The Effects of Gentrification and Displacement on Academic Achievement in Durham Public Schools, 2010-2019

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ECON 345 Term Paper
Professor Charlie Becker
2021

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Abstract

Gentrification has become the latest buzz word for downtown Durham, and views about its impact on public amenities such as local public schools are hotly contested. This study identifies the neighborhoods in Durham that have been gentrifying and displacing residents between 2010 and 2019 and examines the effects of gentrification and displacement on the 3rd grade academic outcomes of students at Durham Public Schools (DPS). Using two datasets containing 3rd grade DPS students' proficiency rates on reading and mathematics standardized tests between 2010-11 to 2018-19 (one of all 30 DPS elementary schools and one of 20 non-magnet schools), I ran eight ordinary least squares regression models to measure the effect of an elementary school being in an "only gentrifying" or "gentrifying + displacing" school zone on 3rd grade math and reading proficiency. The study found that overall, the effect of being in a "gentrifying + displacing" school zone on 3rd grade academic outcomes is less negative or more positive than that of being in an "only gentrifying" zone. Furthermore, it found that the presence of magnet schools may serve as buffers for negative effects of gentrification on 3rd grade reading and math proficiency, but their presence may simultaneously exacerbate the negative effects of minority student enrollment on 3rd grade outcomes for those elementary schools located in "only gentrifying" and/or "gentrifying + displacing" school zones.

I. Introduction

There is extensive literature showing that living in an impoverished neighborhood harms children's academic performance and achievement in a way that extends beyond growing up in an impoverished family (Sampson et al., 2008; Sharkey and Elwert, 2011). As gentrification has accelerated across U.S. cities in recent years, a growing number of higher educated, higher-income households have been moving into once disinvested and impoverished neighborhoods.

While advocates for gentrification have argued that the influx of social, cultural, and economic capital that follows gentrification leads to improved public services and amenities, there have been relatively few studies analyzing the effects of gentrification on local public schools, an important public amenity (Atkinson, 2002). Does this theorized improvement in public services and amenities extend to public schools? What happens to academic performance of a high-poverty local public schools when its surrounding neighborhood undergoes gentrification or displacement?

This question is especially pertinent to Durham, a city that has undergone massive neighborhood change, from changing racial composition to surging median household income (MHI) and home values, over the past few years. Despite these changes, the Durham Public School (DPS) system has experienced steady declines in enrollment paired with a rising proportion of students qualifying for free and reduced-price lunch (FRPL) in the past decade. Many activists and community members in Durham have attributed these trends to gentrification, which brings in larger waves of middle and upper-middle-income families who are assumed to enroll their children in Durham's charter, private, and magnet schools rather than traditional local public schools.

Moreover, DPS has struggled with significant racial and socioeconomic achievement gaps. Black, Hispanic, and economically disadvantaged students score much lower than White and non-economically disadvantaged students across DPS (DPS, 2018). Given these issues within DPS, combined with the city's recent uptick in gentrification and the role of education as a key driver of social mobility, it is critical for policy makers and community advocates to more comprehensively understand the effects of gentrification on local public schools.

This study features 2 parts, the first of which identifies census block groups in Durham that have been gentrifying and displacing residents between 2010 to 2019. Using those block groups, the second part of the study will quantitatively measure the effect of gentrification and displacement on DPS's 3rd grade student performance on standardized tests between the 2010-2011 to 2018-2019 academic years. Specifically, the paper aims to answer the following research questions: What is the relationship between gentrification and 3rd grade proficiency on reading and math standardized exams, and does this relationship differ if neighborhood displacement is present? Does the relationship differ depending on whether DPS magnet schools are included in the dataset? Does the relationship differ if interaction terms are included to capture the effect of minority student enrollment on academic performance in specifically gentrifying / displacing school zones? It is worth noting that all results found show associations, rather than causality.

II. Literature Review

(i) Defining and measuring gentrification and displacement

"Gentrification" was first coined in 1964 by British sociologist Ruth Glass to describe the transformation of London's working-class neighborhoods by middle- and upper-class groups who bought and upgraded properties. Although the term has been continually redefined in the literature, it is most commonly defined today as the in-migration of more highly educated individuals of higher socioeconomic status into neighborhoods of lower socioeconomic status (Grube-Cavers and Patterson, 2014). Though many studies define and measure gentrification differently, it is typically measured through rising property values and rental costs, the renewal or creation of new housing stock, and demographic changes (Banzhaf and McCormick, 2006). Often, proxies such as the percentage of high-income or higher-educated residents moving into a city and the change in median rent prices and home values have been used to identify gentrification (Atkinson, 2000).

Displacement occurs when a household is forced to move from its residence due to conditions beyond its ability to control or prevent, affecting its dwelling or immediate surroundings (Grier and Grier, 1980). Some scholars argue that there is little to no evidence of displacement due to gentrification (McKinnish et al., 2010), but overall, the literature maintains an association between gentrification and displacement, though the relationship is not necessarily causal (Atkinson, 2000). Displaced individuals are disproportionately low-income, minority

households who are pushed out to city fringes, and they often suffer significant economic, social, and health costs as a result (Atkinson, 2000; Lim et al., 2017). Scholars have leveraged different methods to capture displacement, from comparing in-migrator and out-migrator characteristics, to measuring exit probabilities of vulnerable households (Spain et al., 1980; Vigdor et al., 2002).

(ii) Gentrification and Academic Performance

There is currently limited research quantitatively assessing the effects of gentrification on children's academic performance in local public schools. Most existing studies present singular school or neighborhood case studies or are heavily theoretical, limiting the generalizability about the effects of gentrification and displacement on education outcomes (DeSena, 2006; Cucchiara and Horvat, 2010). A study conducted by Keels et al. (2013) is one of the only studies to date to quantitatively assess the relationship between city-wide gentrification and student academic performance in Chicago public schools. Their study found that gentrification had little effect on neighborhood public schools, which experienced no significant improvement in both aggregate and individual academic performance over time.

Overall, the existing literature remains inconclusive about the effects of gentrification on student academic performance. Scholars have theorized that in the ideal situation, gentrifying parents would enroll their children in local public schools, where they integrate and interact with lower income children. These higher educated, higher income gentrifying parents would then be more likely to invest more economic, political, and social resources towards school events, PTA meetings, and improving school quality (Cucchiara and Horvat, 2010). However, there are caveats to this theory: gentrifiers often do not have school-age children, as they are typically young professionals, artists, and gay and lesbian couples (Kennedy and Leonard, 2001). Moreover, the academic capital and resources of gentrifying parents could be diverted to private, charter, or magnet schools—rather than to neighborhood public schools. School choice literature suggests that higher-income, more educated, and nonminority parents are more likely than their counterparts to exercise school choice (Keels et al., 2013; Burgess et al. 2004).

In a recent study, Pearman (2019) showed that especially when gentrifiers are White, gentrification tends to be associated with declining enrollment at neighborhood public schools. This may be due to both displacement of lower-income school children and gentrifying families

choosing to enroll their children in private, charter, or magnet schools. Moreover, Keels et al. (2013) found that gentrification was associated with declines in public school enrollment and lower proportions of economically disadvantaged students—attributed to displacement of lower-income residents.

(iii) School Choice in Durham

The city of Durham provides expansive school choice programs that are segregated by race and class (Bifulco et al., 2009a). Durham currently has 14 charter schools—a higher concentration than any other district in the state—and nearly half of schools in Durham Public Schools (DPS) are magnet schools. Although Whites make up about 40% of Durham, they accounted for only 19% of the DPS student population in the 2020-21 academic year. At the same time, the proportion of economically disadvantaged students in public schools has risen steadily over time (DPS, 2021).

Bifulco et al. (2009a) found that large numbers of White families use school choice programs to avoid schools with high concentrations of racial minorities, though the overall effect is small. However, they also found that school choice programs in Durham have larger effects on segregation by class and student achievement, with substantially higher percentages of college-educated parents opting out of schools with less college-educated parents. Studies also show that parents who choose to enroll their children in magnet schools have higher levels of education, and in some cases income, than parents who send their children to their assigned local public school. (Martinez et al., 1996). Furthermore, in studies across various states, some charter schools were found to enroll more White students than the nearest local public school (Cobb & Glass, 1999; Booker et al., 2005).

As a result, some argue that due to Durham's extensive school choice programs, neighborhood public schools will not capture the benefits of gentrification. Instead, newly arriving, higher-income families may choose not to send their children to traditional public schools, opting for charter, private, or magnet schools instead (Vaughan, 2018).

III. Data & Methodology

(i) PART 1: Identifying gentrifying and displacing census block groups

The first part of this study identifies and maps gentrifying and displacing neighborhoods in Durham (Fig. 1). To do this, I used datasets from the 2010 and 2019 American Community Survey's 5-year estimates data for the census block group and city-wide levels. Since gentrification can only occur in low-income neighborhoods, I filtered the data for "gentrifiable" block groups in Durham by selecting block groups with a MHI below a threshold of 80% of Durham's 2010 MHI, $58,630. This threshold follows the U.S. Department of Housing and Urban Development's definition of "low-income households."

