ bneigh_{2001+k}^j &= \text{Percent black of neighborhood } j \text{ in year } 2001 + k \\ \Delta bschl_shock^j &= bschl_shock_{2002}^j - bschl_{2001}^j \\ &= (\text{Percent black of elementary school assigned to neighborhood } j \text{ in 2002} \\ &\quad \text{computed using "shock measure"}) - (\text{Percent black of elementary school} \\ &\quad \text{assigned to neighborhood } j \text{ in 2001}) \\ \alpha_{FE} &= \text{2001 elementary school polygon fixed effects.} \end{aligned}$$

¹¹Each neighborhood contained at least 10 students for each year analyzed: 2001 to 2006, inclusive. Neighborhoods with fewer than 10 students were almost always tiny areas created when a 2001 school assignment zone only slightly overlapped a 2002 school assignment zone, as a result of boundaries common to both years that did not match perfectly.

The dependent variable, $bneigh_{2001+k}^j - bneigh_{2001}^j$, is the change in the percent black of neighborhood j from 2001 to the year $2001 + k$. I compute the percent black of the assigned elementary school in 2002, $bschl_shock_{2002}^j$, and the corresponding change in the percent black of the assigned elementary school from 2001 to 2002, $\Delta bschl_shock^j$, using the "shock measure" defined later in this section. The coefficient of interest is β : the impact (in percentage points) of a one percentage point increase in the percent black of the assigned elementary school on the percent black of the neighborhood one to five years after the dismissal of busing. Control variables in equations (3.1) include 2001 elementary school polygon fixed effects, α_{FE} , and neighborhood percent black in 2001, $bneigh_{2001}^j$.¹²

I now discuss why I analyzed neighborhood racial sorting for the black versus non-black populations, instead of, say, the non-white versus white populations. I then motivate the control variables in equations (3.1) and describe how I constructed school and neighborhood racial characteristics.

3.4 Definition of Racial Groups

I used annual averages of the *student-level* data by neighborhood to construct neighborhood racial characteristics.¹³ I thus measured neighborhood racial dynamics for the population likely most affected by the changes in school compositions, since many of the students directly experienced the change in school assignment by having attended the school with the changed composition. This direct effect is in contrast to a likely smaller, more indirect effect of changes in school racial compositions on rents or housing values that might have led to residential mobility for households with and without children in CMS.¹⁴

I looked at neighborhood racial sorting for the black versus non-black (white, Asian, multiracial, Hispanic, and Native American) populations. I defined the groups in this way for the following reasons. As court-ordered busing in CMS focused on black versus non-black enrollment, it is interesting to look at the dynamics in neighborhood black compositions separately from other racial/ethnic groups typically considered minority groups (e.g., Hispanics or Asians). In addition, the growth rates of the black and Hispanic populations in CMS from 2001 to 2006 were very different: the percentage of the student population that was black remained about the same at 43 percent, while the percentage of the student population that was Hispanic went from 7.1 percent in 2001 to 14.1 percent in 2006, accounting for 45.1

¹²Twenty-eight of the 102 polygons contained only one neighborhood; that is, everybody living in the polygon was assigned to the same elementary school in 2002 (e.g., Triangle II in Figure 1). By including polygon fixed effects in equations (3.1), I effectively drop these polygons from the analysis, since there was no variation in the treatment ($\Delta bschl_shock^j$) within these polygons. The estimated coefficients did not change, and the standard errors changed only slightly, when I actually dropped these 28 polygons before estimating equations (3.1).

¹³Demographic data for the entire population at an annual, disaggregated level (e.g., neighborhood level) are not available.

¹⁴Lending support to this is Barrow's (2002) finding that white families with children were more likely to locate in an area with higher test scores than white families without children.

percent of the overall district growth over the period (see Table 1 below). In Section 5.3, I compare the main empirical results that look at the black versus non-black populations with results that look at the non-white versus white populations to see if there were different patterns of neighborhood sorting in response to changes in school characteristics.

Table 1 gives the racial/ethnic distribution for students in CMS in each of the six years analyzed (2001 to 2006), as well as the overall Mecklenburg County racial/ethnic distribution for 2001 to 2006 from the United States Census Bureau Population Estimates Program (July 1 reference date).¹⁵ Overall, the school district had a higher percent black and a lower percent white than the county as a whole. This was likely due to higher private school enrollment for whites versus blacks: in 2000, four percent of black students in Mecklenburg County were enrolled in private schools, versus 22 percent of white students (the overall rate was 14 percent).¹⁶ The percent black remained roughly constant in both CMS and in the county as a whole over time, while there was a decline in the percent white in both CMS and in the county as a whole (the decrease was a couple of percentage points larger in CMS). The percent Hispanic increased in both CMS and in the county as a whole, with a larger increase in CMS.¹⁷

3.5 Baseline Characteristics

Table 2 compares baseline characteristics across students reassigned and not reassigned to a different elementary school because of the redistricting. If baseline characteristics differed across reassigned and non-reassigned students, then the measured effects of changes in assigned school racial compositions on neighborhood racial compositions could be spurious: pre-existing differences between reassigned and non-reassigned neighborhoods might have implied different patterns of neighborhood sorting regardless of the change in school assignments. Columns (1) and (2) give estimates of β from student-level linear probability models of the form:

$$R_i = \alpha + X_i' \beta + \varepsilon_i \quad i = 1, \dots, n, \quad (3.2)$$

where R_i is an indicator that takes the value of one if student i was reassigned to a different elementary school, X_i is a vector of baseline characteristics for student i , and ε_i is a random error term that allows

¹⁵Recall that CMS and Mecklenburg County are geographically equivalent.

¹⁶These numbers were obtained from the 2000 Decennial Census.

¹⁷The raw correlation between block group percent black in 2001 in CMS (constructed by assigning student residences to block groups) and block group percent black from the 2000 Decennial Census is 0.9463. For whites and Hispanics, the raw correlations are 0.9382 and 0.8093, respectively.

for clustering at the polygon level. β is the vector of coefficients of interest; estimates of β indicate which baseline characteristics influenced the probability of reassignment.

Baseline characteristics include indicators for whether the student was black, Hispanic, female, and a recipient of lunch subsidies; number of absences and suspensions; and test score. Column (1) includes the first six baseline characteristics; the estimation sample is all students in the 2001 20th day CMS student census with a complete set of baseline characteristics that live in one of the 249 neighborhoods described earlier.¹⁸ Column (2) adds in baseline test score, which is the average of reading and math scores on North Carolina exams administered in Spring 2002. Each student's test score was standardized by the district-wide mean and standard deviation within each grade. Only students in third through ninth grade take these examinations (ninth graders only take an English exam), so the sample size in column (2) is smaller. As shown in columns (1) and (2), since the busing plan in CMS typically assigned students from an area with a large percentage of black students to a school located in an area with a large percentage of non-black students, reassigned students were more likely to have been black and eligible for lunch subsidies, and they had lower test scores and more absences.

Columns (3) and (4) of Table 2 add 2001 elementary school polygon fixed effects to equation (3.2). The estimates of the vector β are then the within-polygon (within small geographic area) effects of the baseline characteristic of interest on the likelihood of reassignment. In general, the magnitudes of the estimates in the third and fourth columns are less than one third of the corresponding magnitudes in the first and second columns and are much less significant. After controlling for polygon fixed effects, baseline test score and number of absences are no longer statistically significant determinants of the probability of reassignment. In all cases, p-values in columns (3) and (4) are greater than 0.05, but some of the baseline characteristics are marginally statistically significant determinants of the probability of reassignment (p-values greater than 0.05 but less than 0.10).

Overall, while some baseline characteristics did vary across reassigned and non-reassigned students after controlling for the 2001 elementary school polygon fixed effects, these fixed effects did absorb much of the variation in observed baseline characteristics between the two groups; thus, I include them in equations (3.1). In addition, to capture some of the within-polygon variation in baseline characteristics, I also control for the percent black of neighborhood j in 2001. I repeated the analysis in Table 2 using reassignment at the middle and high school levels. These results (available upon request) indicate that some of the baseline characteristics are strong and statistically significant predictors (at the five percent

¹⁸Black, Hispanic, female, and lunch subsidy reciprocity data are available for all students. Absence and suspension data were compiled in June 2002, so due to attrition during the school year, this variable is missing for some students.

level) of reassessment, even after controlling for 2001 middle or high school polygon fixed effects.

3.6 Construction of Neighborhood and School Racial Characteristics

Table 3 gives summary statistics for neighborhood percent black (computed using 20th day student censuses) for 2001 to 2006, inclusive, where each row is for a different year ($N = 249$). The first two columns contain the mean and standard deviation of neighborhood percent black, and the remaining columns contain percentiles of its distribution: minimum, fifth percentile, first decile to ninth decile, 95th percentile, and maximum.

Table 4 gives summary statistics for 2001 and 2002 assigned elementary school percent black, as well as the difference between 2002 and 2001 assigned elementary school percent black, across neighborhoods ($N = 249$). For 2001, I computed percent black, $bschl_{2001}^j$, based on school assignments observed in the 2001 20th day student census. I constructed school racial characteristics for this year mainly to show that redistricting did indeed affect school racial characteristics; given that I control for 2001 elementary school polygon fixed effects in equations (3.1), 2001 school compositions get soaked up by the fixed effects.¹⁹ For 2002, I computed percent black using student locations in the 2001 20th day student census to determine which elementary school each elementary school student would have been assigned to in 2002 and then averaging the student characteristics over these 2002 assignment zones. By constructing 2002 school compositions in this manner, as opposed to using the observed school compositions from the 2002 20th day student census, I avoided using school compositions in which some families had already sorted into a more preferred school by time the 20th day student census was collected (either through changing residential locations or winning lotteries to attend non-assigned schools). In other words, I treat the change in school compositions as a shock due to the redistricting because the 2002 school compositions were calculated close to when the 2002 school boundaries were announced, around the end of 2001, using student residential locations from before the redistricting and before the school choice lottery took place. As a result, I denote this measure of 2002 assigned elementary school percent black as the "shock measure", $bschl_shock_{2002}^j$. An alternative measure, which I revisit in Section 5.2, is the "observed measure", $bschl_observed_{2002}^j$: observed school compositions from the 2002 20th day student census.

The first column of Table 4 says that neighborhoods, on average, were assigned to elementary schools that were 44.3 percent black in 2001 and 51.2 percent black in 2002 (2002 assigned elementary school percent black was computed using the shock measure). From the second column (standard deviations),

¹⁹This, along with the fact that 2001 school compositions were constructed using only pre-redistricting data, explains why I do not need multiple measures of the percent black of the assigned elementary school in 2001.

it is immediately obvious that the 2002 distribution was more dispersed than the 2001 distribution of assigned elementary school percent black. This makes sense given that CMS was (mostly) required to maintain school racial compositions within certain bands while under the busing system, within 15 percentage points of the district-wide percent black, but assigned each student to a school close to residence once busing was terminated. The remaining columns contain the percentiles of the distribution of assigned elementary school percent black and the difference between 2001 and 2002 assigned elementary school percent black: minimum, fifth percentile, first decile to ninth decile, 95th percentile, and maximum. These numbers also imply that assigned elementary school percent black was much more dispersed in 2002 versus 2001 and, moreover, that far fewer neighborhoods were assigned to an elementary school within 15 percentage points of the district-wide percent black in 2002 versus 2001.

The third row of Table 4 confirms that the redistricting generated large and varied changes in the racial composition of the assigned elementary school across neighborhoods in CMS: approximately half of the neighborhoods experienced an increase in assigned elementary school percent black, while the other half experienced a decrease in assigned elementary school percent black. About half of the neighborhoods had a change in assigned elementary school percent black of 20 percentage points or more (increase or decrease). Figure 2 presents a histogram of the difference between 2002 and 2001 assigned elementary school percent black. This histogram tells the same story as Table 4 about how the impact of the redistricting on the percent black of the assigned elementary school varied across neighborhoods. Overall, redistricting in CMS led to extensive changes in assigned school racial characteristics, allowing for credible estimation of the impact of changes in school racial characteristics on neighborhood racial characteristics.

3.7 Discussion

I focus on how neighborhood racial compositions changed as a result of changes in the racial characteristics of the assigned school, that is, the role or value of neighborhood school assignment in determining neighborhood racial compositions. I ignore the fact that parents had the option of entering the lottery to send their children to a magnet program or to a regular, non-magnet program at an alternative school in CMS after the redistricting (although there were magnet options prior to the redistricting). If parents not happy with their school assignments after redistricting entered their children into the lottery, instead of relocating to the assignment zone of a more-preferred school, there would be less residential sorting as a result of the changed school assignments (all else equal), thus working against finding an impact of the

change in assigned school racial characteristics on neighborhood racial characteristics.²⁰

Recall that there was a four year gap between the time that CMS was first sued for its magnet admissions policy (September 1997) and the actual dismissal of busing (September 2001). Thus, it is possible that a parent forecasted that school assignments were going to change and acted accordingly by, say, immediately changing her residential location if she was not satisfied with the characteristics of what she thought was going to be her new assigned school. However, this forecasting is unlikely since the legal process went through numerous appeals before the actual dismissal. There was a ruling in September 1999 that race could not be used to determine school assignments; the school board voted to appeal that decision in October 1999. There was a ruling in November 2000 that CMS was not unitary in all areas, then a full court review of this ruling, and then in September 2001 CMS was declared unitary. A group even tried to appeal the decision in December 2001 after parents had already received their choice forms, but the United States Supreme Court said in April 2002 that it would not hear the appeal.²¹

4 Simple Model of Short-Run Neighborhood Racial Dynamics

Given the large changes in school assignments outlined above, how might neighborhood racial characteristics be expected to change over time? I present a simple model, extending the theoretical framework used by Card, Mas, and Rothstein (2006) in their study of neighborhood tipping behavior, to examine qualitative predictions for short-run neighborhood racial dynamics. According to Schelling (1971), tipping occurs "when a recognizable new minority enters a neighborhood in sufficient numbers to cause the earlier residents to begin evacuating", and the tipping point is the neighborhood fraction minority where the above process begins. Card, Mas, and Rothstein (2006) analyzed a simple model of neighborhood racial dynamics to generate testable implications of the long-run behavior of the neighborhood minority share around a tipping point.²² I incorporate school racial compositions into this framework and use it to trace out the short-run impact of a change in school assignments on neighborhood racial compositions.²³

²⁰Lending support to this idea is Walden's (1990) finding that test scores and racial compositions had smaller impacts on housing prices when magnet programs were more widely implemented.

²¹Sources: <http://www.cms.k12.nc.us/discover/history.asp> and <http://www.cms.k12.nc.us/discover/narrative.asp>

²²Using United States Census data, the authors found evidence of tipping behavior in most cities, with the average estimated tipping point around 0.13 fraction minority.

²³The framework presented below is likely less useful for examining long-run impacts of changes in school racial compositions on neighborhood racial compositions because it predicts that all neighborhoods will become completely segregated in the long run, an unlikely outcome.

4.1 Assumptions

These assumptions are in line with the construction of neighborhoods in the previous section. There are two race categories: black and non-black. A school district consists of neighborhoods defined in such a way that each neighborhood was assigned to exactly one school before redistricting and exactly one school after redistricting. Note that while each neighborhood was assigned to exactly one school, that school was typically populated by multiple neighborhoods. Each student attended the public school assigned to her neighborhood both before and after the redistricting; there were no public school choice options or private schools. I also abstract away from different school levels (elementary, middle, and high).

Following Card, Mas, and Rothstein (2006), I assume that the law of motion for the neighborhood black population is

$$\Delta b_t^j \equiv b_t^j - b_{t-1}^j = f(b_{t-1}^j, sch_{t-1}^j) \equiv \gamma^0 + \gamma^1 b_{t-1}^j + \gamma^2 sch_{t-1}^j, \quad (4.1)$$

where

$$\begin{aligned} b_t^j &= \text{Fraction black of neighborhood } j \text{ in year } t \\ sch_{t-1}^j &= \text{Fraction black of school assigned to neighborhood } j \text{ in year } t - 1. \end{aligned}$$

Equation (4.1) implies that the one-year change in the fraction black for a neighborhood (Δb_t^j) depends linearly on the initial fraction black in the neighborhood (b_{t-1}^j) and on the initial fraction black of the school assigned to the neighborhood (sch_{t-1}^j).²⁴ γ^0 , γ^1 , and γ^2 are known parameters that govern the law of motion for b_t^j , and along the same lines as Card, Mas, and Rothstein (2006), I assume $\gamma^0 < 0$, $\gamma^1 > 0$, and $\gamma^2 > 0$. These assumptions mean that a larger neighborhood fraction black in year $t - 1$ is associated with a larger increase in neighborhood fraction black from year $t - 1$ to year t , and a larger fraction black at the assigned school in year $t - 1$ is associated with a larger increase in neighborhood fraction black from year $t - 1$ to year t .²⁵ As in Card, Mas, and Rothstein (2006), this sign pattern generates an unstable equilibrium fraction black for neighborhood j .

²⁴The equation for the law of motion for the neighborhood black (minority) population in Card, Mas, and Rothstein (2006) is equation (4.1) without the term $\gamma^2 sch_{t-1}^j$.

²⁵I ignore the fact that b_t^j cannot be less than 0 or greater than 1 for all j and for all t .

Given how neighborhoods were defined above, the following accounting identity for sch_{t-1}^j holds:

$$sch_{t-1}^j \equiv f_{t-1}^j b_{t-1}^j + (1 - f_{t-1}^j) b_{t-1}^{-j}, \quad (4.2)$$

where

f_{t-1}^j = Fraction of students attending the school assigned to neighborhood j
who live in neighborhood j in year $t - 1$

b_{t-1}^{-j} = Fraction black of students attending the school assigned to
neighborhood j who do not live in neighborhood j in year $t - 1$.

Equation (4.2) expresses the fraction black of the school assigned to neighborhood j in year $t - 1$ as a weighted average of the fraction black from neighborhoods that send students to this school. For simplicity, from the standpoint of neighborhood j , I assume that f_{t-1}^j and b_{t-1}^{-j} are taken as given and constant and let $f_{t-1}^j \equiv f^j$ and $b_{t-1}^{-j} \equiv b^{-j}$.²⁶ Hence, plugging equation (4.2) into equation (4.1), I have

$$\Delta b_t^j = \gamma^0 + \gamma^1 b_{t-1}^j + \gamma^2 (f^j b_{t-1}^j + (1 - f^j) b^{-j}). \quad (4.3)$$

4.2 Equilibrium

An equilibrium neighborhood fraction black requires that $\Delta b_t^j = 0$ and $b_t^j \equiv b_*^j$ for all t . If the fraction black of neighborhood j is in equilibrium, then the fraction black of the assigned school is also in equilibrium (i.e., $sch_*^j = f^j b_*^j + (1 - f^j) b^{-j}$). Under the assumptions that $\gamma^0 < 0$, $\gamma^1 > 0$, and $\gamma^2 > 0$, b_*^j is an unstable equilibrium fraction black for neighborhood j : $b_{t-1}^j > b_*^j \Rightarrow \Delta b_t^j > 0$, and vice versa. In addition, $|\Delta b_t^j|$ is larger when b_{t-1}^j is further away from b_*^j .

4.3 Short-Run Impact of School Redistricting

I trace out the short-run impact on b_t^j resulting from a shock to the racial composition of the school assigned to neighborhood j in year t (i.e., sch_t^j). This shock is the result of the 2002 school redistricting. I assume that, before this shock to school compositions, b_t^j was in equilibrium as described above, so that

²⁶Consistent with these assumptions are a fixed supply of housing, no vacancies, and no population growth. Admittedly, these assumptions are not very realistic for CMS due to large increases in the number of students, but they greatly simplify the task of generating qualitative predictions.

$b_t^j = b_*^j$ and $sch_*^j = f^j b_*^j + (1 - f^j) b^{-j}$. While this implies that neighborhoods were in unstable equilibria prior to the termination of busing, one of the requirements of the desegregation order in CMS provides some support for it. Recall that there were smaller-scale episodes of redistricting under busing for the district to maintain, as best as it could, school racial compositions within required bands. These episodes of redistricting might have helped to prevent neighborhood compositions from changing too much, as a neighborhood that had started to experience large changes in its black share would have caused the assigned school to deviate too much from the court-ordered mandate. Changing school assignment zones would have been necessary to prevent schools from drifting further and further outside of the required bands. Without this assumption, it is more difficult to derive implications of changes in school racial compositions on neighborhood racial compositions because neighborhood racial compositions would have been evolving independently of the discrete change in school compositions at the time that the discrete change occurred (based on equation (4.1)), thus making it harder to disentangle the two effects.