Then, to identify Durham's "likely gentrifying" block groups within the subset of "gentrifiable" groups, I used 5 Census-based indicators for gentrification and neighborhood change and calculated the percent change between 2010 and 2019 for each of them. I did the same for the Durham-wide level data to establish a baseline to which I compared the percent changes on the block group-level (see Appendix Table 1A). If the "gentrifiable" block group had a percent change greater than the Durham-wide percent change for at least 4 out of 5 of the indicators, it was defined as "likely gentrifying" (see Appendix Table 2A for full list of identified "likely gentrifying" block groups). These 5 indicators are as follows, with all monetary values adjusted for inflation to 2019 dollars:

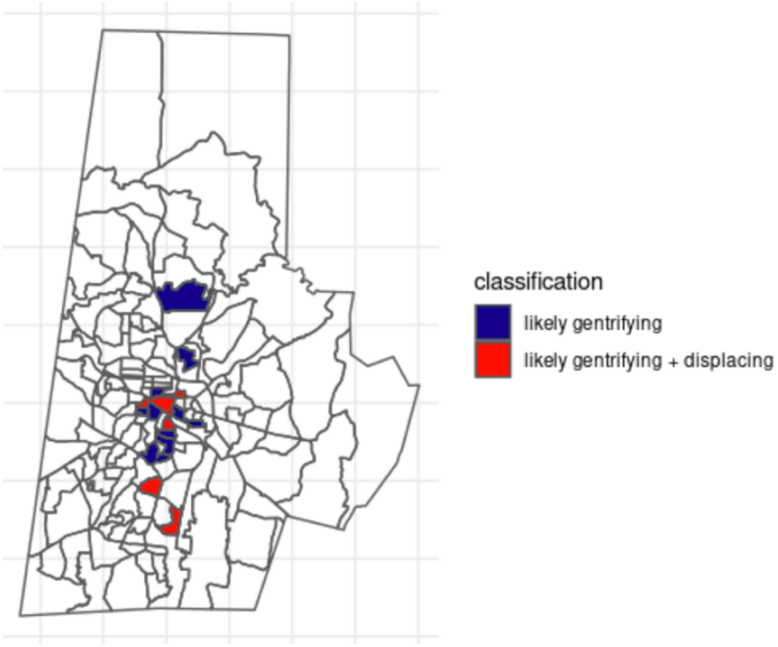
(1) Median household income (MHI)
(2) Median home value
(3) Median gross rent value
(4) Percent of population 25 years and over with at least a bachelor's degree
(5) Percent of population who are non-Hispanic White

I then identified whether displacement was occurring within these "likely gentrifying" block groups by assessing whether new renters are entering in an area at the same time that low-income households are leaving—which would suggest displacement. I use the presence of 2 indicators to identify likely displacement in gentrifying areas. If the percent change in the percentage of low-income families was less than that of the Durham-wide percent change and if the percent of householders moving into renter-occupied housing units in 2017 or later was greater than that of the Durham-wide percentage, the area was defined "likely gentrifying + displacing"

(see Appendix Table 3A for full list of identified "likely gentrifying + displacing" block groups). These two indicators include:

(1) Percent of families with income below the poverty level
(2) Percent of householders who moved into renter-occupied housing units in each block group in 2017 or later

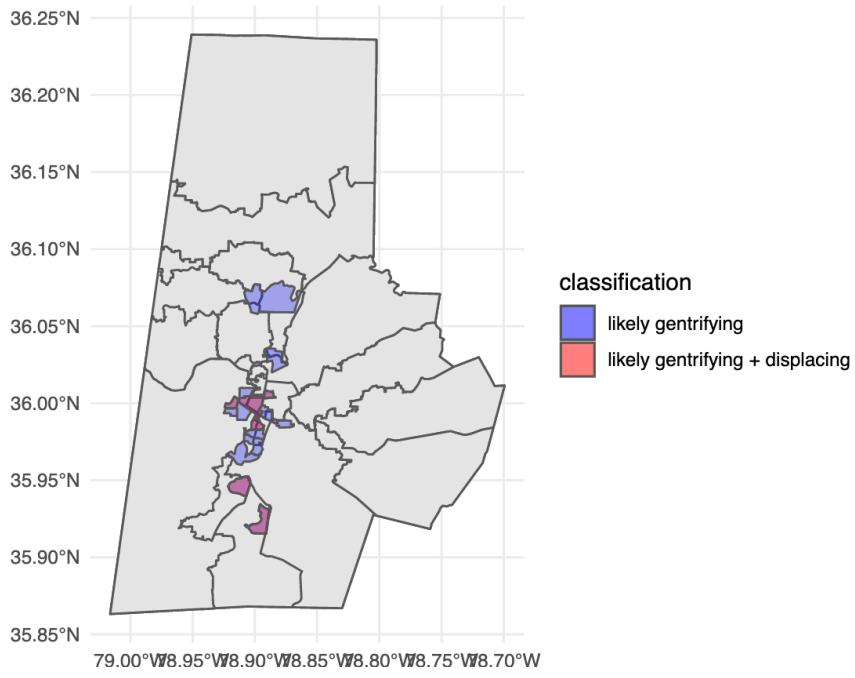
Fig. 1. "Likely gentrifying" and "likely gentrifying + displacing" block groups in Durham, 2019



(ii) PART 2: Assessing the effects of gentrification and displacement on academic performance

The second part of the study involves quantitatively assessing the relationship between gentrification and academic performance on 3rd grade standardized test scores between the 2010-2011 to 2018-2019 academic years. To do this, I first mapped the previously identified "likely gentrifying" and "likely gentrifying + displacing" block groups onto the 2021 school zones of all Durham public elementary schools, which include both magnet and non-magnet schools (Fig. 2). A potential limitation to using the 2021 DPS school zone boundaries may have changed in the years spanning 2010, 2019, and 2021.

Fig. 2. "Likely gentrifying" and "likely gentrifying + displacing" block groups mapped onto 2021 DPS elementary school zones



Then, I created two dummy columns in the dataset, "only_gentrify" and "gentrify_displace," and used RStudio to calculate what percentage of each block group was contained within the elementary school boundary zone. If over 40% of the block group's surface area is contained within the zone, the elementary school is considered "gentrifying." Specifically, if only "likely gentrifying" block group(s) are contained within an elementary school zone, it is marked as "1" for "only_gentrify" and "0" for "gentrify_displace." If any block group that is "likely gentrifying + displacing" is contained within an elementary school zone, it is marked as "1" for "gentrify_displace" and "0" for "only_gentrify." If the zone contains neither "likely gentrifying" nor "gentrifying + displacing" block groups, it is marked as "0" under both dummy columns.

(iii) DATA

This study uses DPS school-level data obtained from the DPS website for the 2010-2011 to 2018-2019 academic years. DPS had 29 elementary schools serving 3rd graders during the 2010-2011 academic year, and 30 during the 2018-2019 academic year. This increase reflects the addition of Sandy Ridge Elementary School, a magnet school for visual and performing arts that

opened in 2011. Of the 30 public elementary schools, 10 are magnet schools and 20 are non-magnet schools. All 30 of these elementary schools were included in the full dataset.

I built my own dataset to use for the analysis using the previously defined elementary school gentrification classifications, 3rd grade DPS mathematics and reading standardized test proficiency, and student body characteristics data. Each of these data points were gathered for each elementary school and for each academic year between 2010-2011 to 2018-2019. The full dataset contained all 30 elementary schools and had 269 total observations. I also created a filtered dataset that included only the 20 non-magnet schools, which had 207 total observations.

(a) Dependent Variables:

(1) **reading_prof** – *quantitative:* aggregate 3rd grade reading proficiency on the NC End-of-Grade assessment per elementary school per academic year
(2) **math_prof** – *quantitative:* aggregate 3rd grade mathematics proficiency on the NC End-of-Grade assessment per elementary school per academic year

I chose to separate the dependent variables into math and reading proficiency because Hispanic student enrollment in DPS has been increasing over time. Since Hispanic students are most likely to be identified as English language learners (ELLs), it is important to disaggregate math and reading tests, on which ELLs may perform substantially differently (U.S. Department of Education).

I specifically focus on 3rd grade standardized test outcomes as a way to measure gentrification's effect on academic achievement, based on literature showing that any effects of gentrification on schooling will be more evident in children in earliest grades. This is because children of higher grades have already completed several years of schooling prior to the effects of neighborhood gentrification settling in (Keels et al. 2013). Joseph and Feldman (2009) also show that parents tend to be more involved in younger than older children's academic routines.

There is also evidence that parents are less likely to exercise school choice for earlier levels of education than for higher levels of education. Specifically in Durham, Bifulco et al. (2009b) suggest that because Durham is divided into more elementary school attendance zones than middle school attendance zones, advantaged parents have less reason to opt out of their

assigned school zone at the elementary level than at the middle school level, as they can more readily access elementary schools with higher concentrations of achievement via residential location. In another study, Bifulco et al. (2009a) show that while high-achieving students are more likely than low-achieving ones to opt out of public school assignments at the middle school level, a student's achievement does not significantly influence their likelihood of opting out at the elementary school level. Moreover, unlike test scores from higher grades, 3rd grade test scores contain less contamination from prior experiences, typically reflecting education from a single elementary school rather than multiple years of education. As a result, the effects of gentrification on student academic achievement, if any, are most likely to be captured through 3rd grade standardized test proficiency scores, which is the first year that standardized testing takes place for students in North Carolina.