The shock to the racial composition of the school assigned to neighborhood j in year t is a shock to f^j and b^{-j} . Suppose the post-shock values of f^j and b^{-j} are $f^{j'}$ and $b^{-j'}$, respectively. Thus,

$$sch_t^j = f^{j'} b_*^j + (1 - f^{j'}) b^{-j'}. \quad (4.4)$$

I obtain three qualitative predictions from this simple framework that I examine using the CMS data. Proposition 1 is for the one-year change in the fraction black of neighborhood j , $\Delta b_{t+1}^j = b_{t+1}^j - b_*^j$, due to the shock to school racial compositions. It says that larger increases (decreases) in the fraction black of the school assigned to a neighborhood imply larger increases (decreases) in the fraction black of the neighborhood in the year immediately following the dismissal of busing.

Proposition 1 $(b_{t+1}^j - b_*^j)$ is an increasing function of $(sch_t^j - sch_*^j)$.

Proof. See the Appendix. ■

The following two predictions are for two-year and longer changes in the fraction black of neighborhood j , $(b_{t+n}^j - b_*^j)$ for $n \geq 2$, as a result of the shock to school racial compositions. Proposition 2 is an extension of the first prediction to longer time horizons. It says that, under an assumption on the magnitude of γ^2 , larger increases (decreases) in the fraction black of the school assigned to a neighborhood imply larger increases (decreases) in the fraction black of the neighborhood two or more years after the dismissal of busing. Proposition 3 deals with the relative magnitudes of the one-year, two-year, and longer changes in the fraction black of the neighborhood. It says that, under the same assumption on

the magnitude of γ^2 , the magnitude of the one-year change is smaller than the magnitude of the two-year change, which is in turn smaller than the magnitude of the three-year change, and so on.

Proposition 2 *Under the assumption that $(\gamma^2)^2$ is negligible, $(b_{t+n}^j - b_*^j)$ is an increasing function of $(sch_t^j - sch_*^j)$ for $n \geq 2$.*

Proof. See the Appendix. ■

Proposition 3 *Under the assumption that $(\gamma^2)^2$ is negligible, for a given increase (decrease) in $(sch_t^j - sch_*^j)$, the increase (decrease) in $(b_{t+n}^j - b_*^j)$ is larger for larger values of n .*

Proof. See the Appendix. ■

The proofs of Propositions 2 and 3 give the following formula for the n -year change in the fraction black of neighborhood j , $(b_{t+n}^j - b_*^j)$, as a result of the shock to school racial characteristics:

$$b_{t+n}^j - b_*^j = \gamma^2 \left(\sum_{i=0}^{n-1} (1 + \gamma + \gamma^2 f^{j'})^i \right) (sch_t^j - sch_*^j) \quad \text{for } n \geq 1. \quad (4.5)$$

For $n \geq 2$, the term that multiplies $(sch_t^j - sch_*^j)$ in equation (4.5) depends on $f^{j'}$, the post-shock fraction of students attending the school assigned to neighborhood j who live in neighborhood j ($f^{j'}$ drops out of the formula when $n = 1$). Thus, without making the assumption that $(\gamma^2)^2$ is negligible, the predictions for the impact of the shock to school racial compositions on neighborhood racial compositions more than one year after the dismissal of busing are not as straightforward as the prediction for the one-year change. This is because school racial compositions after the shock depend on both $f^{j'}$ and $b^{-j'}$ ($sch_t^j = f^{j'} b_*^j + (1 - f^{j'}) b^{-j'}$), and the mapping of $f^{j'}$ and $b^{-j'}$ to sch_t^j is not one-to-one. For example, a neighborhood with a high concentration of blacks can be reassigned to a school with a higher black concentration by either becoming a larger share of the new school and being paired with a sufficiently small neighborhood with a lower concentration of blacks than before, or it can become a smaller share of the new school but be paired with a sufficiently large neighborhood with a higher concentration of blacks than before. By making the assumption that $(\gamma^2)^2$ is negligible, the terms involving $f^{j'}$ in equation (4.5) for $n \geq 2$ become negligible, and so the model predictions are much more straightforward. This assumption is consistent with the existence of a sufficiently small one-year change in neighborhood fraction black for a given initial assigned school fraction black. Looking ahead to my empirical results, I find that the estimated impact of the change in the fraction black of the assigned elementary school due to redistricting on the one-year change in neighborhood fraction black was very small and insignificant.

5 Empirical Results for Neighborhood Racial Dynamics

5.1 Ordinary Least Squares Results

To examine the effect of changes in school racial compositions on neighborhood racial compositions, I provide estimates of equations (3.1). These five neighborhood-level equations (one for each k) were estimated as a system of seemingly unrelated regressions (SUR) because the error terms are correlated across equations.²⁷ Standard errors are adjusted for clustering at the level of the 2001 elementary school polygon. The dependent variable is the change in percent black in neighborhood j from 2001 to year $2001+k$. In line with the statements of the qualitative predictions from the simple model in the previous section, the one-year change in elementary school percent black, $\Delta bschl_shock^j$, is used for each k . Recall that the percent black of the assigned elementary school for 2002, $bschl_shock_{2002}^j$, was constructed as a shock: student residences in 2001 were used to determine the 2002 assigned elementary school for each elementary school student, and student characteristics were then averaged over 2002 assignment zones.

For reasons mentioned in Section 3, I include fixed effects for each 2001 elementary school polygon (α_{FE}), since they absorbed a lot of the variation in baseline characteristics across neighborhoods that were and were not reassigned to a different elementary school as a result of the redistricting. This implies that my empirical results compare changes in neighborhood racial compositions over time for neighborhoods similar prior to the redistricting (in the same polygon) but exposed to different shocks to school racial characteristics due to the redistricting. Recall that I include the percent black in neighborhood j in 2001, $bneigh_{2001}^j$, as a regressor to help capture remaining differences in baseline characteristics across reassigned and non-reassigned neighborhoods, even within a 2001 elementary school polygon (Table 2). I will also show results where I re-estimate equations (3.1) with four additional baseline neighborhood controls: percent Hispanic, percent receiving lunch subsidies, percent female, and average test score. To the extent that these variables are correlated with $\Delta bschl_shock^j$ and affect neighborhood sorting, even after controlling for $bneigh_{2001}^j$ and the polygon fixed effects (i.e., $bneigh_{2001}^j$ does not capture all of the within-polygon variation in baseline characteristics across reassigned and non-reassigned neighborhoods), the inclusion of these additional baseline characteristics would tend to lessen the estimated impact of school racial characteristics on neighborhood racial characteristics ($\hat{\beta}$).

Recall that β is the coefficient of interest: the impact (in percentage points) of a one percentage point increase in the percent black of the assigned elementary school on the percent black of the neighborhood

²⁷ Another reason why I estimated equations (3.1) as a system of seemingly unrelated regressions is that I tested for the equality of β across equations.

one to five years after the dismissal of busing. The first qualitative prediction of the simple model, that the one-year change in neighborhood fraction black is an increasing function of the one-year change in assigned school fraction black, is consistent with $\hat{\beta} > 0$ for $k = 1$. The second prediction, that the k -year change in neighborhood fraction black is an increasing function of the one-year change in assigned school fraction black for $k \geq 2$, is consistent with $\hat{\beta} > 0$ for $k = 2, \dots, 5$. Finally, the third prediction, that for a given increase (decrease) in assigned school fraction black, the increase (decrease) in neighborhood fraction black is larger over time, is consistent with larger values of $\hat{\beta}$ for larger values of k .

Table 5 gives the estimates of equations (3.1), where each column is for a different value of k . Estimates of β are in the first row. Standard errors are in parentheses, and p-values are brackets. A χ^2 test for the equality of β across k rejects the null hypothesis that the impact of a change in assigned elementary school percent black on neighborhood percent black was the same for all k (p-value = 0.0387), consistent with the third prediction of the model because the estimates of β increase over time.

Column (1) gives the estimated impact of the change in assigned elementary school percent black on neighborhood percent black one year after dismissal of busing. It is negative, inconsistent with the first prediction of the model, but very small and statistically insignificant. The estimated coefficient implies that a 10 percentage point increase in the percent black of the assigned elementary school led to a 0.18 percentage point decrease (relative to a mean of 53.6 percent in 2001; see Table 3) in the percent black of the neighborhood one year after dismissal, which translates into a 0.34 percent decrease in neighborhood percent black at its mean.

Column (2) gives the estimated impact of the change in assigned elementary school percent black on neighborhood percent black two years after dismissal. It is greater than zero, consistent with the second prediction of the model, but still statistically insignificant. This effect is marginally statistically significantly different from the one-year impact with a p-value of 0.0853. The estimated coefficient implies that a 10 percentage point increase in the percent black of the assigned elementary school led to a 0.42 percentage point increase (relative to a mean of 53.6 percent in 2001) in the percent black of the neighborhood two years after dismissal, which translates into a 0.78 percent increase in neighborhood percent black at its mean.

Column (3) gives the estimated impact of the change in assigned elementary school percent black on neighborhood percent black three years after dismissal. It is greater than zero, in line with the second prediction of the model, about 80 percent larger in magnitude relative to the coefficient for the two-year impact but still statistically insignificant, although marginally statistically significantly positive (at the 10

percent level; dividing the p-value in half). The effect is statistically indistinguishable from the two-year impact with a p-value of 0.3227. The estimated coefficient implies that a 10 percentage point increase in the percent black of the assigned elementary school led to 0.75 percentage point increase (relative to a mean of 53.6 percent in 2001) in the percent black of the neighborhood three years after dismissal, which translates into a 1.40 percent increase in neighborhood percent black at its mean.

Column (4) gives the estimated impact of the change in assigned elementary school percent black on neighborhood percent black four years after dismissal. It is greater than zero, in line with the second prediction of the model, about 50 percent larger in magnitude relative to the coefficient for the three-year impact, and statistically significant at the five percent level. The effect is statistically indistinguishable from the three-year change with a p-value of 0.4227, but I reject (at the 10 percent level) the null hypothesis that β is indistinguishable across the one- to four-year changes (p-value = 0.0765). The estimated coefficient implies that a 10 percentage point increase in the percent black of the assigned elementary school led to a 1.11 percentage point increase (relative to a mean of 53.6 percent in 2001) in the percent black of the neighborhood four years after dismissal, which translates into a 2.07 percent increase in neighborhood percent black at its mean.

Finally, column (5) gives the estimated impact of the change in assigned elementary school percent black on neighborhood percent black five years after dismissal. It is greater than zero, in line with the second prediction of the model, about six percent larger in magnitude relative the coefficient for the four-year impact, and statistically significant at the five percent level. However, the effect is statistically indistinguishable from the four-year impact with a p-value of 0.8600. It says that a 10 percentage point increase in the percent black of the assigned elementary school led to a 1.18 percentage point increase (relative to a mean of 53.6 percent in 2001) in the percent black of the neighborhood five years after dismissal, which translates into a 2.20 percent increase in neighborhood percent black at its mean.

Overall, the empirical findings in Table 5 show evidence of neighborhood racial sorting in response to changes in assigned elementary school racial compositions, with larger effects over time, and are broadly consistent with the qualitative predictions from the simple model of the previous section.

Table 6 provides estimates of equations (3.1) with four added baseline neighborhood controls: percent Hispanic, percent receiving lunch subsidies, percent female, and average test score. The inclusion of these variables as controls when estimating equations (3.1) is intended to address the concern that $bneigh_{2001}^j$ does not capture all of the variation in baseline characteristics across reassigned and non-reassigned neighborhoods, even within polygon. Comparing the first row of Table 5 with the first row of Table

6, the estimated impacts of the change in assigned elementary school percent black on neighborhood percent black with the additional control variables are generally smaller than the corresponding estimates without the additional control variables. However, for a given time horizon (e.g., five-year change in neighborhood percent black), the impact of a change in the percent black of the assigned elementary school is not statistically significantly different across the two specifications (p-values are greater than 0.10 in all five cases). This finding suggests that $bneigh_{2001}^j$ does absorb much of the within-polygon variation in baseline characteristics across reassigned and non-reassigned neighborhoods.²⁸

5.2 Instrumental Variables Results

Table 7 presents instrumental variables estimates of the impact of the change in the percent black of the assigned elementary school on the percent black of the neighborhood. I use the observed elementary school percent black in 2002, $bschl_observed_{2002}^j$, to construct the change in the percent black of the assigned elementary school from 2001 to 2002, $\Delta bschl_observed^j$, but instrument $\Delta bschl_observed^j$ with $\Delta bschl_shock^j$, the difference between the shock measure of elementary school percent black in 2002, $bschl_shock_{2002}^j$, and elementary school percent black in 2001, $bschl_{2001}^j$:

$$bneigh_{2001+k}^j - bneigh_{2001}^j = \alpha_{FE} + \beta \Delta bschl_observed^j + \delta bneigh_{2001}^j + \varepsilon_{2001+k}^j \quad k = 1, \dots, 5 \quad (5.1)$$

$$\Delta bschl_observed^j = \theta_{FE} + \mu \Delta bschl_shock^j + \eta bneigh_{2001}^j + \nu^j. \quad (5.2)$$

Recall that the shock measure of 2002 assigned elementary school percent black was constructed to capture variation in school racial compositions due solely to the 2002 redistricting. Because it is constructed using observed school assignments around the end of September 2002, observed 2002 elementary school percent black includes not only the 2002 redistricting but also factors endogenous to neighborhood racial compositions, such as the outcome of the school choice lottery and residential sorting between Fall 2001 and Fall 2002. Thus, the instrumental variables approach uses variation in school composition changes generated by the 2002 redistricting to estimate the impact of the observed change in the percent black of the assigned elementary school on the percent black of the neighborhood one to five years after dismissal of busing. While the interpretations of the reduced-form estimates of β in Tables 5 and 6 (where the shock

²⁸Using the middle school reassignments, I estimated equations (3.1) with and without the four added baseline neighborhood controls. These findings suggest that $bneigh_{2001}^j$ does not capture all of the within-polygon variation in baseline characteristics across neighborhoods that were and were not reassigned to a different middle school, which is in contrast to the elementary school results.

measure of 2002 assigned elementary school percent black enters the estimating equation directly) and the instrumental variables estimates of β in Table 7 (where the shock measure is used as an instrument for the observed measure) are different, both use variation in school racial compositions due to redistricting to identify the impact of changes in school racial compositions on neighborhood racial compositions.

I do not include the four additional baseline neighborhood controls; the results are very similar if I include these variables. First-stage OLS estimates (equation (5.2)) show that the change in assigned elementary school percent black calculated using the shock measure is a statistically significant and strong predictor of the change in assigned elementary school percent black computed using the observed measure. A 10 percentage point increase in the shock measure led to a 7.69 percentage point increase in the observed measure, which is significant at the one percent level (p-value is 0.000).²⁹ The prediction is not perfect, as the estimated effect is not equal to one. This is due to neighborhood sorting immediately following the redistricting (although the estimates in the first column of Tables 5 and 6 suggest that there was very little sorting from 2001 to 2002 in response to changes in school racial compositions), as well as the fact that some students gained admission to alternative schools through the lottery.

The instrumental variables estimates in Table 7 are larger in magnitude than the corresponding reduced-form estimates in Table 5. This reflects the estimated relationship between the two measures of the change in assigned elementary school percent black, as discussed above. Nevertheless, both the instrumental variables and reduced-form estimates tell a similar story about how neighborhood racial compositions changed over time in response to the school reassignments.

5.3 Alternative Definition of Racial Groups

To see if there were different patterns of neighborhood sorting in response to changes in school assignments across two racial group definitions, I compare the main empirical results that looked at the black versus non-black populations (Table 5) with results that look at the non-white versus white populations. Table 8 presents estimates of equations (3.1) for the non-white versus white populations. The mean neighborhood percent non-white in 2001 was 66.2 percent across the 249 neighborhoods. Compared to the results in Table 5, the estimated impacts are much smaller in magnitude and never statistically significant, and all but the five-year impact are negative. Overall, the estimates in Table 8 do not provide evidence of neighborhood racial sorting in response to changes in the percent non-white of the assigned elementary school. This could be explained by the different population growth rates across the racial/ethnic groups

²⁹Full estimates of equation (5.2) are available upon request.

that comprised the non-white population, as shown in Table 1, implying that the racial/ethnic mix of the non-white population changed a lot over time. It could also be due to different interactions both within and across the groups in terms of the coordination of residential location decisions.³⁰

5.4 Discussion

I have focused on how neighborhood racial compositions were affected by changes in the characteristics of the assigned school, ignoring the fact that, after the dismissal of busing for desegregation, a parent was able to enter a lottery to send her child to a magnet program or to a non-magnet program at an alternative school (although there were magnet options prior to the redistricting). That is, I have concentrated on the role or value of neighborhood school assignment in determining neighborhood racial compositions. The availability of public school choice options would tend to decrease neighborhood sorting to the extent that parents not happy with their post-redistricting school assignments would not necessarily need to move to the assignment zones of more-preferred schools if their children gained admission to such schools through the lottery. One possible reason why my results still show evidence of neighborhood racial sorting is that, after the first year of school choice, the district did not further expand capacities at high-demand schools (Hastings and Weinstein (2008), Hastings, Kane, and Staiger (2009)). Thus, attendance at a given school was more tied to residence in the later versus the earlier years of the choice plan. Also, given that admission to a non-assigned school was not guaranteed if the school was oversubscribed (students would be assigned by lottery), parents might have still decided to locate in the neighborhood of a more-preferred school to be guaranteed admission, implying neighborhood sorting.

6 Student-Level Attrition and Moving

6.1 Motivation and Empirical Strategy

The results from Tables 5-7 showed evidence of neighborhood racial sorting in response to changes in assigned elementary school percent black. However, by themselves, these findings cannot determine whether the increase (decrease) in the percent black of a given neighborhood was caused by black families' moving into (out of) the neighborhood, non-black families' moving out of (into) the neighborhood, or

³⁰Card, Mas, and Rothstein (2008), the published version of Card, Mas, and Rothstein (2006), explored three different definitions of the minority population (non-white plus white Hispanic, black plus Hispanic, and black only), finding that estimated tipping behavior was similar across the three definitions during the 1980s and 1990s but was more a function of the neighborhood fraction black during the 1970s.

a combination of both. In other words, it remains unclear if the residential location decisions of black families or non-black families were more responsive to changes in elementary school racial compositions.

In this section, I shed light on the above by using the student-level administrative data from CMS to study families' decisions to leave the CMS school district (attrition) and decisions to switch residences within CMS, conditional on not having left CMS (i.e., while the student remained enrolled in the public school district), both as a result of the changes in the percent black of the assigned elementary school.³¹ I analyze attrition first because I do not observe the residential location of a student upon her leaving the public school district; thus, I cannot tell for sure if a student who left CMS moved out of Mecklenburg County or remained in Mecklenburg County but transferred to a non-CMS school (e.g., a private school). I explore annual attrition and moving decisions from 2001 to 2006 by estimating equations that relate the change in the percent black of the assigned elementary school to individual decisions to leave CMS or to change residence within CMS. I estimate the equations separately for black and non-black students to determine which families were more responsive to changes in assigned elementary school percent black.

My approach is as follows. I began with the 110,434 students in the 2001 20th day CMS student census, dropping students with special academic needs (including preschoolers), students with missing baseline characteristics or addresses, and students not in one of the 249 neighborhoods used in the analysis (293 students). A student is counted as not being enrolled in CMS in a given year (2002 to 2006, inclusive) if and only if she did not appear in the 20th day student census for that year. Due to graduation in Spring 2002, almost all 12th grade students in 2001 did not appear in the 2002 20th day student census; those that did appear were retained and hence are not representative of 12th graders. I thus further drop all 12th grade students in 2001 when exploring attrition in 2002, giving a sample size of 83,382 students. Likewise, I further drop 11th grade students in 2001 when looking at attrition in 2003, giving a sample of 78,228 students; 10th grade students in 2001 when considering 2004 attrition, giving a sample of 71,813 students; 9th grade students in 2001 when analyzing 2005 attrition, giving a sample of 64,096 students; and 8th grade students in 2001 when investigating 2006 attrition, giving a sample of 57,116 students.