Fig. 3. Dependent Variables Summary Statistics

For all DPS elementary schools (including magnet schools):

mean_math	sd_math	mean_read	sd_read
53.69	20.01	46.17	17.53

year	mean_math	sd_math	mean_read	sd_read
2010-2011	72.15	9.96	53.87	14.14
2018-2019	51.26	15.15	45.30	16.06

For non-magnet schools:

mean_math	sd_math	mean_read	sd_read
51.81	20.28	42.47	16.51

year	mean_math	sd_math	mean_read	sd_read
2010-2011	71.05	9.51	50.93	13.31
2018-2019	47.30	13.58	39.33	13.79

According to Figure 3, the dataset including magnet elementary schools has a higher mean math and reading proficiency compared to that including only non-magnet schools. Mean math and reading proficiency decline between 2010-2011 and 2018-19 for both datasets.

(b) Independent Variables:

(1) **enrollment** – *quantitative:* total enrollment per elementary school per academic year

(2) **FRPL** – *quantitative:* percent of students eligible for free and reduced-price lunch (FRPL) per elementary school per academic year
(3) **perc_black** – *quantitative:* percent Black enrollment per elementary school per academic year
(4) **perc_hispanic**– *quantitative:* percent Hispanic enrollment per elementary school per academic year
(5) **year** – *categorical:* academic year between 2010-2011 to 2019-2020
(6) **only_gentrify** – *categorical:* whether or not the school zone contains only gentrifying (not displacing) block groups
(7) **gentrify_displace** – *categorical:* whether or not the school zone contains both gentrifying and displacing block groups
(8) **magnet** – *categorical:* whether or not the elementary school is a magnet school

The "enrollment," "FRPL," "perc_black," and "perc_hispanic" variables represent annual student turnover rates for all students, students eligible for FRPL, Black students, and Hispanic students. Since I only include "perc_black" and "perc_hispanic" in the regression equation, the omitted variable is "perc_whiteasian," or the combined percent of White and Asian enrollment, against which the coefficients of "perc_black" and "perc_hispanic" are compared. Annual eligibility for FRPL represents economic disadvantage: families with household incomes at or below 130% of the federal poverty level are eligible for free lunch, and families at or below 185% are eligible for reduced-price lunch. A potential limitation to measuring student turnover through demographic changes in school enrollment is that we are not able to discern the cause of these changes. For example, a drop in public school enrollments could be because the gentrifiers do not have as many children as long-term residents or could also be because they are sending schools their children to private or charter schools in lieu of neighborhood public schools.

The "only_gentrify" and "gentrify_displace" variables allow me to separately capture the effects of gentrification and displacement on annual academic achievement by comparing the magnitude of their regression output coefficients. Furthermore, the "magnet" variable will allow me to measure and control for the effect of whether a school is a magnet school, on annual academic achievement. This is important especially given the argument that higher-income, gentrifying parents are more likely to enroll their children in magnet schools than traditional public schools. Although we are unable to directly measure where gentrifying parents are enrolling their children, differences in magnet school performance could indicate potential

patterns. For the "year" variable, the 2010-2011 serves as the omitted variable, against which the rest of the years until 2018-2019 is compared.

Fig. 4. Quantitative Independent Variable Summary Statistics

For all DPS elementary schools (including magnet schools):

mean_enroll	mean_FRPL	mean_black	mean_whiteasian	mean_hispanic
526.88	69.80	0.44	0.22	0.30

year	mean_enroll	mean_FRPL	mean_black	mean_whiteasian	mean_hispanic
2010-2011	551.83	68.92	0.48	0.22	0.26
2018-2019	504.83	70.36	0.42	0.22	0.33

For non-magnet DPS elementary schools:

mean_enroll	mean_FRPL	mean_black	mean_whiteasian	mean_hispanic
546.16	73.90	0.47	0.20	0.30

year	mean_enroll	mean_FRPL	mean_black	mean_whiteasian	mean_hispanic
2010-2011	572.57	72.76	0.50	0.21	0.26
2018-2019	525.45	74.65	0.44	0.20	0.32

According to Figure 4, when magnet elementary schools are included in the dataset, the mean percent of students eligible for FRPL, mean enrollment, and mean percentage of Black students declines relative to only non-magnet schools. In general, for both datasets, the mean enrollment and percent of Blacks students decreased from 2010-2011 to 2018-2019, and the mean percent eligible for FRPL and percent of Hispanic students increased.

(iv) ANALYSIS

I first ran 4 separate ordinary least squares regressions to understand whether 3rd grade math and reading standardized test proficiency for each DPS elementary school is associated with gentrification and whether these results differ when magnet schools are included. The first two regressions use 3rd grade reading proficiency as the dependent variable—one uses the full dataset of all 30 DPS elementary schools (including magnet schools) and the other uses the filtered dataset of only the 20 non-magnet local public schools. The other two regressions use 3rd

grade math proficiency as the dependent variable and similarly uses the full dataset of all DPS elementary schools for one regression and a filtered dataset of only non-magnet schools for the other regression. These regressions using the full dataset of all elementary schools had 253 degrees of freedom and these regressions using the filtered dataset of only non-magnet elementary schools had 192 degrees of freedom:

Dependent Variable 1: **3rd grade reading proficiency (no interaction terms)**

All DPS elementary schools:	$reading\_prof = \beta_0 + \beta_1\ only\_gentrify + \beta_2\ gentrify\_displace + \beta_3\ magnet + \beta_4 year + \beta_5\ enrollment + \beta_6\ perc\_black + \beta_7\ perc\_hispanic + \beta_8\ FRPL$
Non-magnet DPS elementary schools:	$reading\_prof = \beta_0 + \beta_1\ only\_gentrify + \beta_2\ gentrify\_displace + \beta_3 year + \beta_4\ enrollment + \beta_5\ perc\_black + \beta_6\ perc\_hispanic + \beta_7\ FRPL$

Dependent Variable 2: **3rd grade mathematics proficiency (no interaction terms)**

All DPS elementary schools:	$math\_prof = \beta_0 + \beta_1\ only\_gentrify + \beta_2\ gentrify\_displace + \beta_3\ magnet + \beta_4 year + \beta_5\ enrollment + \beta_6\ perc\_black + \beta_7\ perc\_hispanic + \beta_8\ FRPL$
Non-magnet DPS elementary schools:	$math\_prof = \beta_0 + \beta_1\ only\_gentrify + \beta_2\ gentrify\_displace + \beta_3 year + \beta_4\ enrollment + \beta_5\ perc\_black + \beta_6\ perc\_hispanic + \beta_7\ FRPL$

To specifically assess the joint effects of minority enrollment and gentrification on academic performance, I ran 4 more regressions using the same 4 equations as above (for both all DPS and only non-magnet elementary schools), but with 4 additional interaction terms in each equation: “only_gentrify*perc_black”, “gentrify_displace*perc_black”, “only_gentrify*perc_hispanic”, and “gentrify_displace*perc_hispanic.” Adding these interaction terms capture the effect of the percentage of Black or Hispanic enrollment on academic performance in “only gentrifying” and “gentrifying + displacing” school zones. The regressions using the full dataset of all elementary schools had 249 degrees of freedom and the regressions using the filtered dataset of only non-magnet elementary schools had 188 degrees of freedom:

Dependent Variable 1: **3rd grade reading proficiency (with interaction terms)**

All DPS elementary schools:	$reading\_prof = \beta_0 + \beta_1\ only\_gentrify + \beta_2\ gentrify\_displace + \beta_3\ magnet + \beta_4 year + \beta_5\ enrollment + \beta_6\ perc\_black + \beta_7\ perc\_hispanic + \beta_8\ FRPL + \beta_9\ only\_gentrify * perc\_black + \beta_{10}\ gentrify\_displace * perc\_black + \beta_{11}\ only\_gentrify * perc\_hispanic + \beta_{12}\ gentrify\_displace * perc\_hispanic$

Non-magnet DPS elementary schools:	$$reading\_prof = \beta_0 + \beta_1\ only\_gentrify + \beta_2\ gentrify\_displace + \beta_3 year + \beta_4\ enrollment + \beta_5\ perc\_black + \beta_6\ perc\_hispanic + \beta_7\ FRPL + \beta_8\ only\_gentrify * perc\_black + \beta_9\ gentrify\_displace * perc\_black + \beta_{10}\ only\_gentrify * perc\_hispanic + \beta_{11}\ gentrify\_displace * perc\_hispanic$$

Dependent Variable 2: **3rd grade mathematics proficiency (with interaction terms)**

All DPS elementary schools:	$$math\_prof = \beta_0 + \beta_1\ only\_gentrify + \beta_2\ gentrify\_displace + \beta_3\ magnet + \beta_4 year + \beta_5\ enrollment + \beta_6\ perc\_black + \beta_7\ perc\_hispanic + \beta_8\ FRPL + \beta_9\ only\_gentrify * perc\_black + \beta_{10}\ gentrify\_displace * perc\_black + \beta_{11}\ only\_gentrify * perc\_hispanic + \beta_{12}\ gentrify\_displace * perc\_hispanic$$
Non-magnet DPS elementary schools:	$$math\_prof = \beta_0 + \beta_1\ only\_gentrify + \beta_2\ gentrify\_displace + \beta_3 year + \beta_4\ enrollment + \beta_5\ perc\_black + \beta_6\ perc\_hispanic + \beta_7\ FRPL + \beta_8\ only\_gentrify * perc\_black + \beta_9\ gentrify\_displace * perc\_black + \beta_{10}\ only\_gentrify * perc\_hispanic + \beta_{11}\ gentrify\_displace * perc\_hispanic$$

IV. Results & Discussion

Using the methodology from part 1 to identify likely gentrifying and displacing block groups, 57 of 153 census block groups were identified as "gentrifiable," and of those 57, 16 were considered "likely gentrifying." Of the 16 "likely gentrifying" neighborhoods, 6 were considered to be "likely gentrifying + displacing" lower-income residents (Fig. 1). Notably, gentrifying census block groups are primarily located in the central city, in or near downtown Durham. Many of them correspond to historically Black neighborhoods that have been redlined, including Cleveland-Holloway, Golden Belt, and Old East Durham.

Of the 30 DPS elementary school zones, 16, or 53%, contained gentrifying block groups. 6 of those 16 schools surrounding gentrifying neighborhoods are magnet schools (Table 1). This means that magnet school zones are more likely than non-magnet school zones to contain gentrifying neighborhoods— 60% of magnet schools compared to 50% of non-magnet schools. Of those 16 elementary school zones, 8 contained only "likely gentrifying" block groups and 8 contained at least one "likely gentrifying + displacing" block group.

Table 1. Identified DPS elementary schools containing gentrifying census block groups

School Name	Block Group(s)	magnet	only_gentrify	gentrify_displace
C.C. Spaulding Elementary School	Block Group 1, Census Tract 7; Block Group 2, Census Tract 23	0	1	0

E.K. Powe Elementary School	Block Group 2, Census Tract 5; Block Group 3, Census Tract 3.02	0	0	1
Eastway Elementary School	Block Group 2, Census Tract 2; Block Group 1, Census Tract 11	0	0	1
Eno Valley Elementary School	Block Group 1, Census Tract 17.08	0	1	0
Fayetteville St Elementary School	Block Group 1, Census Tract 13.04	0	1	0
George Watts Montessori School	Block Group 3, Census Tract 3.02	1	1	0
Glenn Elementary School	Block Group 2, Census Tract 1.01; Block Group 1, Census Tract 22	0	0	1
Holt Elementary Language Academy	Block Group 2, Census Tract 1.01; Block Group 2, Census Tract 2; Block Group 1, Census Tract 11; Block Group 1, Census Tract 22	1	0	1
Lakewood Elementary School	Block Group 3, Census Tract 5	0	1	0
Morehead Montessori School	Block Group 3, Census Tract 5	1	1	0
Parkwood Elementary School	Block Group 3, Census Tract 20.25	0	0	1
Pearsontown Elementary School	Block Group 1, Census Tract 20.26; BG 1, CT 13.01; BG 2, CT 5; BG 1, CT 11; BG 1, CT 13.03; BG 1, CT 13.04; BG 3, CT 10.01; BG 3, CT 3.02; BG 3, CT 20.25; BG 2, CT 23; BG 3, CT 5; BG1, CT 7	1	0	1
Sandy Ridge Elementary School	Block Group 1, Census Tract 17.08	1	1	0
Southwest Elementary School	Block Group 1, Census Tract 20.26	0	0	1
W.G. Pearson Elementary School	Block Group 2, Census Tract 23; Block Group 1, Census Tract 13.01; Block Group 1, Census Tract 11	1	0	1

Y.E. Smith Elementary School	Block Group 2, Census Tract 10.01	0	1	0

(i) Effects on 3rd grade reading proficiency

The results from the 3rd grade reading proficiency model without interaction terms for all DPS elementary schools and for non-magnet DPS elementary schools are shown in Table 2 and Table 3 below, respectively. The models' adjusted R^2 values are 81% and 84%, respectively. The results from the 3rd grade reading proficiency model with interaction terms for all DPS elementary schools and for non-magnet DPS elementary schools are shown in Table 4 and Table 5, respectively. The models' adjusted R^2 values are 82% and 84%, respectively.

According to Table 2, without including the effect of percent of minority student enrollment in a gentrifying / displacing school zone, we expect the 3rd grade reading proficiency scores of elementary schools in an "only gentrifying" school zone to be 5.23 percentage points less, on average, than everywhere else, holding all else constant. Whether the elementary school was both "gentrifying + displacing" has a slightly less negative effect on 3rd grade reading proficiency. When regressing on only non-magnet elementary schools, this trend persisted: the presence of "only gentrifying" neighborhoods within a school zone had a more negative effect on 3rd grade reading proficiency than the presence of both "gentrifying + displacing" neighborhoods within a school zone. These trends are further reinforced when visualizing mean math and reading proficiency scores over time for non-gentrifying -vs- only gentrifying and non-gentrifying -vs- gentrifying + displacing elementary schools (see Appendix Figs. 1B and 2B). On average, "gentrifying + displacing" elementary schools experienced a slower decline (less negative slope) in 3rd grade reading and math proficiency over time, compared to only gentrifying elementary schools.

When incorporating the effect of the percent of Black and Hispanic student enrollment in a gentrifying / displacing school zone, the coefficients changed significantly (Table 4). The effect of being in an "only gentrifying" school zone was no longer statistically significant, while the effect of being in a "gentrifying + displacing" school zone became significantly positive:

With the interaction terms, we expect the 3rd grade reading proficiency of an elementary school that is in a "gentrifying + displacing" school zone to be 15.66 percentage points greater, on average, than non-gentrifying or only gentrifying schools, holding all else constant. When regressing on only non-magnet elementary schools, the effects of being in "only gentrifying" and "gentrifying + displacing" school zones were no longer statistically significant, but the trend remained: the effect of "only gentrifying" neighborhoods in a school zone was more negative, albeit insignificant, on 3rd grade reading proficiency than the effect of "gentrifying + displacing" neighborhoods in a school zone (Table 5).

This trend describing a less negative or positive effect of being in a "gentrifying + displacing" school zone compared to that of being in an "only gentrifying" zone could be because lower-income students in elementary schools located in "gentrifying + displacing" school zones are being replaced with students of higher socioeconomic status who perform better on standardized tests, thereby raising mean 3rd grade reading outcomes. Meanwhile, in elementary schools located in "only gentrifying" non-displacing school zones, lower-income students may not be getting displaced from their elementary schools but may nonetheless be experiencing some degree of residential instability, which has been shown to increase student absenteeism and worsen academic outcomes (Cunningham and MacDonald, 2012). Additionally, rent-burdened or housing insecure parents are less able to prioritize helping children with schoolwork or activities (Cunningham et al., 2010). To discern the reasons underlying this trend, further analysis should be done on the students enrolled in elementary schools located within only gentrifying school zones versus those enrolled in schools located within gentrifying and displacing school zones.

However, the interaction terms between "only gentrifying" neighborhoods and percentage of Black students and between "gentrifying + displacing" neighborhoods and percentage of Black and Hispanic students are large and negative (Table 4). This indicates that in elementary schools located in both "only gentrifying" and "gentrifying + displacing" school zones (and not elsewhere), the percentage of Black students has a very negative effect on 3rd grade reading proficiency, relative to the percentage of White and Asian students (28-29 percentage points lower than elsewhere, on average, holding all else constant.) Similarly, we expect each one percentage increase in the Hispanic student enrollment in "gentrifying +

displacing" school zones to decrease 3rd grade reading proficiency by an additional 23.62 percentage points, on average, relative to a one percentage increase in White and Asian enrollment, compared to elsewhere, holding all else constant.

Therefore, while the overall effect of an elementary school being in an "only gentrifying" school zone has no significant effect on 3rd grade reading proficiency, an increase in Black students in an "only gentrifying" school has a significantly negative effect on 3rd grade reading proficiency. Moreover, while the overall effect of an elementary school being in a "gentrifying + displacing" school zone has a significantly positive effect on 3rd grade reading proficiency, an increase in Black and Hispanic students in a "gentrifying + displacing" school has a significantly negative effect on these same outcomes. This suggests that especially in "gentrifying + displacing" school zones, the demographic of displaced students in these schools may not only be disproportionately lower income, but also disproportionately minorities who tend to have a large, negative effect on 3rd grade reading outcomes.