Table 9 presents summary statistics for the probability of attrition in each of the five years: overall, for black students, and for non-black students. In each year, the probability was statistically significantly different across the two racial groups (p-value = 0.0000) and larger for non-black students. However, this finding of differential rates of attrition across racial groups does not necessarily imply that non-

³¹I treat the CMS school district and Mecklenburg County as distinct objects for the remainder of this section, even though they are geographically equivalent. For instance, a student could have left CMS but not the county. This would occur if, say, the student transferred to a private school but did not change residence.

black students were more likely than black students to leave CMS in response to the changes in assigned elementary school percent black.

I estimated the following linear probability models, separately for black and non-black students, to study the effect of changes in assigned elementary school percent black on the probability of attrition:

$$A_{2001+k}^j = \alpha_{FE} + \beta \Delta bschl_shock^j + \delta bneigh_{2001}^j + X_j' \theta + \varepsilon_{2001+k}^j \quad k = 1, \dots, 5, \quad (6.1)$$

where

k = Number of years since dismissal of busing in 2001

A_{2001+k}^j = Indicator for whether student j was not enrolled in CMS in year $2001 + k$

$\Delta bschl_shock^j$ = $bschl_shock_{2002}^j - bschl_{2001}^j$
= (Percent black of 2002 assigned elementary school computed using "shock measure")
- (Percent black of 2001 assigned elementary school) [based on 2001 residence]

$bneigh_{2001}^j$ = Percent black of student j 's neighborhood in 2001

X_j = Baseline student characteristics

α_{FE} = 2001 elementary school polygon fixed effects.

Equations (6.1) are similar in form to equations (3.1). These five equations (one for each k) were estimated as a system of seemingly unrelated regressions (SUR) because the error terms are correlated across equations. Standard errors are adjusted for clustering at the level of the 2001 elementary school polygon. The dependent variable, A_{2001+k}^j , is an indicator for whether student j was not in the 20th day student census for the year $2001 + k$. As $\Delta bschl_shock^j$ must capture only the impact of the redistricting on school racial compositions, I constructed $bschl_shock_{2002}^j$ as a shock due solely to the redistricting and used each student's 2001 residence to obtain the assigned elementary school for both 2001 and 2002.

I include fixed effects for each 2001 elementary school polygon (α_{FE}), since they absorbed much of the variation in baseline characteristics across reassigned and non-reassigned students (Table 2). As with equations (3.1), the percent black of student j 's neighborhood in 2001, $bneigh_{2001}^j$, is included as a regressor to help capture remaining differences in baseline characteristics across reassigned and non-reassigned students, even within a 2001 elementary school polygon. I also control for student-level baseline (2001) characteristics, X_j , including indicators for whether the student was female, a recipient

of lunch subsidies, and in a magnet program; number of absences and suspensions; and grade dummies.

The coefficient of interest is β : the impact of a one percentage point increase in the percent black of the assigned elementary school on the probability of non-enrollment in CMS one to five years after the dismissal of busing. My interpretation of the results in Section 5 depends on whether the change in assigned elementary school percent black statistically significantly predicted attrition.

I then look at the decision to change residence within CMS for students who had not left CMS. The estimation sample for each year is the same as the estimation sample used in the corresponding attrition regression, excluding the students no longer in CMS at the beginning of that year. For a student enrolled in CMS in a given year (2002 to 2006, inclusive), I count the student as living in a different residence in that year if and only if her residence was located in a different neighborhood than her residence in 2001. Recall that neighborhoods were defined at the level of the intersection of 2001 and 2002 elementary school assignment zones and that I focus on racial sorting across neighborhoods. Moreover, the right hand side variable of interest, the change in the percent black of the assigned elementary school, varies only at the neighborhood level. For these reasons, I do not treat a within-neighborhood move as changing residence.

Table 10 presents summary statistics for the probability of moving within CMS, conditional on not having left in CMS, in each of the five years: overall, for black students, and for non-black students. In each year, the probability was statistically significantly different across the two racial groups (p-value = 0.0000) and larger for black students. However, this finding of differential rates of moving does not necessarily imply that black students were more likely than non-black students to move in response to the changes in assigned elementary school percent black.

To study the impact of changes in assigned elementary school percent black on the probability of moving within CMS, conditional on not having left CMS, I estimated equations (6.1), replacing A_{2001+k}^j with M_{2001+k}^j , an indicator for whether student j was in a different residence (neighborhood) in 2001 than in the year $2001 + k$. The coefficient of interest is again β : the effect of a one percentage point increase in the percent black of the assigned elementary school on the probability of moving within CMS one to five years after the dismissal of busing. The estimated effects provide insight into the mechanism by which assigned elementary school percent black affected neighborhood percent black.

6.2 Empirical Results: Attrition

The top panel of Table 11 gives the estimates of the attrition regression equations for black students, where each column is for a different value of k . Estimates of β are in the first row. Standard errors are in

parentheses. None of the estimates of β is statistically significant, implying that, for each of the five years, I fail to reject the null hypothesis that the change in the percent black of the assigned elementary school had an impact on the decision to enroll in CMS for black students. The magnitudes of the coefficient estimates and the corresponding percent increases in the probability of attrition at the appropriate mean attrition rates are small; for example, the estimate of β in column (1) says that a 10 percentage point increase in the percent black of the assigned elementary school implied a 0.13 percentage point increase in the probability that a black student present in CMS in 2001 was not enrolled in a CMS school in 2002, relative to the 2002 average attrition rate of 5.4 percent for black students, which translates into a 2.41 percent increase in the probability of attrition at its mean.

The bottom panel of Table 11 gives the estimates for non-black students. None of the estimates of β is statistically significant, except for the 2002 estimate, where I find a statistically significant positive relationship between the change in the percent black of the assigned elementary school and the probability of attrition for non-black students (p-value = 0.049). This estimate says that a 10 percentage point increase in the percent black of the assigned elementary school led to a 0.62 percentage point increase in the probability that a non-black student present in CMS in 2001 was not enrolled in CMS in 2002, relative to the 2002 average attrition rate of 7.0 percent for black students, which translates into a 8.86 percent increase in the probability of attrition at its mean. The estimates of β for the other years imply smaller percent increases in the probability of attrition (the estimate of β is about 44 percent larger for 2004 non-enrollment in CMS relative to 2002 non-enrollment in CMS, but the mean attrition rate for 2004 is about three times as large as the mean attrition rate for 2002). Thus, in the first year following the dismissal of busing, there was some response by non-black families to the changes in the racial characteristics of the assigned elementary school, in terms of the families' decisions to continue their children's enrollment in CMS. However, this finding will likely not affect the interpretation of the estimated one-year impact of changes in assigned elementary school racial compositions on neighborhood racial compositions in Table 5, as there was very little immediate sorting in response to the school reassignments.

More importantly for this research, for both the black and non-black samples, I fail to reject the null hypothesis that changes in the racial characteristics of the assigned elementary school affected enrollment decisions in CMS four or five years after the dismissal of busing, the time periods when the estimated impacts of an increase in the percent black of the assigned elementary school on the percent black of the neighborhood were larger relative to earlier years and statistically significant. Hence, it does not appear that attrition is driving the results in Section 5; that is, what I interpret as neighborhood racial

resorting is indeed neighborhood racial resorting (intradistrict residential mobility), rather than changes in the composition of public school students in Mecklenburg County (due to attrition).

6.3 Empirical Results: Moving

The top panel of Table 12 presents the estimates of the moving regression equations for black students, where each column is for a different value of k . Estimates of β are in the first row, and standard errors are in parentheses. None of the estimates of β is statistically significant; I always fail to reject the null hypothesis that the change in the percent black of the assigned elementary school had an impact on the decision to change residence (neighborhood) within CMS for black students that continued enrolled in CMS. In each year, a 10 percentage point increase in assigned elementary school percent black led to a less than one percent change in the probability of changing residence for black students, relative to the mean for that year (negative relationship for 2002-2004 and positive relationship for 2005-2006). Overall, these findings suggest that black families did not respond to the change in the racial characteristics of the assigned elementary school by moving within CMS.

The bottom panel of Table 12 presents the estimates for non-black students. The estimated relationship between assigned elementary school percent black and the decision to change residence five years after the dismissal of busing, given continued enrollment in CMS, is statistically significant at the five percent level. It says that a 10 percentage point increase in the percent black of the assigned elementary school implied a 1.88 percentage point increase in the probability that a non-black student present in CMS in both 2001 and 2006 moved to a different neighborhood between 2001 and 2006, relative to the average moving rate of 25.9 percent. This translates into a 7.26 percent increase in the probability of moving at its mean. Combining this result with the findings of small and statistically insignificant impacts of changes in assigned elementary school racial compositions on attrition in 2006 for black students, attrition in 2006 for non-black students, and moving in 2006 for black students, suggests an explanation for the positive estimated effect of changes in assigned elementary school percent black on neighborhood percent black: non-blacks moved from neighborhoods with increases in the percent black of the assigned elementary school to neighborhoods with declines in the percent black of the assigned elementary school, while black residents did not change residential locations in response to the school reassignments.

The estimated relationship between assigned elementary school percent black and the decision to change residence four years after the dismissal of busing is statistically insignificant, although marginally statistically significantly positive (at the 10 percent level; dividing in half the p-value for the two-tailed

test, which is 0.174). A 10 percentage point increase in the percent black of the assigned elementary school brought about a 1.12 percentage point increase in the probability that a non-black student present in CMS in both 2001 and 2005 moved to a different neighborhood between 2001 and 2005, relative to the average moving rate of 22.6 percent. This translates into a 4.96 percent increase in the probability of moving at its mean. Because the effect of a change in the percent black of the assigned elementary school on the percent black of the neighborhood was positive and statistically significant for 2005, a similar conclusion as above can be drawn with regard to the mechanism that might have led to neighborhood racial change. Overall, the attrition and moving results shed light on the underlying factors that brought about neighborhood racial sorting in response to changes in assigned elementary school racial compositions.

7 Conclusions, Policy Implications, and Future Research

This paper provided empirical evidence on how changes in school racial compositions affect neighborhood racial compositions. I used a natural experiment in CMS: school redistricting that coincided with the end of court-ordered busing for desegregation in the fall of 2001. Approximately 50 percent of families were reassigned to different schools due to the redistricting, which led to large changes in school racial compositions across the district. I found that the impact of an increase in the percent black of the assigned elementary school on the percent black of the neighborhood was positive and statistically significant over the five-year period, 2001 to 2006. A 10 percentage point increase in the percent black of the assigned elementary school led to an approximately 1.2 percentage point increase (relative to a mean of 53.6 percent) in the percent black of the neighborhood five years after the termination of busing. I also found increasing effects over time, consistent with predictions from a simple model of short-run neighborhood racial dynamics. Moreover, the estimated responses of neighborhood racial compositions to changes in assigned elementary school racial compositions (at least for the longer time horizons) were consistent with non-black residents' moving from neighborhoods with increases in the percent black of the assigned elementary school to neighborhoods with decreases in the percent black of the assigned elementary school, while black residents did not change residential locations in response to the school reassignments.

These findings also have implications for possible impacts of changes in school racial desegregation policies on the racial compositions of neighborhoods. The 1991 *Board of Education of Oklahoma City v. Dowell* decision described how a school district could be declared unitary and thus no longer subject to a racial desegregation order. Since that time, many school districts have been released from court-

ordered racial desegregation; for instance, a recent Supreme Court ruling declared that race-based student assignment plans in Seattle, Washington and Louisville, Kentucky were unlawful.³² These and other school districts are then faced with designing alternative school assignment systems not based on race. Possible alternatives to racial busing include school choice, local residential neighborhood assignment, or “social integration” programs where students are assigned to schools based on other factors, such as income or prior academic achievement.³³ There is empirical evidence that school racial segregation has increased as a result of dismissal from court-ordered racial desegregation (Orfield and Eaton (1996), Lutz (2005), Clotfelter, Ladd, and Vigdor (2006)). These findings, together with the results from this paper, lend support to the idea that neighborhood racial sorting may occur if school racial compositions change after the termination of court-ordered racial desegregation.

This work has found short-run evidence of neighborhood racial sorting in response to changes in school racial characteristics. Longer-term impacts on neighborhood racial compositions as a result of these changes in school assignments and, more broadly, the end of court-ordered racial desegregation remain to be seen.³⁴ In addition, these results are unable to address how changes in school racial characteristics affect neighborhood racial sorting for households without children in CMS. Comparing patterns of neighborhood racial sorting across households with and without children in the public school system would provide a better understanding of the importance of school racial compositions in determining location decisions, that is, the extent to which school racial compositions more directly influence location decisions (through having a child attend the assigned school) and the extent to which they more indirectly affect location decisions (through rents or housing values). Finally, the estimated changes in neighborhood racial compositions could be linked to panel data on individual economic outcomes, such as educational achievement, labor market activity, or health, to better understand how neighborhood effects operate and to hopefully separate the effects of schools from the effects of neighborhoods on these outcomes.

A Appendix

A.1 Proof of Proposition 1

Proposition 1 $(b_{t+1}^j - b_*^j)$ is an increasing function of $(sch_t^j - sch_*^j)$.

³²High court rejects school integration plans. (2007, June 27). *The Seattle Times*.

³³See Kahlenberg (2007) and Wake Education Partnership (2008) for a listing of school districts that use socioeconomic status as a factor in assigning students to schools and the history of school desegregation for some of these districts.

³⁴As stated in an earlier footnote, a different model of neighborhood racial dynamics would probably have to be developed to look at long-run impacts of changes in school assignments on neighborhood racial compositions.

Proof.

$$\begin{aligned}
b_{t+1}^j &\equiv b_t^j + \gamma^0 + \gamma^1 b_t^j + \gamma^2 sch_t^j && \text{by (4.1)} \\
&= b_*^j + \gamma^0 + \gamma^1 b_*^j + \gamma^2 \left(f^{j'} b_*^j + (1 - f^{j'}) b^{-j'} \right) && \text{since } b_t^j = b_*^j.
\end{aligned}$$

$$\begin{aligned}
\Rightarrow \Delta b_{t+1}^j &= b_{t+1}^j - b_*^j \\
&= \left(b_*^j + \gamma^0 + \gamma^1 b_*^j + \gamma^2 \left(f^{j'} b_*^j + (1 - f^{j'}) b^{-j'} \right) \right) \\
&\quad - \left(b_*^j + \gamma^0 + \gamma^1 b_*^j + \gamma^2 \left(f^j b_*^j + (1 - f^j) b^{-j} \right) \right) \\
&= \gamma^2 \left(\left(f^{j'} b_*^j + (1 - f^{j'}) b^{-j'} \right) - \left(f^j b_*^j + (1 - f^j) b^{-j} \right) \right) \\
&= \gamma^2 \left(sch_t^j - sch_*^j \right).
\end{aligned}$$

The final line of the above derivation and the assumption that $\gamma^2 > 0$ prove the first prediction. ■

A.2 Proofs of Propositions 2 and 3

Proposition 2 *Under the assumption that $(\gamma^2)^2$ is negligible, $(b_{t+n}^j - b_*^j)$ is an increasing function of $(sch_t^j - sch_*^j)$ for $n \geq 2$.*

Proposition 3 *Under the assumption that $(\gamma^2)^2$ is negligible, for a given increase (decrease) in $(sch_t^j - sch_*^j)$, the increase (decrease) in $(b_{t+n}^j - b_*^j)$ is larger for larger values of n .*

Proof. The two-year change in neighborhood fraction black, $(b_{t+2}^j - b_*^j)$, is derived as follows:

$$\begin{aligned}
b_{t+2}^j &\equiv b_{t+1}^j + \gamma^0 + \gamma^1 b_{t+1}^j + \gamma^2 sch_{t+1}^j \\
&= b_{t+1}^j + \gamma^0 + \gamma^1 b_{t+1}^j + \gamma^2 \left(f^{j'} b_{t+1}^j + (1 - f^{j'}) b^{-j'} \right).
\end{aligned}$$

$$\begin{aligned}
\Rightarrow \Delta b_{t+2}^j &= b_{t+2}^j - b_{t+1}^j \\
&= \left(b_{t+1}^j + \gamma^0 + \gamma^1 b_{t+1}^j + \gamma^2 \left(f^{j'} b_{t+1}^j + (1 - f^{j'}) b^{-j'} \right) \right) \\
&\quad - \left(b_*^j + \gamma^0 + \gamma^1 b_*^j + \gamma^2 \left(f^{j'} b_*^j + (1 - f^{j'}) b^{-j'} \right) \right) \\
&= \left(\left(b_{t+1}^j - b_*^j \right) + \gamma^1 \left(b_{t+1}^j - b_*^j \right) + \gamma^2 f^{j'} \left(b_{t+1}^j - b_*^j \right) \right) \\
&= \left(1 + \gamma^1 + \gamma^2 f^{j'} \right) \Delta b_{t+1}^j.
\end{aligned}$$

$$\begin{aligned}
\Rightarrow b_{t+2}^j - b_*^j &= \Delta b_{t+1}^j + \Delta b_{t+2}^j \\
&= \Delta b_{t+1}^j + (1 + \gamma^1 + \gamma^2 f^{j'}) \Delta b_{t+1}^j \\
&= \gamma^2 (1 + (1 + \gamma^1 + \gamma^2 f^{j'})) (sch_t^j - sch_*^j).
\end{aligned}$$

The three-year change in neighborhood fraction black, $(b_{t+3}^j - b_*^j)$, is derived as follows:

$$\begin{aligned}
b_{t+3}^j &\equiv b_{t+2}^j + \gamma^0 + \gamma^1 b_{t+2}^j + \gamma^2 sch_{t+2}^j \\
&= b_{t+2}^j + \gamma^0 + \gamma^1 b_{t+2}^j + \gamma^2 (f^{j'} b_{t+2}^j + (1 - f^{j'}) b^{-j'}).
\end{aligned}$$

$$\begin{aligned}
\Rightarrow \Delta b_{t+3}^j &= b_{t+3}^j - b_{t+2}^j \\
&= (b_{t+2}^j + \gamma^0 + \gamma^1 b_{t+2}^j + \gamma^2 (f^{j'} b_{t+2}^j + (1 - f^{j'}) b^{-j'})) \\
&\quad - (b_{t+1}^j + \gamma^0 + \gamma^1 b_{t+1}^j + \gamma^2 (f^{j'} b_{t+1}^j + (1 - f^{j'}) b^{-j'})) \\
&= ((b_{t+2}^j - b_{t+1}^j) + \gamma^1 (b_{t+2}^j - b_{t+1}^j) + \gamma^2 f^{j'} (b_{t+2}^j - b_{t+1}^j)) \\
&= (1 + \gamma^1 + \gamma^2 f^{j'}) \Delta b_{t+2}^j \\
&= (1 + \gamma^1 + \gamma^2 f^{j'})^2 \Delta b_{t+1}^j.
\end{aligned}$$

$$\begin{aligned}
\Rightarrow b_{t+3}^j - b_*^j &= \Delta b_{t+1}^j + \Delta b_{t+2}^j + \Delta b_{t+3}^j \\
&= \Delta b_{t+1}^j + (1 + \gamma^1 + \gamma^2 f^{j'}) \Delta b_{t+1}^j + (1 + \gamma^1 + \gamma^2 f^{j'})^2 \Delta b_{t+1}^j \\
&= \gamma^2 (1 + (1 + \gamma^1 + \gamma^2 f^{j'}) + (1 + \gamma^1 + \gamma^2 f^{j'})^2) (sch_t^j - sch_*^j)
\end{aligned}$$

and so on. Thus, the n -year change in neighborhood fraction black, $(b_{t+n}^j - b_*^j)$, is

$$b_{t+n}^j - b_*^j = \gamma^2 \left(\sum_{i=0}^{n-1} (1 + \gamma^1 + \gamma^2 f^{j'})^i \right) (sch_t^j - sch_*^j) \quad \text{for } n \geq 1.$$

As long as $(\gamma^2)^2$ is negligible, the terms involving $f^{j'}$ in the expression for $(b_{t+n}^j - b_*^j)$ for $n \geq 2$ become negligible, proving the second and third predictions. ■

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Table 1: Racial/Ethnic Distribution of CMS Versus Mecklenburg County

	% Black, Not Hispanic	% White, Not Hispanic	% Hispanic	% Other Ethnicities	Total Number of Students/ Residents
	(1)	(2)	(3)	(4)	(5)
CMS: 2001	43.0	43.7	7.1	6.1	110,434
CMS: 2002	43.0	42.4	8.1	6.4	113,954
CMS: 2003	43.1	40.7	9.4	6.7	118,623
CMS: 2004	43.3	38.8	11.0	6.9	123,707
CMS: 2005	43.3	36.7	12.6	7.4	129,340
CMS: 2006	42.7	35.3	14.1	7.9	135,367
County: 2001	28.0	60.4	7.1	4.5	719,552
County: 2002	28.4	59.3	7.6	4.6	735,194
County: 2003	28.6	58.5	8.1	4.8	752,227
County: 2004	28.8	57.5	8.6	5.0	770,638
County: 2005	29.2	56.5	9.2	5.1	796,369
County: 2006	29.5	55.4	9.8	5.3	827,445

Notes: The CMS racial/ethnic distributions were taken from 20th day student censuses. The county racial/ethnic distributions were taken from the United States Census Bureau Population Estimates Program (July 1 reference date). The “% Other Ethnicities” category includes Asian, Native American, and Multiracial.

Table 2: Determinants of Reassignment to Different Elementary School

	Dependent Variable: Indicator if Student Was Reassigned to Different Elementary School [Without Polygon Fixed Effects]		Dependent Variable: Indicator if Student Was Reassigned to Different Elementary School [With Polygon Fixed Effects]	
	(1)	(2)	(3)	(4)
Black	0.197*** (0.038)	0.185*** (0.035)	0.052* (0.029)	0.051* (0.027)
Hispanic	0.039 (0.038)	0.033 (0.035)	0.011 (0.021)	0.011 (0.022)
Lunch Recipient	0.112*** (0.026)	0.101*** (0.027)	0.030* (0.017)	0.034* (0.018)
Female	0.002 (0.003)	0.012** (0.005)	0.002 (0.002)	0.007* (0.003)
Number of Absences	0.002*** (0.0004)	0.001** (0.001)	0.0004 (0.0003)	0.0001 (0.0004)
Number of Suspensions	-0.0003 (0.001)	0.001 (0.001)	0.00006 (0.0004)	0.001 (0.0005)
Test Score	– –	-0.019** (0.008)	– –	-0.002 (0.005)
Dep. Var. Mean	0.449	0.439	0.449	0.439
Number of Students	99,104	50,066	99,104	50,066
Adjusted R ²	0.0738	0.0757	0.5065	0.5021

Notes: OLS estimation of equation (3.2). Columns (1) and (3) omit baseline test score as an explanatory variable, since not all students take standardized exams. 2001 elementary school polygon fixed effects are included in columns (3) and (4) but not shown. Standard errors, clustered at the polygon level, are in parentheses. Asterisks indicate significance (*=.10, **=.05, ***=.01).

Table 3: Summary Statistics for Neighborhood Percent Black

			Percentiles												
	μ	σ	Min	5	10	20	30	40	50	60	70	80	90	95	Max
2001	53.6	32.9	0	4.2	6.3	15.2	28.7	43.2	54.8	69.8	80.9	89.9	96.1	97.6	100
2002	53.7	32.2	0	4.3	6.7	16.9	30.9	44.4	54.8	67.8	81.4	88.9	95.1	97.4	100
2003	54.0	31.7	0	4.8	7.5	18.2	30.8	46.3	55.8	67.2	77.7	89.2	94.3	97.3	100
2004	54.2	31.3	0	4.8	8.7	17.8	35.1	46.7	56.9	65.9	77.0	89.1	95.1	97.7	100
2005	54.3	30.7	0	5.0	8.4	18.6	34.5	47.2	56.4	67.2	76.1	87.6	94.2	97.0	100
2006	53.9	30.5	0	4.3	7.7	22.1	35.3	46.1	56.8	65.0	76.2	86.3	93.4	96.7	100

Note: These statistics were constructed using neighborhood-level data.

Table 4: Summary Statistics for Assigned Elementary School Percent Black

			Percentiles												
	μ	σ	Min	5	10	20	30	40	50	60	70	80	90	95	Max
2001	44.3	16.5	3.2	7.0	25.3	33.3	37.3	40.9	44.4	46.1	51.1	59.2	66.3	72.3	82.8
2002	51.2	28.9	3.0	6.7	8.1	20.4	31.8	40.2	53.1	62.8	70.1	84.1	90.7	95.4	97.5
Diff.	6.9	27.0	-50.2	-32.1	-25.6	-16.2	-8.8	-2.7	1.0	8.7	22.0	33.6	48.8	57.3	64.8

Notes: These statistics were constructed using neighborhood-level data. 2002 numbers were computed using the shock measure described in the text. "Diff." is the difference between 2002 and 2001 assigned elementary school percent black.

Table 5: Impact of Change in Assigned Elementary School Percent Black on Neighborhood Percent Black

	Dep. Var.: $\Delta\%$ Black in Neigh. from 2001 to 2002	Dep. Var.: $\Delta\%$ Black in Neigh. from 2001 to 2003	Dep. Var.: $\Delta\%$ Black in Neigh. from 2001 to 2004	Dep. Var.: $\Delta\%$ Black in Neigh. from 2001 to 2005	Dep. Var.: $\Delta\%$ Black in Neigh. from 2001 to 2006
	(1)	(2)	(3)	(4)	(5)
$\Delta\%$ Black in Assigned Elem. School from 2001 to 2002 [Shock Measure]	-0.018 (0.039) [0.635]	0.042 (0.046) [0.358]	0.075 (0.050) [0.131]	0.111** (0.052) [0.032]	0.118** (0.050) [0.019]
% Black in Neigh. in 2001	-0.052 (0.034) [0.128]	-0.131*** (0.037) [0.000]	-0.188*** (0.041) [0.000]	-0.257*** (0.049) [0.000]	-0.306*** (0.064) [0.000]
Total Observations	249	249	249	249	249
Adjusted R ²	0.3603	0.4330	0.4945	0.5656	0.6099
χ^2 Test for Equality of β Across Equations: P-value = 0.0387					

Notes: SUR estimation of equations (3.1) (each column is for a different value of k). 2001 elementary school polygon fixed effects are included but not shown. Standard errors, clustered at the polygon level, are in parentheses, and p-values are in brackets. Asterisks indicate significance (*=.10, **=.05, ***=.01).

Table 6: Impact of Change in Assigned Elementary School Percent Black on Neighborhood Percent Black (With Added Controls)

	Dep. Var.: $\Delta\%$ Black in Neigh. from 2001 to 2002	Dep. Var.: $\Delta\%$ Black in Neigh. from 2001 to 2003	Dep. Var.: $\Delta\%$ Black in Neigh. from 2001 to 2004	Dep. Var.: $\Delta\%$ Black in Neigh. from 2001 to 2005	Dep. Var.: $\Delta\%$ Black in Neigh. from 2001 to 2006
	(1)	(2)	(3)	(4)	(5)
$\Delta\%$ Black in Assigned Elem. School from 2001 to 2002 [Shock Measure]	-0.018 (0.040) [0.656]	0.018 (0.046) [0.687]	0.059 (0.050) [0.239]	0.092* (0.051) [0.075]	0.105** (0.048) [0.030]
% Black in Neigh. in 2001	-0.038 (0.048) [0.429]	-0.165*** (0.055) [0.002]	-0.233*** (0.049) [0.000]	-0.314*** (0.065) [0.000]	-0.326*** (0.083) [0.000]
Total Observations	249	249	249	249	249
Adjusted R ²	0.3525	0.4435	0.4930	0.5668	0.6063
χ^2 Test for Equality of β Across Equations: P-value = 0.0745					

Notes: SUR estimation of equations (3.1) (each column is for a different value of k) with four additional 2001 neighborhood-level controls (not shown): % Hispanic, % lunch, % female, and average test score. 2001 elementary school polygon fixed effects are included but not shown. Standard errors, clustered at the polygon level, are in parentheses, and p-values are in brackets. Asterisks indicate significance (*=.10, **=.05, ***=.01).

Table 7: Instrumental Variables Estimates of Impact of Change in Assigned Elementary School Percent Black on Neighborhood Percent Black

	Dep. Var.: $\Delta\%$ Black in Neigh. from 2001 to 2002	Dep. Var.: $\Delta\%$ Black in Neigh. from 2001 to 2003	Dep. Var.: $\Delta\%$ Black in Neigh. from 2001 to 2004	Dep. Var.: $\Delta\%$ Black in Neigh. from 2001 to 2005	Dep. Var.: $\Delta\%$ Black in Neigh. from 2001 to 2006
	(1)	(2)	(3)	(4)	(5)
$\Delta\%$ Black in Assigned Elem. School from 2001 to 2002 [Observed Measure]	-0.024 (0.050) [0.632]	0.054 (0.060) [0.362]	0.098 (0.066) [0.141]	0.144** (0.068) [0.035]	0.153** (0.064) [0.017]
% Black in Neigh. in 2001	-0.052 (0.032) [0.105]	-0.130*** (0.036) [0.000]	-0.186*** (0.040) [0.000]	-0.253*** (0.047) [0.000]	-0.302*** (0.061) [0.000]
Total Observations	221	221	221	221	221

Notes: IV estimation of equations (5.1) (each column is for a different value of k). Equation (5.2) is the first-stage equation. 2001 elementary school polygon fixed effects are included but not shown. Singleton groups (i.e., polygons with exactly one neighborhood, like Triangle II in Figure 1) were dropped before performing the estimation, reducing the sample size to 221 neighborhoods. Standard errors, clustered at the polygon level, are in parentheses, and p-values are in brackets. Asterisks indicate significance (*=.10, **=.05, ***=.01).

Table 8: Impact of Change in Assigned Elementary School Percent Non-White on Neighborhood Percent Non-White

	Dep. Var.: $\Delta\%$ Non-White in Neigh. from 2001 to 2002	Dep. Var.: $\Delta\%$ Non-White in Neigh. from 2001 to 2003	Dep. Var.: $\Delta\%$ Non-White in Neigh. from 2001 to 2004	Dep. Var.: $\Delta\%$ Non-White in Neigh. from 2001 to 2005	Dep. Var.: $\Delta\%$ Non-White in Neigh. from 2001 to 2006
	(1)	(2)	(3)	(4)	(5)
$\Delta\%$ Non-White in Assigned Elem. School from 2001 to 2002 [Shock Measure]	-0.034 (0.031) [0.277]	-0.017 (0.049) [0.725]	-0.014 (0.047) [0.762]	-0.027 (0.045) [0.547]	0.040 (0.051) [0.437]
% Non-White in Neigh. in 2001	-0.042 (0.026) [0.104]	-0.109*** (0.041) [0.008]	-0.164*** (0.055) [0.003]	-0.205*** (0.060) [0.001]	-0.296*** (0.064) [0.000]
Total Observations	249	249	249	249	249
Adjusted R ²	0.3236	0.3674	0.4555	0.5551	0.6381

χ^2 Test for Equality of β Across Equations: P-value = 0.0867

Notes: SUR estimation of equations (3.1) (each column is for a different value of k) for the non-white versus white populations. 2001 elementary school polygon fixed effects are included but not shown. Standard errors, clustered at the polygon level, are in parentheses, and p-values are in brackets. Asterisks indicate significance (*=.10, **=.05, ***=.01).

Table 9: Probability of Attrition by Race

		All Students	Black Students	Non-Black Students
2002	Probability of Attrition	0.063	0.054	0.070
	Sample Size	83,382	34,635	48,747
2003	Probability of Attrition	0.135	0.114	0.150
	Sample Size	78,228	32,821	45,407
2004	Probability of Attrition	0.183	0.149	0.208
	Sample Size	71,813	30,342	41,471
2005	Probability of Attrition	0.219	0.161	0.260
	Sample Size	64,096	26,943	37,153
2006	Probability of Attrition	0.261	0.198	0.306
	Sample Size	57,116	23,940	33,176

Table 10: Probability of Moving by Race

		All Students	Black Students	Non-Black Students
2002	Probability of Moving	0.146	0.231	0.084
	Sample Size	78,120	32,774	45,346
2003	Probability of Moving	0.237	0.369	0.138
	Sample Size	67,680	29,087	38,593
2004	Probability of Moving	0.304	0.456	0.184
	Sample Size	58,648	25,816	32,832
2005	Probability of Moving	0.360	0.524	0.226
	Sample Size	50,090	22,598	27,492
2006	Probability of Moving	0.400	0.569	0.259
	Sample Size	42,228	19,207	23,021

Table 11: Impact of Change in Assigned Elementary School Percent Black on Attrition

	Dep. Var.: Indicator if Not Enrolled in CMS in 2002 (1)	Dep. Var.: Indicator if Not Enrolled in CMS in 2003 (2)	Dep. Var.: Indicator if Not Enrolled in CMS in 2004 (3)	Dep. Var.: Indicator if Not Enrolled in CMS in 2005 (4)	Dep. Var.: Indicator if Not Enrolled in CMS in 2006 (5)
<i>Panel 1: Black Students</i>					
$\Delta\%$ Black in Assigned Elem. School from 2001 to 2002 [Shock Measure]	0.00013 (0.00016)	0.00026 (0.00031)	0.00026 (0.00034)	0.00014 (0.00039)	0.00021 (0.00038)
Dep. Var. Mean	0.054	0.114	0.149	0.161	0.198
Total Observations	34,635	32,821	30,342	26,943	23,940
Adjusted R ²	0.0378	0.0943	0.1119	0.0665	0.0684
<i>Panel 2: Non-Black Students</i>					
$\Delta\%$ Black in Assigned Elem. School from 2001 to 2002 [Shock Measure]	0.00062** (0.00031)	0.00037 (0.00044)	0.00089 (0.00056)	0.00026 (0.00060)	0.00051 (0.00061)
Dep. Var. Mean	0.070	0.150	0.208	0.260	0.306
Total Observations	48,747	45,407	41,471	37,153	33,176
Adjusted R ²	0.0197	0.0430	0.0496	0.0490	0.0458

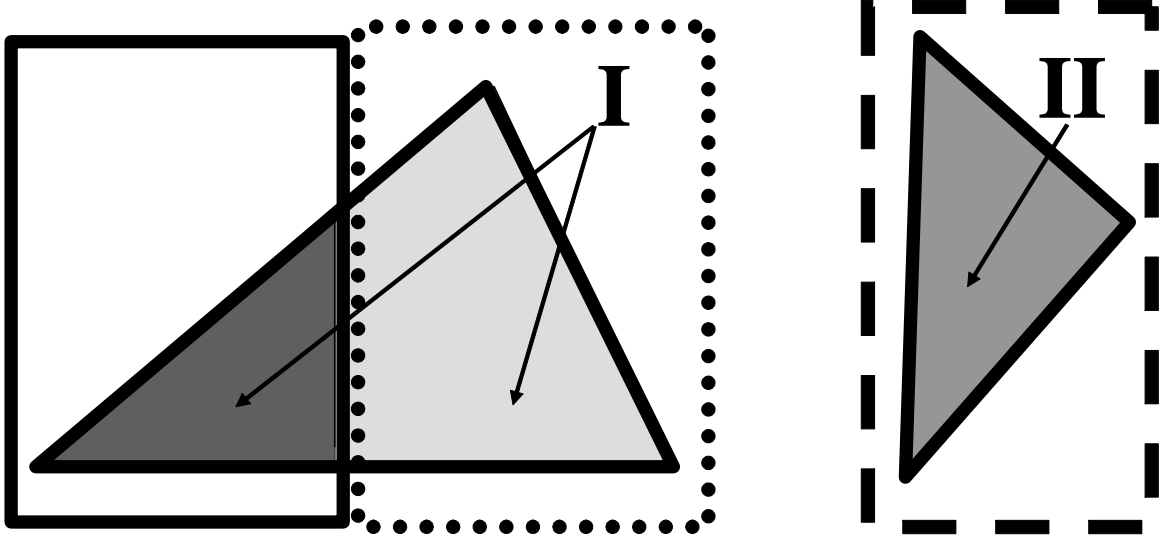
Notes: Within-panel SUR estimation of equations (6.1) (each column is for a different value of \hat{k}). 2001 elementary school polygon fixed effects and the following baseline controls are included but not shown: 2001 neighborhood % black, an indicator if female, an indicator if lunch recipient, an indicator if in magnet program, number of absences, number of suspensions, and grade dummies. Standard errors, clustered at the polygon level, are in parentheses. Asterisks indicate significance (*=.10, **=.05, ***=.01).

Table 12: Impact of Change in Assigned Elementary School Percent Black on Moving

	Dep. Var.: Indicator if Different Residence Within CMS in 2002 (1)	Dep. Var.: Indicator if Different Residence Within CMS in 2003 (2)	Dep. Var.: Indicator if Different Residence Within CMS in 2004 (3)	Dep. Var.: Indicator if Different Residence Within CMS in 2005 (4)	Dep. Var.: Indicator if Different Residence Within CMS in 2006 (5)
<i>Panel 1: Black Students</i>					
$\Delta\%$ Black in Assigned Elem. School from 2001 to 2002 [Shock Measure]	-0.00020 (0.00061)	-0.00014 (0.00083)	-0.00017 (0.00094)	0.00026 (0.00107)	0.00047 (0.00114)
Dep. Var. Mean	0.231	0.369	0.456	0.524	0.569
Total Observations	32,774	29,087	25,816	22,598	19,207
Adjusted R ²	0.0583	0.0938	0.1080	0.1254	0.1278
<i>Panel 2: Non-Black Students</i>					
$\Delta\%$ Black in Assigned Elem. School from 2001 to 2002 [Shock Measure]	-0.00010 (0.00051)	0.00032 (0.00072)	0.00079 (0.00077)	0.00112 (0.00082)	0.00188** (0.00085)
Dep. Var. Mean	0.084	0.138	0.184	0.226	0.259
Total Observations	45,346	38,593	32,832	27,492	23,021
Adjusted R ²	0.0684	0.1032	0.1262	0.1418	0.1581

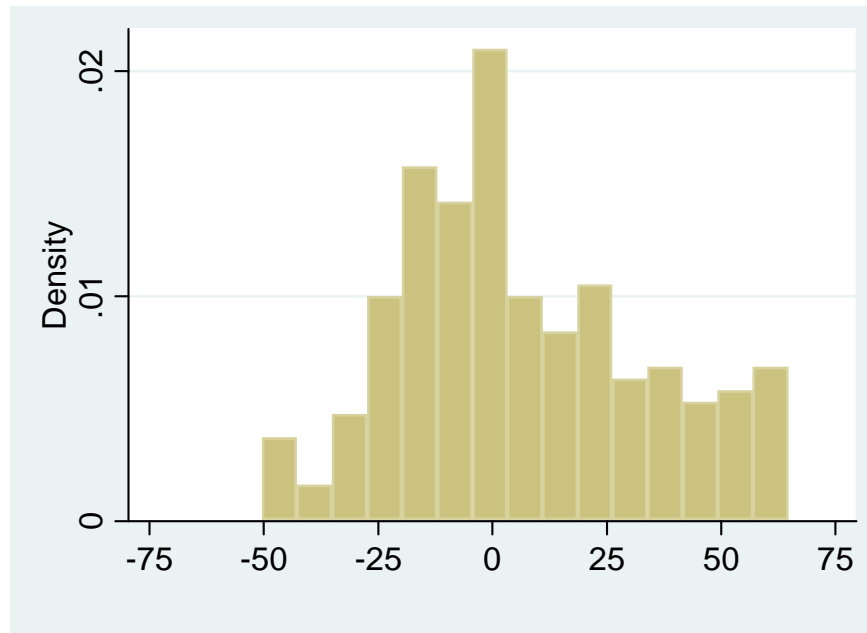
Notes: Within-panel SUR estimation of equations (6.1) (each column is for a different value of k) with the moving indicator as the dependent variable. 2001 elementary school polygon fixed effects and the following baseline controls are included but not shown: 2001 neighborhood % black, an indicator if female, an indicator if lunch recipient, an indicator if in magnet program, number of absences, number of suspensions, and grade dummies. Standard errors, clustered at the polygon level, are in parentheses. Asterisks indicate significance (*=.10, **=.05, ***=.01).

Figure 1: Construction of Neighborhoods



- Triangles I and II were assigned to the same elementary school in 2001.
- Call each individual triangle a polygon.
- School redistricting in 2002 created new elementary school assignment zones (rectangles), three of which overlapped the two polygons.
- Each of the three overlaps is a different neighborhood (shown in different shadings).

Figure 2: Histogram of Difference Between 2002 and 2001 Assigned Elementary School Percent Black



Notes: This figure was constructed using neighborhood-level data. I used the default width as computed by Stata. 2002 assigned elementary school percent black was computed using the shock measure described in the text.