In general, the effect of "magnet" on reading proficiency was expected based on the literature: both with and without interaction terms, we expect 3rd grade reading proficiency of magnet elementary schools to be greater, on average, than non-magnet elementary schools (Table 2, 4). Moreover, for both models, when magnet schools were excluded from the dataset, the magnitude of the negative effect of "only_gentrify" and "gentrify_displace" increased (Table 3, 5). This reveals both the presence of magnet schools in gentrifying areas, and also suggests that magnet schools may serve as a buffer for the negative effects of gentrification on 3rd grade reading proficiency. This is potentially because parents who enroll their children in magnet schools tend to be more educated and higher income, which is associated with better education outcomes (Martinez et al., 1996). This magnet school trend also becomes visually apparent in Appendix 3B and 4B. On average, elementary schools including magnet schools experienced a slower decline (less negative slope) in 3rd grade reading and math proficiency over time, compared to elementary schools excluding magnet schools.

However, while regressing on all elementary schools including magnet schools yielded significant negative interaction effects between minority student enrollment and gentrification, these interaction effects were no longer significant when regressing on only non-magnet schools

(Table 5). In other words, without magnet schools, the increase in percent of minority student enrollment in "only gentrifying" and "gentrifying and displacing" school zones no longer had significant negative effects on 3rd grade reading proficiency. This suggests that although in general, the presence of magnet schools mitigate the negative effects of gentrification on 3rd grade reading outcomes, the presence of magnet schools may exacerbate the negative effects of minority student enrollment on reading outcomes in these gentrifying / displacing areas. In a study, Manderscheid (2008) found marked racial and class segregation in Durham's magnet programs, noting that there are two disparate populations enrolled in the same magnet program at some of Durham's elementary schools: higher-income Whites from educated, intact families and lower-income minorities. Therefore, it may be that magnet schools primarily reduce the negative effects of gentrification through the considerably higher reading performance of its White students, while increased enrollment of its poorer minority students in gentrifying school zones tend to worsen such performance. Future research should seek to further analyze the demographics of magnet schools and their effects on academic performance in gentrifying / displacing school zones. It should also seek to more generally understand the reason(s) underlying why minority student enrollment has a negative effect on 3rd grade reading outcomes in gentrifying / displacing areas, and not elsewhere.

Furthermore, excluding interaction terms, the effect of race and enrollment on 3rd grade reading proficiency is not statistically significant for all DPS elementary schools, but the percent of Hispanic students has a significant, negative effect on reading proficiency for non-magnet elementary schools. Including interaction terms for all DPS elementary schools, the percent of Hispanic students has a significant, negative effect on reading proficiency, whereas for non-magnet elementary schools, the percent of Black students has a significant, negative effect on reading proficiency. All other race and enrollment effects were not significant.

Moreover, the percent of students eligible for FRPL has a negative effect on 3rd grade reading outcomes: on average in all DPS elementary schools, for each one percentage increase in students eligible for FRPL, we expect reading proficiency to decrease by 0.48 percentage points when excluding interaction terms and 0.3 percentage points when including interaction terms on—holding all else constant (Tables 2, 4). For all models, the "year" effects are mostly statistically significant, with reading proficiency falling each year since 2012-2013, relative to

2010-2011. However, it is ambiguous whether these effects are due to lower competency and preparedness of 3rd grade students or due to annual increases in standardized test difficulty.

Table 2. 3rd grade reading proficiency for all DPS elementary schools *(including magnet schools)*, excluding interaction terms

$$reading\_prof = \beta_0 + \beta_1\ only\_gentrify + \beta_2\ gentrify\_displace + \beta_3\ magnet + \beta_4 year + \beta_5\ enrollment + \beta_6\ perc\_black + \beta_7\ perc\_hispanic + \beta_8\ FRPL$$

term	estimate	std.error	statistic	p.value
(Intercept)	95.53	3.17	30.11	0.00
only_gentrify1	-5.23	1.40	-3.73	0.00
gentrify_displace1	-4.96	1.20	-4.14	0.00
magnet1	5.60	1.26	4.45	0.00
year2011-2012	0.92	2.02	0.46	0.65
year2012-2013	-21.03	2.01	-10.45	0.00
year2013-2014	-5.22	2.00	-2.61	0.01
year2014-2015	-6.79	2.01	-3.38	0.00
year2015-2016	-7.01	2.01	-3.49	0.00
year2016-2017	-7.82	2.02	-3.88	0.00
year2017-2018	-8.84	2.02	-4.37	0.00
year2018-2019	-7.58	2.03	-3.74	0.00
enrollment	0.00	0.00	-1.15	0.25
perc_black	-3.84	7.15	-0.54	0.59
perc_hispanic	-11.90	9.58	-1.24	0.22
FRPL	-0.48	0.07	-6.81	0.00

Table 3. 3rd grade reading proficiency for non-magnet elementary schools only, excluding interaction terms

$$reading\_prof = \beta_0 + \beta_1\ only\_gentrify + \beta_2\ gentrify\_displace + \beta_3 year + \beta_4\ enrollment + \beta_5\ perc\_black + \beta_6\ perc\_hispanic + \beta_7\ FRPL$$

term	estimate	std.error	statistic	p.value
(Intercept)	96.94	3.48	27.83	0.00
only_gentrify1	-7.25	1.99	-3.65	0.00
gentrify_displace1	-5.44	1.34	-4.07	0.00
year2011-2012	0.36	2.13	0.17	0.87
year2012-2013	-20.73	2.12	-9.76	0.00
year2013-2014	-5.55	2.11	-2.63	0.01
year2014-2015	-8.26	2.12	-3.89	0.00
year2015-2016	-7.90	2.12	-3.73	0.00
year2016-2017	-7.17	2.13	-3.37	0.00
year2017-2018	-11.05	2.14	-5.16	0.00
year2018-2019	-10.59	2.14	-4.94	0.00
enrollment	0.00	0.00	-0.89	0.37
perc_black	-12.68	7.24	-1.75	0.08
perc_hispanic	-21.21	10.36	-2.05	0.04
FRPL	-0.39	0.08	-4.95	0.00

Table 4. 3rd grade reading proficiency for all DPS elementary schools *(including magnet schools)*, including interaction terms

$$reading\_prof = \beta_0 + \beta_1\ only\_gentrify + \beta_2\ gentrify\_displace + \beta_3\ magnet + \beta_4 year + \beta_5\ enrollment + \beta_6\ perc\_black + \beta_7\ perc\_hispanic + \beta_8\ FRPL + \beta_9\ only\_gentrify * perc\_black + \beta_{10}\ gentrify\_displace * perc\_black + \beta_{11}\ only\_gentrify * perc\_hispanic + \beta_{12}\ gentrify\_displace * perc\_hispanic$$

term	estimate	std.error	statistic	p.value
(Intercept)	89.64	3.35	26.77	0.00
only_gentrify1	8.70	5.78	1.51	0.13
gentrify_displace1	15.66	6.47	2.42	0.02
magnet1	6.23	1.30	4.79	0.00
year2011-2012	1.80	1.95	0.92	0.36
year2012-2013	-20.36	1.94	-10.49	0.00
year2013-2014	-5.17	1.93	-2.68	0.01
year2014-2015	-6.70	1.94	-3.46	0.00
year2015-2016	-6.83	1.94	-3.52	0.00
year2016-2017	-7.56	1.95	-3.87	0.00
year2017-2018	-8.58	1.96	-4.38	0.00
year2018-2019	-7.32	1.97	-3.72	0.00
enrollment	0.00	0.00	-0.36	0.72
perc_black	-7.23	7.61	-0.95	0.34
perc_hispanic	-33.99	11.27	-3.02	0.00
FRPL	-0.30	0.08	-3.86	0.00
only_gentrify1:perc_black	-27.97	7.73	-3.62	0.00
gentrify_displace1:perc_black	-29.18	10.97	-2.66	0.01
only_gentrify1:perc_hispanic	-3.19	10.79	-0.30	0.77
gentrify_displace1:perc_hispanic	-23.62	9.47	-2.49	0.01

Table 5. 3rd grade reading proficiency for non-magnet elementary schools only, including interaction terms

$$reading\_prof = \beta_0 + \beta_1\ only\_gentrify + \beta_2\ gentrify\_displace + \beta_3 year + \beta_4\ enrollment + \beta_5\ perc\_black + \beta_6\ perc\_hispanic + \beta_7\ FRPL + \beta_8\ only\_gentrify * perc\_black + \beta_9\ gentrify\_displace * perc\_black + \beta_{10}\ only\_gentrify * perc\_hispanic + \beta_{11}\ gentrify\_displace * perc\_hispanic$$

term	estimate	std.error	statistic	p.value
(Intercept)	94.51	3.76	25.11	0.00
only_gentrify1	-50.39	30.30	-1.66	0.10
gentrify_displace1	-1.05	6.76	-0.16	0.88
year2011-2012	1.01	2.05	0.50	0.62
year2012-2013	-20.04	2.05	-9.78	0.00
year2013-2014	-5.28	2.03	-2.60	0.01
year2014-2015	-8.72	2.04	-4.28	0.00
year2015-2016	-8.12	2.04	-3.98	0.00
year2016-2017	-7.80	2.05	-3.80	0.00
year2017-2018	-10.57	2.07	-5.11	0.00
year2018-2019	-9.30	2.10	-4.43	0.00
enrollment	0.00	0.01	-0.32	0.75
perc_black	-15.64	7.84	-2.00	0.05
perc_hispanic	-22.88	14.14	-1.62	0.11
FRPL	-0.35	0.08	-4.50	0.00
only_gentrify1:perc_black	43.86	31.95	1.37	0.17
gentrify_displace1:perc_black	-3.31	11.26	-0.29	0.77
only_gentrify1:perc_hispanic	51.58	37.15	1.39	0.17
gentrify_displace1:perc_hispanic	-6.29	11.71	-0.54	0.59

(ii) Effects on 3rd grade math proficiency

The results from the 3rd grade mathematics proficiency model without interaction terms for all DPS elementary schools and for non-magnet DPS elementary schools are presented in Table 6 and Table 7 below, respectively. Similar to the reading models above, the adjusted R^2 values are quite high, at 74% and 77%, respectively. The results from the 3rd grade mathematics proficiency model with interaction terms for all DPS elementary schools and for non-magnet DPS elementary schools are shown in Table 8 and Table 9, respectively. The models' adjusted R^2 values are 75% and 77%, respectively.

The above trend—of "only gentrifying" neighborhoods in a school zone having a more negative effect on test proficiency than both gentrifying and displacing neighborhoods in a school zone—persisted for 3rd grade math proficiency. In fact, compared to the reading models excluding interaction terms, the coefficient for "only_gentrify" was more negative for the math models excluding interaction terms: holding all else constant, we expect the 3rd grade math proficiency scores of an elementary school that is "only gentrifying" to be 8.5 percentage points less, on average, than non-gentrifying or gentrifying and displacing schools (Table 6). This trend continued and became more negative when excluding magnet schools in the dataset, further suggesting that magnet schools either capture less of the negative effects or more of the positive effects of gentrification (Table 7).

However, when including interaction terms, the effects of "only gentrifying" and "gentrifying + displacing" neighborhoods in a school zone on 3rd grade math proficiency were no longer significant for all DPS and non-magnet elementary schools (Tables 8, 9). Despite being statistically insignificant, this trend persisted: for all DPS elementary schools, the effect of being in a "gentrifying + displacing" school zone was more positive than that of being in an "only gentrifying" school zone, on 3rd grade math outcomes (Table 8). Further, for non-magnet schools, the effect of being in a "gentrifying + displacing" school zone was less negative than that of being in an "only gentrifying" school zone" (Table 9).

Similar to the reading models for all DPS elementary schools in Tables 2 and 4, 3rd grade math proficiency is higher, on average, than that of non-magnet elementary schools—though the

effect of the presence of magnet schools in both math models including and excluding interaction terms is both smaller and statistically insignificant. Similarly, like the trends noted in the reading models, including magnet schools in the dataset makes the effects of "only gentrifying" or "gentrifying + displacing" school zones become less negative or become positive, compared to excluding them in the dataset (Tables 6, 7, 8, 9). This is true for both math proficiency models including and excluding interaction terms (though all the effects become insignificant when including interaction terms.) Nonetheless, this reinforces the trend that the presence of magnet schools tends to mitigate the negative effects of gentrification on 3rd grade academic outcomes.

Moreover, following what was seen in the reading models, the effects of Black student enrollment in an "only gentrifying" school zone was significantly negative when including magnet schools in the dataset, but became statistically insignificant when excluding magnet schools from the dataset. Specifically, when including magnet schools, we expect a one percentage increase in Black student enrollment in "only gentrifying" school zones to, on average, lower 3rd grade math proficiency by an additional 23.72 percentage points relative to a one percentage increase in White and Asian student enrollment, compared to elsewhere, holding all else constant (Table 8). Similar to the reading models, this suggests that although the presence of magnet schools may buffer any negative effects of gentrification on 3rd grade math outcomes, they may also exacerbate the negative effects of Black student enrollment on math outcomes in those elementary schools located in "only gentrifying" school zones.

As expected, where they are significant, the coefficients for "perc_hispanic" in the math proficiency models became much less negative compared to those in the reading models since a larger share of Hispanic students are ELLs who may perform better on math than reading exams. Similar to the reading models, the percent of students eligible for FRPL has a negative effect on 3rd grade math proficiency for all 4 models. Future studies should also examine the effects of gentrification on school demographic composition. For example, is an influx of higher income households associated with a significant decrease in the proportion of students eligible for FRPL? Finally, like in the reading models, the "year" effects for math proficiency are mostly statistically significant for all 4 models, with proficiency falling each academic year since 2012-2013, relative to 2010-2011. However, as noted before, it is unclear to what this decline is attributed.

Table 6. 3rd grade mathematics proficiency for all DPS elementary schools *(including magnet schools)*, excluding interaction terms

$$math\_prof = \beta_0 + \beta_1\ only\_gentrify + \beta_2\ gentrify\_displace + \beta_3\ magnet + \beta_4 year + \beta_5\ enrollment + \beta_6\ perc\_black + \beta_7\ perc\_hispanic + \beta_8\ FRPL$$

term	estimate	std.error	statistic	p.value
(Intercept)	107.91	4.20	25.67	0.00
only_gentrify1	-8.50	1.86	-4.57	0.00
gentrify_displace1	-3.08	1.59	-1.94	0.05
magnet1	1.27	1.67	0.76	0.45
year2011-2012	3.29	2.68	1.23	0.22
year2012-2013	-39.65	2.67	-14.87	0.00
year2013-2014	-23.26	2.65	-8.77	0.00
year2014-2015	-24.15	2.66	-9.08	0.00
year2015-2016	-19.56	2.66	-7.35	0.00
year2016-2017	-22.80	2.67	-8.54	0.00
year2017-2018	-13.44	2.68	-5.01	0.00
year2018-2019	-19.90	2.68	-7.41	0.00
enrollment	0.00	0.01	-0.94	0.35
perc_black	0.20	9.47	0.02	0.98
perc_hispanic	-6.75	12.69	-0.53	0.59
FRPL	-0.42	0.09	-4.45	0.00

Table 7. 3rd grade mathematics proficiency for non-magnet elementary schools only, excluding interaction terms

$$math\_prof = \beta_0 + \beta_1\ only\_gentrify + \beta_2\ gentrify\_displace + \beta_3 year + \beta_4\ enrollment + \beta_5\ perc\_black + \beta_6\ perc\_hispanic + \beta_7\ FRPL$$

term	estimate	std.error	statistic	p.value
(Intercept)	113.27	4.96	22.84	0.00
only_gentrify1	-10.32	2.83	-3.65	0.00
gentrify_displace1	-4.30	1.90	-2.26	0.03
year2011-2012	3.20	3.03	1.05	0.29
year2012-2013	-39.80	3.02	-13.16	0.00
year2013-2014	-23.85	3.01	-7.93	0.00
year2014-2015	-25.60	3.02	-8.48	0.00
year2015-2016	-21.27	3.02	-7.05	0.00
year2016-2017	-24.36	3.03	-8.04	0.00
year2017-2018	-17.08	3.05	-5.60	0.00
year2018-2019	-23.43	3.05	-7.67	0.00
enrollment	-0.01	0.01	-1.22	0.23
perc_black	-10.43	10.30	-1.01	0.31
perc_hispanic	-11.04	14.75	-0.75	0.46
FRPL	-0.36	0.11	-3.15	0.00

Table 8. 3rd grade mathematics proficiency for all DPS elementary schools *(including magnet schools)*, including interaction terms

$$math\_prof = \beta_0 + \beta_1\ only\_gentrify + \beta_2\ gentrify\_displace + \beta_3\ magnet + \beta_4 year + \beta_5\ enrollment + \beta_6\ perc\_black + \beta_7\ perc\_hispanic + \beta_8\ FRPL + \beta_9\ only\_gentrify * perc\_black + \beta_{10}\ gentrify\_displace * perc\_black + \beta_{11}\ only\_gentrify * perc\_hispanic + \beta_{12}\ gentrify\_displace * perc\_hispanic$$

term	estimate	std.error	statistic	p.value
(Intercept)	103.11	4.56	22.62	0.00
only_gentrify1	0.15	7.87	0.02	0.99
gentrify_displace1	13.69	8.81	1.55	0.12
magnet1	2.17	1.77	1.23	0.22
year2011-2012	4.06	2.66	1.53	0.13
year2012-2013	-39.03	2.64	-14.76	0.00
year2013-2014	-23.14	2.62	-8.82	0.00
year2014-2015	-23.99	2.63	-9.10	0.00
year2015-2016	-19.32	2.64	-7.32	0.00
year2016-2017	-22.46	2.66	-8.46	0.00
year2017-2018	-13.09	2.67	-4.90	0.00
year2018-2019	-19.52	2.68	-7.29	0.00
enrollment	0.00	0.01	-0.41	0.68
perc_black	-0.23	10.36	-0.02	0.98
perc_hispanic	-29.11	15.35	-1.90	0.06
FRPL	-0.27	0.11	-2.53	0.01
only_gentrify1:perc_black	-23.72	10.53	-2.25	0.03
gentrify_displace1:perc_black	-26.88	14.94	-1.80	0.07
only_gentrify1:perc_hispanic	7.00	14.69	0.48	0.63
gentrify_displace1:perc_hispanic	-15.12	12.90	-1.17	0.24

Table 9. 3rd grade mathematics proficiency for non-magnet elementary schools only, including interaction terms

$$math\_prof = \beta_0 + \beta_1\ only\_gentrify + \beta_2\ gentrify\_displace + \beta_3 year + \beta_4\ enrollment + \beta_5\ perc\_black + \beta_6\ perc\_hispanic + \beta_7\ FRPL + \beta_8\ only\_gentrify * perc\_black + \beta_9\ gentrify\_displace * perc\_black + \beta_{10}\ only\_gentrify * perc\_hispanic + \beta_{11}\ gentrify\_displace * perc\_hispanic$$

term	estimate	std.error	statistic	p.value
(Intercept)	109.11	5.40	20.22	0.00
only_gentrify1	-8.91	43.45	-0.21	0.84
gentrify_displace1	-0.93	9.70	-0.10	0.92
year2011-2012	4.31	2.94	1.47	0.14
year2012-2013	-38.83	2.94	-13.21	0.00
year2013-2014	-23.37	2.91	-8.03	0.00
year2014-2015	-25.70	2.92	-8.79	0.00
year2015-2016	-20.44	2.93	-6.98	0.00
year2016-2017	-24.02	2.94	-8.16	0.00
year2017-2018	-15.34	2.96	-5.17	0.00
year2018-2019	-21.37	3.01	-7.10	0.00
enrollment	-0.01	0.01	-0.82	0.41
perc_black	-13.49	11.24	-1.20	0.23
perc_hispanic	-27.43	20.28	-1.35	0.18
FRPL	-0.23	0.11	-2.02	0.04
only_gentrify1:perc_black	-9.33	45.82	-0.20	0.84
gentrify_displace1:perc_black	-8.62	16.14	-0.53	0.59
only_gentrify1:perc_hispanic	7.51	53.28	0.14	0.89
gentrify_displace1:perc_hispanic	1.04	16.79	0.06	0.95

V. Limitations

While this study is one of few to quantitatively assess the effects of gentrification on all neighborhood elementary schools within a public school system—Durham Public Schools—it comes with important limitations. First, I use the 2021 DPS school zone boundaries to map onto the previously identified "likely gentrifying" and "likely gentrifying + displacing" block groups. Any changes in these boundaries between 2010 and 2019 were not considered, which could potentially alter how some elementary schools are classified. Furthermore, although the results suggest some strong relationships between gentrification / displacement and 3rd grade academic performance, these are only correlations and do not show any form of causation.

Moreover, it is difficult to fully explain changes in student demographics and enrollment—it could be that gentrifiers are not sending their children to local public schools, it could be that many gentrifiers do not have school-age children, or there could be other reasons not yet explored. Therefore, because we do not know how or whether gentrifying parents are enrolling their children in schools, it is difficult to definitively pinpoint the true effects of gentrification on academic performance. It could be that gentrification in fact produces more significant positive effects on academic performance, but they are just not spilling into local public schools due to other factors such as expanding school choice programs or rising standardized test difficulty over time.

Finally, although this study identifies gentrifying regions by measuring neighborhood change between 2010-2019, it does not identify when gentrification in the neighborhood began—whether the neighborhood changed steadily over the decade or whether it changed rapidly during just a few years. As a result, the study did not identify or consider any potential lags in the effects of gentrification and changes in student academic performance.

VI. Conclusion

Despite these limitations, this study presents several interesting and useful findings. While many proponents of gentrification believe that increasing the share of higher-income families in a city will benefit all children by bringing new economic, social, and academic capital

into a city's public school system, this study challenges the simplicity of that narrative with two main conclusions.

First, I found that when controlling for school year, student demographics, and enrollment while excluding interaction terms, gentrification may in fact be associated with negative effects on the DPS system—particularly on lower-income children not enrolled in magnet elementary schools. Specifically, a DPS elementary school classified as "only gentrifying" generally has a more negative effect on 3rd grade math and reading proficiency, on average, than a DPS school classified as both "gentrifying + displacing." For models with interaction terms between minority student enrollment and whether the school zone is gentrifying / displacing, the main effects of "only gentrifying" and "gentrifying + displacing" on 3rd grade academic performance become either positive or no longer significant. Despite these changes, this trend persisted: the effect of being in a "gentrifying + displacing" school zone is less negative or more positive than that of being in an "only gentrifying" school zone. These trends could be due to lower-income and/or minority students (who tend to have more negative effects on academic performance) in elementary schools located in "gentrifying + displacing" school zones being replaced by more well-off and/or non-minority students who perform better on standardized tests. At the same time, lower-income students in "only gentrifying" elementary schools may not be replaced, but instead experience residential instability, which has been shown worsen academic outcomes. To better understand the factors underlying these trends, future ethnographic studies should examine the students enrolled in "only gentrifying" schools versus those enrolled in "gentrifying + displacing" schools.

Second, this study proposes that magnet schools are present in gentrifying areas and may serve as buffers for the negative effects of gentrification on 3rd grade reading and math proficiency. This suggests that if gentrification brings any positive spillovers to academic performance, magnet elementary schools may be capturing more of it than non-magnet elementary schools. This is potentially because gentrifying parents are more likely to enroll their children in magnet schools than traditional public schools, consistent with arguments commonly raised by Durham activists. It could also be due to high-achieving students being more likely to enroll in magnet schools, independent of the enrollment choices of gentrifying parents, making academic performance in magnet schools less susceptible to any negative effects of

gentrification. Future studies should more broadly investigate the relationship between gentrification, academic performance, and school choice programs to pinpoint how school choice influences the effect of gentrification on local public schools.

However, at the same time, I found that when magnet schools are included in the dataset, some or most of the interaction terms between percent of minority student enrollment and whether the school zone was gentrifying / displacing were significantly negative while they became insignificant when excluding magnet schools from the dataset. This suggests that while the presence of magnet schools may buffer any potential negative effects of gentrification on 3rd grade academic performance, their presence may exacerbate the negative effects of minority student enrollment on 3rd grade academic outcomes for those elementary schools located in "only gentrifying" and/or "gentrifying + displacing" school zones. In magnet schools in those school zones, we can expect an increase in the proportion of Black and/or Hispanic student enrollment to be associated with steeper declines in outcomes. Based on existing knowledge on the wide racial and class segregation of Durham's magnet schools, this buffer effect may be due to the higher-than-average performance of higher-income, White students from more educated families, while the latter effect may be due to the lower-than-average performance of lower-income minority students. However, it could also be that changes in sample sizes between regressions using the dataset with all DPS elementary schools and regressions using the dataset with only non-magnet elementary schools may be driving some of these results.

Overall, this study adds to growing literature pointing to the complicated and potentially negative effects of gentrification on low-income school children (Keels et al., 2013; Cucchiara and Horvat, 2010). Consistent with previous recommendations, these findings suggest that low-performing DPS elementary schools should work to ensure that gentrification does not reinforce or increase the unequal distribution of public educational resources (Joseph and Feldman, 2009).

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VIII. Appendix

(i) Appendix A: PART 1- Identifying gentrifying and displacing census block groups

Table 1A. Durham-wide indicators of neighborhood change, 2010-2019

Indicator	2010	2019	Percent Change
Median Household Income*	$58,630	$60,958	+3.97%
Median Home Value*	$206,934	$223,000	+7.76%
Median Gross Rent Value*	$931	$1067	+14.61%
Percent of population 25+ with at least a bachelor's degree	44.12%	48.22%	+9.29%
Percent of non-Hispanic White population	43.12%	42.27%	-1.51%

*****adjusted to 2019 dollars

Table 2A. Identified "likely gentrifying" census block groups in Durham

Note: Block groups that are classified as both "likely gentrifying" and "likely gentrifying + displacing" are in **bold** (6 block groups). Block groups that did not meet the 10% or greater threshold for growth in indicators are in *italics* (6 block groups). The remaining 10 block groups showed at least 10% faster growth for at least 4 of the 5 indicators.

Block Group	% change MHI	% change MHV*	% change Rent	% change bachelor's	% change White	# Households, 2019	Score
Block Group 1, Census Tract 11	+27.611%	+129.16%	+37.62%	+434.50%	+191.32%	717	5
Block Group 1, Census Tract 7	+45.88%	-20.35%	+201.76%	+14.03%	+12.02%	840	4
Block Group 1, Census Tract 13.01	+95.69%	-20.87%	+23.67%	+38.53%	+117.65%	543	4
Block Group 1, Census Tract 13.03	+23.39%	+12.43%	+3.34%	+89.63%	+773.38%	450	4
Block Group 1, Census Tract 13.04	+6.62%	-4.64%	+15.34%	+28.11%	+12.23%	1,188	4
Block Group 1, Census Tract 17.08	+20.80%	-5.84%	+45.56%	+39.24%	+77.86%	1,791	4
Block Group 1, Census Tract 20.26	+24.41%	+20.43%	+10.77%	+142.64%	+29.71%	1,299	4
Block Group 1, Census Tract 22	+58.66%	+96.58%	+42.44%	+81.58%	+45.66%	1,079	5
Block Group 2, Census Tract 1.01	+14.04%	+20.35%	-33.60%	+44.41%	+14.80%	825	4
Block Group 2, Census Tract 10.01	+46.19%	+24.02%	-22.35%	Inf**	+81.25%	515	4
Block Group 2, Census Tract 2	+26.36%	+47.98%	+41.71%	+41.66%	+50.36%	410	5

Block Group 2, Census Tract 5	+76.09%	+176.12%	+24.80%	+127.19%	+41.64%	305	5
Block Group 2, Census Tract 23	+21.17%	NA	+24.67%	Inf**	Inf**	195	4
Block Group 3, Census Tract 3.02	+169.50	+37.75%	+29.23%	+17.04%	+5.60%	643	5
Block Group 3, Census Tract 5	+13.90%	+26.92%	+12.83%	+188.57%	+301.67%	533	4
Block Group 3, Census Tract 20.25	+92.83%	-7.20%	+31.43%	+30.15%	+65.80%	528	4

*****MHV = Median home value
******Inf indicates that the value for 2010 was 0.0

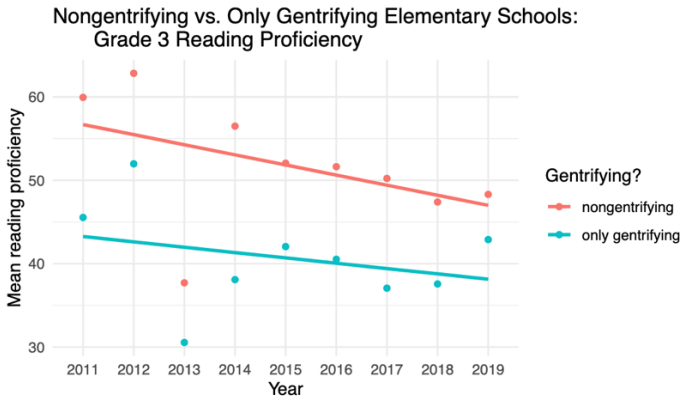
Table 3A. Identified "likely gentrifying + displacing" census block groups in Durham

Block Group	% change percent of low-income families	Percent of households who moved into renter-occupied housing units in 2017 or later
Block Group 1, Census Tract 20.26	+0.09%	32.44%
Block Group 1, Census Tract 22	-85.33%	35.58%
Block Group 2, Census Tract 2	-72.42%	31.67%
Block Group 2, Census Tract 5	-100%	25.26%
Block Group 2, Census Tract 23	-80.38%	51.40%
Block Group 3, Census Tract 20.25	-22.50%	32.43%
Durham County, NC	**+3.06%**	**24.3%**

(ii) Appendix B: PART 2- Assessing the effects of gentrification and displacement on academic performance

Fig. 1B. Mean 3rd grade reading proficiency for all elementary schools *(including magnet schools)*

1B.1. Non-gentrifying -vs- only gentrifying



1B.2. Non-gentrifying vs. gentrifying + displacing

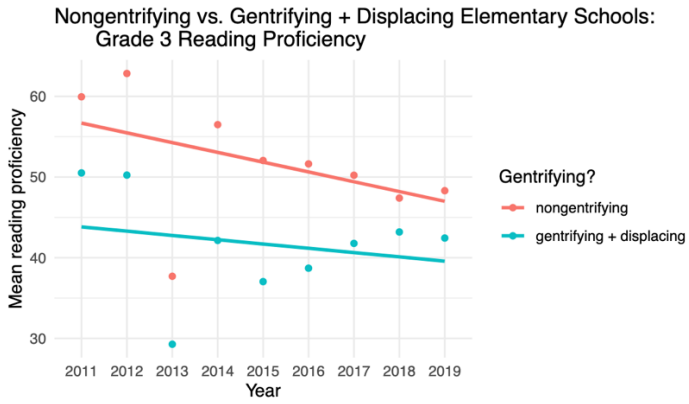
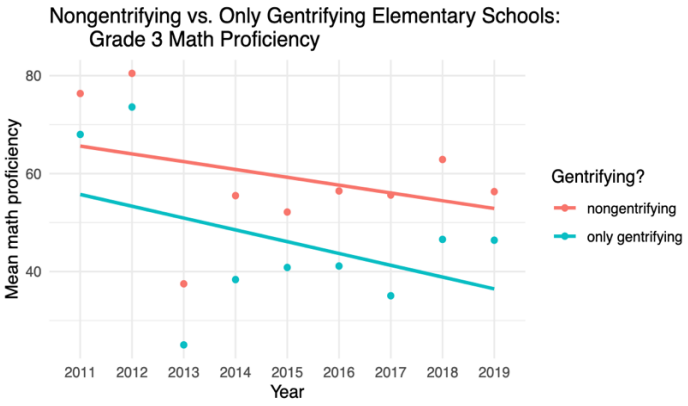


Fig. 2B. Mean 3rd grade math proficiency for all elementary schools *(including magnet schools)*

2B.1. Non-gentrifying -vs- only gentrifying



2B.2. Non-gentrifying vs. gentrifying + displacing

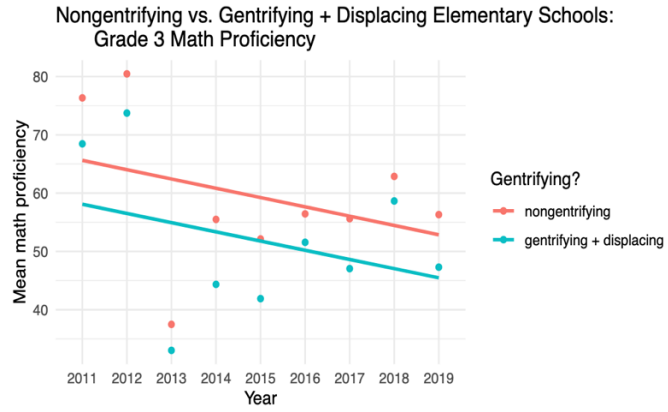
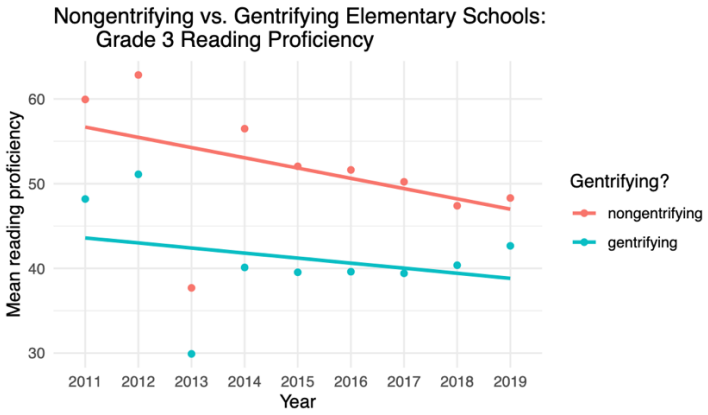


Fig. 3B. Mean 3rd grade reading proficiency over time: non-gentrifying -vs- gentrifying* schools

gentrifying** refers to whether or not the school zone is ***either gentrifying or gentrifying and displacing

3B.1. All elementary schools *(including magnet schools)*:



3B.2. Non-magnet elementary schools:

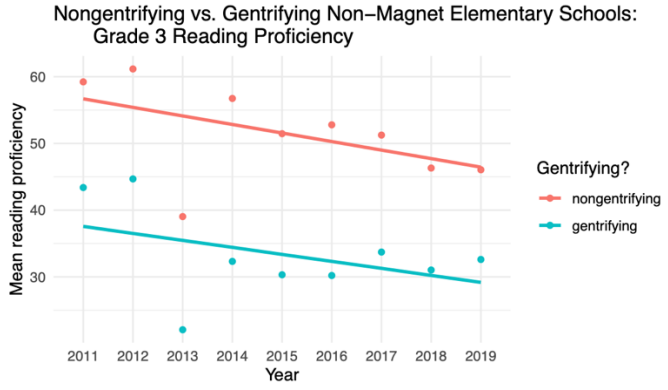
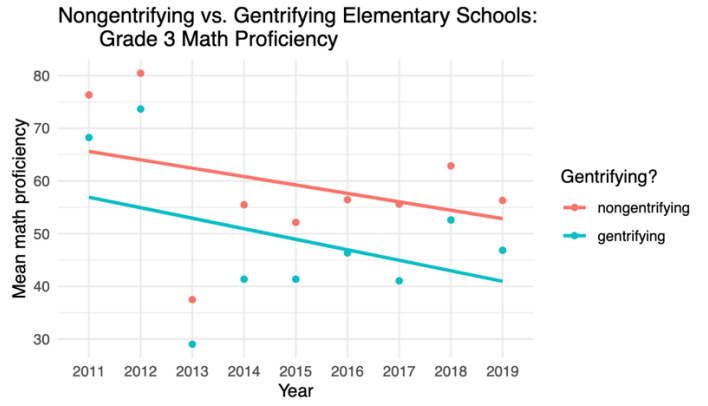


Fig. 4B. Mean 3rd grade math proficiency over time: non-gentrifying -vs- gentrifying schools

4B.1. All elementary schools *(including magnet schools)*:



4B.2. Non-magnet elementary schools: