Does Gentrification Stop at the Schoolhouse Door? Evidence from New York City

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Abstract

Gentrification has reshaped many of America's largest cities in recent decades. While it has been linked to improvements in neighborhood consumption and environmental amenities, the extent to which these positive effects spill into local public schools, a neighborhood amenity vital to the well-being of child residents, is an open empirical question. After matching Census tracts to attendance zones for public elementary schools in New York City, I use detailed school-, grade-, and tract-level data and a natural experiment that spurred gentrification in part of the city to estimate the causal effects of gentrification on outcomes for neighborhood schools. Using an instrumental variables approach to address the endogeneity of gentrification, I find that gentrification reduces math and English language arts test scores by 0.14 and 0.09 standard deviations on average, respectively. I find no statistically significant effect of gentrification on class sizes, school expenditures per pupil, or student demographic characteristics. In contrast, most of the effect on academic performance can be explained by 5% increase in absence rates conditional on changes to school and student characteristics. Lastly, I provide evidence that decreased access to healthcare, measured by the number of healthcare facilities per capita, in gentrifying attendance zones is a possible mechanism for the increased absences.

Keywords: gentrification, neighborhood change, academic performance, school absences
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1 Introduction

Gentrification, or the migration of highly educated and often high-income individuals into historically low-income, urban neighborhoods, has occurred in most of America's largest cities in recent decades (Juday, 2015). Developers and policymakers often tout the benefits of gentrification to communities, citing increasing property values and improved amenities as reasons for tax incentives aimed at spurring redevelopment. While gentrification improves amenities in areas that have struggled historically, the phenomenon is controversial due to concerns about the displacement of low-income, original residents, bringing into question the extent to which current community members benefit from the improvements. Despite these concerns, existing evidence suggests the effect of gentrification on displacement is modest (McKinnish, Walsh, and Kirk White, 2010; Ellen and O'Regan, 2011; Ding, Hwang, and Divringi, 2016; Brummet and Reed, 2019; Dragan, Ellen, and Glied, 2019). Moreover, stayers and in-migrants benefit from declining poverty exposure (Brummet and Reed, 2019; Dragan, Ellen, and Glied, 2019), rising home values (Brummet and Reed, 2019), gains in income (Ellen and O'Regan, 2011), higher levels of neighborhood satisfaction (Ellen and O'Regan, 2011), reductions in crime (Autor, Palmer, and Pathak, 2017), and increases in consumption amenities (Diamond, 2016; Su, 2018).

While existing studies document the association between gentrification and improvements in many neighborhood amenities, the effect of gentrification on local public schools, a desirable amenity vital to the well-being of child residents, is ambiguous and understudied. Advocates argue that the positive neighborhood effects should spill into local public schools, improving educational outcomes for low-income students. Critics argue spillovers do not exist, i.e. "gentrification stops at the schoolhouse door," because low-income students are displaced and/or new residents do not send children to neighborhood schools, or, worse, that gentrification deteriorates academic performance through increased class sizes, shifts in the allocation of resources within schools, increased household pressures, or reduced access to affordable healthcare. Given gentrification's pervasiveness and the importance of education for upward mobility, understanding its effects on schools and students is important, and, if there are negative consequences, understanding the underlying mechanisms can help policymakers and communities work effectively to alleviate them.

This paper directly informs this issue by providing new evidence of the causal effects gentrification on local public schools using detailed school-, grade-, and neighborhood-level data from New York City. After matching Census tracts to school attendance zones and constructing measures of demographic characteristics of neighborhoods assigned to each school, I exploit a change to the city's property tax code that made it costlier for developers to build new, residential buildings in part of the city after 2008 to identify the causal effects of gentrification on public elementary school test scores, class sizes, expenditures per pupil, approximate teacher salaries, student demographic characteristics, and absence rates. The reform was announced in 2006, causing developers to begin new construction projects earlier, and applied only to new properties built on vacant or underutilized land, so I use the plausibly exogenous timing of the announcement and variation in pre-reform land availability to instrument for gentrification in attendance zones located in the part of the city affected by the reform.

I find that gentrification, measured by a 10% increase in the college-educated share of attendance zone residents, reduces 3rd through 5th grade math and English language arts test scores by 0.14 and 0.09 standard deviations on average, respectively. I find no statistically significant effect of gentrification on average class sizes, per pupil expenditures, approximate teacher salaries, or student demographic characteristics, including the percent of students eligible for free lunch, the percent who are English Language Learners, the percent enrolled in special education programs, and the racial and ethnic composition of students. In contrast, I find the adverse effect of gentrification on test scores is driven primarily by a 5% increase in absence rates, conditional on class size, expenditure, and demographic changes. Lastly, I provide evidence that fewer physician's offices, community health centers, and hospitals and emergency centers per capita in gentrifying attendance zones are possible mechanisms for the increased absences.

Just four papers use empirical methods to examine the association between gentrification and outcomes at local public schools. Analyzing the relationship between gentrification and changes in school characteristics using national-level data, Pearman (2019) finds declines in enrollment and the number of students eligible for free lunch at schools in gentrifying areas. Using school-level data, Keels, Burdick-Will, and Keene (2013) conclude that gentrification in Chicago in the 1990s is not associated with changes in 3rd grade math or reading scores, but Barton and Cohen (2019) find gains in 3rd grade English language arts scores (and no differential changes in 3rd grade math scores) in parts of New York City that gentrified between 2005 to 2010. Using individual-level data from New York City, Dragan, Ellen, and Glied (2019) find that low-income children who remain in gentrifying parts of the city between 2009 and 2015 experience larger declines in math scores (and no differential changes in English language arts scores) at their zoned elementary schools than students in persistently low-socioeconomic status neighborhoods.

This study contributes to the literature on the effect of gentrification on public schools in three ways. First, using a novel instrument generated from a natural experiment to address the endogeneity of gentrification, this is the first study to my knowledge to obtain causal estimates of the effect of gentrification on academic achievement at local public schools despite the fact that OLS estimates will be biased upward if college-educated households sort into areas where local public school quality is good or improving. Second, I identify gentrification's effects on multiple, policy-relevant outcomes, including its effects on expenditures per pupil and absence rates, which have not been studied. Third, I identify a key mechanism through which gentrification's effect on academic achievement operates, which can inform school leaders and policymakers concerned with mitigating it.

This paper proceeds as follows. In section 2, I outline the framework, based on findings from the literature and contextual details, used for conceptualizing the relationship between gentrification and outcomes at local public elementary schools in New York City. I describe the policy background needed to support my instrumental variables approach in section 3. In section 4, I describe the data used in the analyses and discuss descriptive statistics that motivate my empirical approach. I present my empirical strategy in section 5 and discuss key findings and potential mechanisms in section 6. Section 7 concludes.

2 Conceptual Framework

Before describing the policy background and data, I discuss how gentrification is expected to affect local public elementary schools in New York City based on theory, existing empirical evidence, and contextual details about the New York City public school system. The literature points to four primary channels through which gentrification affects standardized test scores at local public schools: through changes in class sizes, changes in student characteristics, changes in school resources per pupil, and changes in neighborhood characteristics that directly and indirectly affect academic performance. Understanding the effects of gentrification on these intermediate outcomes in isolation is critical for understanding *how* gentrification affects academic performance at local schools, so I discuss each channel in the following paragraphs conditional on all other intermediate outcomes since they are clearly related to one another.

2.1 Gentrification and Class Sizes

Gentrification could affect test scores at public elementary schools through changes in class sizes. Increasing class sizes increases the share of class time where learning is disrupted and reduces the teacher's ability to tailor instruction to suit the needs of individual students (Lazear, 2001). Therefore, increasing class sizes could impair academic performance, a theory supported by most recent empirical research with credible identification strategies (see Schanzenbach (2020) for a review of this literature).

As new residents move into gentrifying areas, one might expect class sizes to increase at local public schools, especially if in-migrants move into newly constructed housing units. However, existing evidence showing that migrants into gentrifying areas are less likely to have children, and if they do, are less likely to send them to zoned public schools, opting for private or charter schools instead, suggests that class size effects are not clear cut (DeSena and Ansalone, 2009). If in-migrants do not send children to neighborhood schools, gentrification should not impact class sizes if few original resident children are displaced and could even reduce them if enough original resident children move and attend different schools (Pearman, 2020).

It is important to note that elementary school students who change residences within New York City may either remain enrolled in their current school (through 5th grade) or may attend the school for which their new residence is zoned, and 72% of students who change home addresses remain in the same school from one year to the next (NYCIBO, 2017; NYCDOE, 2020a). Since, more often than not, students who move within the city do not change schools, the effects of gentrification on local public school class sizes in New York City may be relatively small compared to effects elsewhere.

2.2 Gentrification and Student Characteristics

Second, gentrification could affect elementary school test scores through changes in the demographic composition of students. As residents of gentrifying neighborhoods change, so could demographic characteristics of public school enrollees correlated with academic achievement, like family income (Dahl and Lochner, 2012). Given the link between income and achievement, if gentrification reduces the share of low-income enrollees via an influx of high-income students and/or the displacement of low-income students, academic performance at local schools should increase. In contrast, ethnographic evidence indicates that high-socioeconomic-status parents are more likely to lobby local schools, advocating for the needs of their children, which could negatively impact low-income students if administrators reallocate resources within the school to better suit the needs of the highest income children (Pearman, 2019). The effect of this reallocation of resources within-school on test scores is ambiguous and potentially zero if performance gains among higher income students offset declines among low-income students.

In his national-level study, Pearman (2020) finds fewer economically students at schools in gentrifying areas. However, in New York City, where migrant students are more likely to remain at their current school than transfer, student body demographic changes associated academic performance effects will likely be less pronounced.[1]

2.3 Gentrification and School Resources Per Pupil

Third, gentrification could affect elementary school test scores through changes in school resources per pupil. Given evidence of a link between school resources (specifically, spending) and academic achievement (Jackson, 2018; Gigliotti and Sorensen, 2018), gentrification-induced increases in per pupil expenditures could lead to improvements in achievement at schools in gentrifying areas, an argument often made by proponents of redevelopment who contend that the increased property values and improved neighborhood amenities accompanying gentrification should translate into improvements in resources at local public schools via increased property tax revenues. To under-

[1]Conditional on observable demographic changes, gentrification could change the composition of the student body at local public schools with respect to innate ability simply because people are moving in and out of neighborhoods, which would impact test scores directly and through peer effects (Burke and Sass, 2013). Because, conditional on demographic changes to the student body, there is no reason to expect gentrification would systematically change the average ability level of students and because I have no way to measure the average ability level of enrollees each year, I abstract from changes to average ability levels when conducting my analyses.

stand whether this argument is salient in New York City, it is important to consider how public elementary schools in the city are funded.

Public elementary school funding in New York City is based solely on enrollment and the needs of students. The Fair Student Funding initiative was launched in the city in 2007 to make school funding directly tied to the cost of providing educational services specific to each school based on characteristics of the student body and to give school leadership greater autonomy over how to allocate funds within schools (Schwartz, Rubenstein, and Stiefel, 2007). Funds are distributed directly to schools, and schools (not districts or central offices) decide each year how to use them. The amount received by each elementary school per year depends only on enrollment, the percent of students at the school eligible for free lunch, the percent of students who are English Language Learners, and special education needs of enrolled students.[2] Since resources per pupil at New York City public elementary schools are directly tied to observable characteristics of the student body, gentrification should affect resources per pupil only through changes in those characteristics and should have no independent effect on resources per pupil.[3]

2.4 Gentrification and Neighborhood Characteristics

Lastly, conditional on changes to school and student characteristics, gentrification could affect academic achievement at local public schools through changes in neighborhood characteristics that directly and indirectly affect academic performance.

For example, community violence is linked to poor academic performance, both directly through adverse cognitive, socio-emotional, and behavioral effects and indirectly through increased absences from school (Pearman, 2019). Therefore, gentrification-induced reductions in crime and violence, which have been documented in the literature (Barton, 2016; Autor, Palmer, and Pathak,

[2] Any student who lives in a household at or below 130% of the federal poverty line is eligible for free lunch at public schools nationwide (USDA, 2017). English Language Learners are students who do not speak English at home and need extra help learning the language in school.

[3] School districts nationwide are primarily funded through property tax revenue, so one could argue that if gentrification causes property values to rise, property tax revenue will increase and so could resources per pupil at schools in gentrifying areas. However, public schools in New York are financed through a combination of federal, state and local sources, with only about 40% of public education funding coming from local property tax revenues in the 2008-2009 school year (NYSED, 2010). Even if funding for public education from local property tax revenues increases because of gentrification, the additional amount of money allocated to each school is determined based on the Fair Student Funding formula, not by the magnitude of the increase in property tax revenue generated from the school's attendance zone. Therefore, an increase in funding should be seen at all schools in the city and should be proportional to the amount of funding the school already receives.

2017), could increase academic achievement at local schools.

Similarly, neighborhood air quality is a another community characteristic related to both gentrification and academic performance at local schools. Currie et al. (2009) and Heissel, Persico, and Simon (2019) show that greater levels of air pollution increase absences among school children, and Heissel, Persico, and Simon (2019) and Persico and Venator (2018) find that pollution hinders academic performance conditional on absences, suggesting adverse cognitive effects associated with increased exposure to pollutants. Given the link between improvements in neighborhood environmental quality and gentrification (Banzhaf and Walsh, 2008; Voorheis, 2017), improvements in air quality accompanying gentrification may increase achievement at local schools directly and indirectly through reduced absence rates.

Lastly, gentrification may affect access to healthcare, which could impact academic achievement at local schools. Barrett et al. (2008) find that gentrification is associated with an increased risk of distant metastasis at breast cancer diagnosis among original neighborhood residents, which they hypothesize is due to reductions in preventative care utilization because of stress, decreased social support, and reduced access to low-cost healthcare facilities. If gentrification reduces access to affordable healthcare, child residents of gentrifying areas may be required to travel farther for care or may be less likely visit a doctor's office altogether when sick, both of which could increase absences from school and decrease learning. Reductions in affordable healthcare availability for sick family members could increase financial pressure and stress for low-income families, which could also negatively impact the academic performance of low-income children.

3 Background

3.1 Why New York City?

I study the effect of gentrification on public schools in New York City because the city is home to the largest school district in the United States, because the New York City Department of Education (NYC DOE) makes detailed school- and grade-level data publicly available, and, most importantly, because of a change in the city's property tax code that generated plausibly exogenous variation in gentrification in part of the city. While focusing on one city could limit the external validity of my findings, I believe the benefits of using an instrumental variables approach to address the endogeneity of gentrification and enabling me to identify causal effects, something not done previously, outweigh the limitations of studying the effects of gentrification in one setting.

3.2 New York City's 421-a Property Tax Reform

The 421-a property tax exemption is available to developers who build new, multi-unit residential buildings on vacant or underutilized land in New York City. However, the type of exemption available depends on the part of the city in which the new building is located, with less generous benefits available for new buildings constructed in the Geographic Exclusion Area (GEA). For a building in the GEA to qualify for the exemption, 20% of its units must be designated as affordable housing units. Since rental and sale values of affordable units are capped, the net benefit of the exemption is higher on average for new construction outside of the GEA, which is not subject to the affordability requirement.

Prior to 2008, the GEA included several blocks in Manhattan only. In 2008, the GEA was expanded to include additional parts of Manhattan and parts of the other four boroughs, thereby reducing the generosity of the tax benefits for new construction in the added areas. Figure 1 shows the original and expanded GEA in yellow and orange, respectively. I refer to the part of the GEA that was added in 2008 as the expanded GEA moving forward.

In February 2006, the mayor of New York City established a task force of professional developers, public officials, and urban planning experts who were charged with exploring options for reforming the 421-a program in light of concerns about the inefficient use of public funds and the need for more affordable housing in the city (Cohen, 2009; Coleman et al., 2014). The task force submitted a report with recommendations to the City Council in October 2006, and the mayor signed the law expanding the GEA in December 2006. However, the law was amended by the City Council and the state legislature in the following months, and the governor of New York did not sign the final version of the law until February 2008. Moreover, any developer who obtained a permit and began construction before July 1, 2008 was eligible for benefits under the old law (Been, 2015). The delayed implementation of the law created an incentive for developers to obtain permits and begin construction early since developers were aware of the proposed changes to the property tax law before they went into effect.

Figure 2 shows, by quarter of issue, the number of tax-exempt permits issued for new construction in elementary school attendance zones at least 75% contained in the expanded GEA, weighted by the number of residential units built. The green line indicates the quarter in which the mayor of New York City created the task force (Q1 2006), and the red line indicates the quarter in which the changes to the 421-a property tax exemption became effective (Q3 2008). There is a clear spike in the number of weighted tax-exempt permits issued prior to the 421-a reform's effective date, which supports the idea that developers moved investment forward in response to the law change.

I examine the effect of gentrification on outcomes for public schools located in the expanded GEA because of this property tax reform, which created plausibly exogenous variation in the timing of gentrification in attendance zones within the expanded GEA. Since the reform created an incentive for developers to move new construction of multi-unit, residential buildings ahead in time, the timing of the accompanying influx of residents into the completed, tax-exempt buildings is driven by the reform-induced construction start time and the project completion time, neither of which should be correlated with outcomes at local public schools.

However, within the expanded GEA, spatial distribution of new construction across attendance zones may not be exogenous to public school outcomes if developers chose to build disproportionately on parcels zoned for good or improving schools. Since the 421-a property tax exemption is available for new construction on vacant or underutilized land only, the pre-reform availability of vacant land within each attendance zone provides exogenous variation in where gentrification occurs within the expanded GEA. Zones with larger shares of vacant land pre-reform have more land available for development, so more tax-exempt units should be built in these zones and more pronounced demographic changes should occur in them once new residents move in.

Figure 3 illustrates the positive relationship between the percent of an elementary school attendance zone's parcels that are vacant in 2005, the year before the 421-a property tax reform was announced, and both the number of tax-exempt, residential units built in the zone between December 2006 and July 2008 (panel A) and the percent change in the college-educated share of the zone's population from 2005 to 2011 (panel B). The positive relationships visible in the raw data support the hypothesis that attendance zones with larger shares of vacant land before the 421-a property tax reform's announcement experienced larger subsequent increases in new residential units and in the college-educated share of the population.[4]

[4]Singh (2019), who exploits this property tax reform to identify the effect of new, tax-exempt residential develop-

Therefore, to obtain the causal effect of gentrification on outcomes for local public schools, I instrument for gentrification in attendance zones located in the expanded GEA using the share of parcels that are vacant in 2005 in each zone. I discuss this instrument in more detail in section 5.

4 Data and Sample Selection

4.1 Selecting Schools

When selecting schools in my sample, I begin with all elementary schools with attendance zones for grades 3, 4, or 5 in the expanded GEA in New York City. In doing so, I compare outcomes at schools in the expanded GEA whose zones gentrified because of the property tax reform to outcomes at schools in the expanded GEA whose zones did not gentrify. I cannot compare schools in the expanded GEA to schools outside the GEA because the GEA was not expanded randomly: it was expanded to areas where housing prices were high and rising. Given the extensive literature documenting the responsiveness of housing prices to local public school quality (see Machin (2011) for a review), schools in the expanded GEA likely differed systematically from those outside, which would bias my results. I examine outcomes for elementary schools, as opposed to middle or high schools, following the literature on gentrification and schools, because elementary school students in New York City are more likely to attend their zoned school than middle school students, and because there is a universal school choice process in place for high school students in the city (NYC311, 2020; NYCDOE, 2020b).

To determine which schools have attendance zones in the expanded GEA, I obtained yearly attendance zone shapefiles for grades 3, 4, and 5 at each of New York City's public elementary schools from the NYC DOE via NYC Open Data.[5] Then, I digitized a map of the expanded GEA, used the resulting shapefile along with the yearly grade-level attendance zone shapefiles to compute the share of each zone that falls in the expanded GEA, and kept zones with at least 75% of

ment on rents for nearby buildings, shows that a building with a vacant parcel within 150 meters before the reform received 0.9 more tax-exempt units between 2006 and 2008 compared to buildings with no vacant parcels within 150 meters pre-reform. She also finds that an additional tax-exempt project start between 2006 and 2008 in a Census tract led to 543 more occupied units, a 23% increase in median rent, a 17% increase in income, and a 14 percentage point increase in the number of tenants with at least a Bachelor's degree in the Census tract after the reform.

[5] Although it is commonly assumed that attendance zones are assigned at the school-level with one attendance zone per school, attendance zones in New York City differ by grade within an elementary school in some cases. I use grades 3, 4 and 5 only in my analyses because test scores, one of my key outcome variables, are not available for students in Kindergarten, grade 1, or grade 2.

their area in the expanded GEA.[6]

On average from 2006 to 2017, there are 735 open, active, public elementary schools offering grades 3, 4 or 5 each year in New York City, and attendance zone shapefiles for grades 3, 4, or 5 are available for 629 (86%) of them, yielding 1,886 3rd through 5th grade attendance zones per year. 748 (40% of 1,886) are at least partially contained within the expanded GEA, and 430 (23% of 1,886) are at least 75% contained within the expanded GEA on average. Standardized test scores are available for 414 (97% of 430) of the school-grade pairs associated with each zone on average each year. Lastly, following Singh (2019), I eliminate all zones with greater than 32% (the 99th percentile value) of parcels vacant in 2005, which leaves 410 attendance zones total and 137 zones per grade in my sample on average in each year. In total, there are 4,923 observations in my sample, and each is a grade-school-year. Appendix Table A1 shows the distribution of observations by grade and year.[7] Appendix Figure A1 is a visual representation of the sample selection criteria, with the 2012-2013 3rd grade attendance zones in my sample in blue overlaying the expanded GEA, which is in gray.

4.2 School- and Grade-Level Data

I use yearly school- and grade-level data in my analyses, beginning with the 2005-2006 school year because that is the first year in which grade-level standardized math and English language arts (ELA) test scores, my main outcome variables of interest, are available for New York City public elementary schools. While test score data are available beginning in the 2005-2006 school year, attendance zone shapefiles are not available until the 2009-2010 school year, so I assume attendance zones are constant from 2006 to 2010. While making any assumption about zones is far from ideal, this one is reasonable given that zones do not change substantially year over year after 2010. I use data through the 2016-2017 school year because that is the most recent year for which another key

[6] To ensure that my results are not being driven by schools with smaller shares of their attendance zones in the expanded GEA, I reestimated all models using the subsample of school-grade pairs with zones at least 90% contained in the expanded GEA, and the results are unchanged. This is due to the fact that even with the 75% cutoff, 97.4% of the average in-sample attendance zone's area falls within the expanded GEA, and only 553 (11%) of 4,923 zones are less than 90% contained in the expanded GEA. Lastly, note that since charter schools do not have attendance zones, they are not included in my sample.

[7] The number of observations in my sample decreases over time due to school closures and schools becoming "unzoned" or choice schools with no (or, in some cases, multiple) attendance zone(s) assigned to them. To check the robustness of my findings, I reestimated all models using a balanced panel, i.e. the subsample of school-grade pairs that appear in my original sample every year, and the results are unchanged.

outcome variable, school expenditures per pupil, are available.

I obtained yearly demographic characteristics of schools and grades from the National Center for Education Statistics' Common Core Data data, the NYC DOE's yearly School Demographic Snapshots, the NYC DOE's Class Size Reports, and the NYC DOE's yearly School Based Expenditure Reports. The CCD data contain enrollment by school, by grade, and by racial and ethnic group for each grade, the number of students eligible for free lunch by school, and the number of full-time equivalent teachers by school. The NYC DOE demographic snapshots contain the percent of students who are English Language Learners (ELL) by school, the NYC DOE class size reports contain average class size by grade, and the NYC DOE expenditure reports contain the number of special education students by school. Lastly, I obtained yearly grade-level math and ELA test score data and daily school-level attendance data from the NYC DOE through NYC Open Data, and I obtained yearly school-level expenditure data from the NYC DOE's School Based Expenditure Reports.

4.3 Attendance Zone Data

Demographic Data. To obtain demographic characteristics of the residents of attendance zones, I mapped Census tracts to zones and aggregated the tract-level demographic data to the zone level. Since Census tracts do not perfectly align with zones, I weighted each Census tract by the share of its area that falls into each zone when aggregating the tract-level demographic data. I use Brown University's Longitudinal Tract Database to convert data based on 2000 Census tract boundaries to estimates based on 2010 tract boundaries.

Tract-level demographic data used in my analyses come from the IPUMS National Historical Geographic Information System. I use data from the 2005-2009 American Community Survey (ACS) to measure pre-reform demographic characteristics of the residents of each zone because, given that 2005 is the first year of the ACS and that the 2005-2009 estimates represent averages over 2005-2009 period, these are the tract-level demographic data available for a time period as close to the period immediately prior to the property tax reform as possible.[8] I use 2011-2015 ACS data to

[8]Since the 2005-2009 ACS is an average over the 2005-2009 period, one could argue that these data describe the state of affairs in 2007 on average. While 2007 is not technically in the pre-reform period (i.e. is not before the creation of the task force in February 2006), most reform-induced construction projects were not completed until 2009 (see Figure 4), which means the salient reform-induced demographic changes could not have occurred prior to 2009 and are therefore likely not captured in the 2005-2009 ACS data.

measure the post-reform, post-construction demographic characteristics of attendance zone residents. I chose the 2011-2015 ACS because, as shown in Figure 4, most reform-induced construction was completed by 2009. If residents move into the new units within one year of construction completion, we should expect the demographic changes of the attendance zones with new, tax-exempt construction to be visible beginning in the 2011-2015 ACS.

From the 2011-2015 ACS, I obtain the tract-level total population, total population aged 25 to 64, and the population aged 25 to 64 with at least a Bachelor's degree. From the 2005-2009 ACS, I obtain for each Census tract the total population, the total population aged 25 to 64, the population aged 25 to 64 with at least a Bachelor's degree, median household income, the number of public elementary school enrollees, total housing units, the number of occupied housing units, the number of housing units built prior to 1940, and median contract rent. Lastly, I construct variables capturing the changes in each of these demographic characteristics from the 2000 Census to the 2005-2009 ACS to use as control variables in my models.

Crime Data. In addition to demographic characteristics of residents, I obtain data on reported crime, air quality, healthcare facilities, and manufacturing and utilities facilities in attendance zones belonging to schools in my sample. Crime data from the New York Police Department via NYC Open Data. Using the coordinates, day, and time of each crime, I map crimes to attendance zones and count the number of crimes occurring in each zone in each school year that belong to one of the following four categories: public disturbances, property crime, violent crime, and drugs and alcohol.[9] Public disturbances include destruction of property/property damage, illegal weapon possession, prostitution, public disturbance, simple assault/menacing, and trespassing. Property crime includes arson, burglary, fraud, larceny, and theft. Violent crime includes abduction, aggravated assault, murder, rape/sexual abuse, and robbery. Drugs and alcohol include possession of a controlled substance, possession of a hypodermic instrument, possession of marijuana, sale of a controlled substance, sale of marijuana, and unlawful sale of alcohol. All crime counts are reported per thousand square meters, following Autor, Palmer, and Pathak (2017).

Air Quality Data. I measure pollution in attendance zones using Census tract-level average estimated daily PM2.5 concentration in micrograms per cubic meter of air ($\mu g/m^3$), which I obtained

[9] These are the same categories used by Autor, Palmer, and Pathak (2017), who exploit the sudden end of rent control in Cambridge, MA to study the effect of gentrification on crime.

from the Centers for Disease Control and Prevention. I created one yearly measure of PM2.5 concentration for each attendance zone and school year by averaging over the daily estimates by tract and year and then averaging over the yearly tract-level estimates by attendance zone, weighting each tract by the share of the attendance zone's area that it makes up. As an alternative measure of pollution in attendance zones, I counted the number of days the PM2.5 concentration in each school year and attendance zone exceeded 12 $\mu g/m^3$, the air quality standard set by the United States Environmental Protection Agency for children, and computed the percent of school days where the zone's PM2.5 concentration fell above the threshold, following Currie et al. (2009).

Healthcare Facilities Data. I use business location data from Infogroup coupled with population estimates from the 2005-2009 and 2011-2015 ACS to measure the number of healthcare facilities per thousand residents in each attendance zone and year. I define offices of physicians as establishments with North American Industry Classification System (NAICS) codes 621111 (offices of physicians except mental health specialists) and 621112 (offices of physicians, mental health specialists). I define community health centers as establishments with NAICS code 621999 (all other miscellaneous ambulatory health care services) after inspecting the list of establishments with this code and determining that most are local healthcare centers. I define hospitals and emergency centers as establishments with NAICS codes 622110 (general medical and surgical hospitals) and 621493 (freestanding ambulatory surgical and emergency centers). Lastly, I define facilities that offer social assistance services as establishments with NAICS codes 624110 (child and youth services), 624190 (other individual and family services), 624210 (community food shelters), 624221 (temporary shelters), 624229 (other community housing services), 624230 (emergency and other relief services), and 624410 (child daycare services). The variables used in the following analyses are the number of establishments in each category in each attendance zone and year divided by either the 2005-2009 ACS population estimate (used for years prior to 2011) or the 2011-2015 ACS population estimate (used for 2011 and the years following). I divide establishment counts by population estimates to measure the availability of healthcare to attendance zone residents because access to healthcare is likely different across two neighborhoods with the same number of healthcare facilities but with different population sizes due to overcrowding and differences in per patient resources.

Manufacturing and Utilities Facilities Data. I also use Infogroup data to measure the number of manufacturing and utilities facilities per thousand square meters located in each attendance zone and school year, which I include as a time-varying control variables in all specifications. I define utilities facilities as all establishments with 2-digit NAICS codes equal to 22 and manufacturing facilities as all establishments with 2-digit NAICS codes equal to 31, 32, or 33.

Parcel Data. Lastly, I instrument for gentrification using the share of an attendance zone's parcels that are vacant in 2005 relative to its residential parcels. I obtained parcel-level data and shapefiles for 2005 from the New York City Department of City Planning's MapPLUTO database, which merges Property Land Use Tax Lot Output (PLUTO) tax lot data with tax lot features from the New York City Department of Finance's Digital Tax Map, and merged these data with attendance zone shapefiles to identify the parcels belonging to each zone in the expanded GEA.

My instrument is defined as the total number of vacant parcels (defined as parcels with land use category 11) in each attendance zone in 2005 by the sum of its total residential parcels (defined as parcels with land use category 01, 02, 03, or 04) and its total vacant parcels in 2005. I exclude non-residential and non-vacant parcels from the denominator because this instrument is intended to predict changes in gentrification measured by changes in the college-educated share of attendance zone residents.[10] Attendance zones with more vacant parcels relative to residential parcels should experience greater increases in the share of college-educated residents due to increases in new residential buildings constructed ahead of the 421-a property tax reform, and the relative increases should be independent of the number of parcels in zones with other uses, conditional on average parcel size.[11]

4.4 Measuring Gentrification

I measure gentrification in each attendance zone using the percent change in the college-educated share of the population aged 25 to 64 from the 2005-2009 ACS to the 2011-2015 ACS. I use changes

[10] See the next subsection for a detailed description of my measure of gentrification.

[11] Consider a simplistic example with two attendance zones, A and B, each with 700 equally-sized parcels. 70 of zone A's parcels are vacant, and the remaining 630 are residential. In contrast, 60 of zone B's parcels are vacant, 540 are residential, and the remaining 100 are non-vacant and non-residential. Both zones have 10% of parcels vacant when the sum of vacant and residential parcels only (700 for zone A and 600 for zone B) is used as the denominator. If the sum of all parcels (700 for both zones) is used as the denominator, 10% of zone A's parcels appear vacant compared to only 8.6% of of zone B's parcels. The increase in the college-educated population share in each zone due to the construction of new residential buildings on vacant land is directly tied to the number of vacant parcels relative to parcels on which residents actually live pre-reform, i.e. residential parcels. Using the sum of all parcels as the denominator is misleading because it suggests zone B should experience a smaller increase in the college-educated population than zone A despite the fact that the number of vacant parcels relative to residential parcels is the same in both zones.

in the level of educational attainment of attendance zone residents as opposed to changes median household income to define gentrification because the pioneers of gentrification are often young professionals and artists with relatively low incomes (Freeman, 2005; Ding, Hwang, and Divringi, 2016). Additionally, changes in the college-educated population share is the measure of gentrification most consistently used in the literature that studies its determinants and consequences.

To check the robustness of my results and to capture any nonlinearities in the effects of gentrification on schools, I estimated my models using binary variables that take the value of 1 if an attendance zone experienced an increase in the college-educated population share from the 2005-2009 ACS to the 2011-2015 ACS that is the top 40%, 30%, 20%, or 10% of attendance zones in my sample and 0 otherwise, and the key findings, which are presented in the appendix, are similar to those obtained using the continuous measure of gentrification.

4.5 Descriptive Statistics

Table 1 shows the means of attendance zone characteristics pre- and post-reform, along with their differences and associated p-values. As discussed in subsection 4.3, I define the pre-reform period (POST=0) as the period from 2005-2010 and use the 2005-2009 ACS 5-year estimates to characterize the demographic composition of attendance zones during this time. I define the post-reform period (POST=1) as the period from 2011 to 2017 and use the 2011-2015 ACS 5-year estimates to characterize the demographic composition of zones during this time.

From 2005 to 2011, total population in school zones in the expanded GEA grew by 414 people (4%), which is due to an 8% increase in the working-age population. The percent of the working-age population with a Bachelor's degree increased by 7.2 percentage points (23%) on average, real median household income increased by over \$5,500 (12%), real median rent grew by almost \$200 (21%) on average, and the housing stock became newer, with the percent of housing units built prior to 1940 declining by 6%. All of these changes are consistent with demographic changes that gentrifying neighborhoods usually experience.

The changes in neighborhood amenities over the period presented in Table 1 paint a similar picture. Crime in all categories except for property crime fell, and air quality and access to healthcare, defined as the number of healthcare facilities per thousand residents, improved on average. Taken together, the facts presented Table 1 in suggest that gentrification occurred in attendance zones in the expanded GEA between 2005 and 2011.

Examining changes in school characteristics that accompany changes in neighborhood characteristics can help us understand how gentrification may translate into changes at local public schools. Table 2 shows the means of school characteristics pre- and post-reform. Both math and ELA standardized test scores improved, despite a two-person average class size increase. Per pupil expenditures rose slightly, likely due to the increase in the percent of students who are English Language Learners, and approximate teacher salaries also increased, driven partially by a decline in the number of full-time equivalent teachers. The number of free lunch eligible students declined by 4 percentage points, and schools with zones in the expanded GEA became less Black and more white and Hispanic. Lastly, the absence rate declined by 7% on average across all elementary schools with zones in the expanded GEA.

These average school-level changes may lead one to conclude that gentrification is associated with improvements at local public schools, but Figure 5, which shows the relationship between math (panel A) and ELA (panel B) standardized test scores after the 421-a property tax reform and gentrification, measured by the percent change in the attendance zone's college-educated population share from 2005 to 2011, paints a different picture. Despite the fact that standardized test scores at schools with attendance zones in the expanded GEA improved on average over the period, there is a negative relationship between the extent of gentrification and subsequent academic performance visible in the raw data. I examine this relationship empirically using Ordinary Least Squares and an instrumental variables approach, which I describe in the next section.

5 Empirical Strategy

5.1 Ordinary Least Squares

Using Ordinary Least Squares, I estimate the association between gentrification and outcomes at local public schools and in their attendance zones using the following equation

$$Y_{gst} = \alpha_0 + \alpha_1 GENT_{gs} * POST_t + \alpha_2 X_{gst} + \lambda_s + \gamma_t + \varepsilon_{gst}$$

where Y_{gst} is outcome for grade g at school s in year t or for the attendance zone assigned to grade g at school s in year t.[12] The primary outcome variables of interest are grade-level math and ELA standardized test scores, but I also examine the relationship between gentrification and other school and neighborhood characteristics. $GENT_{gs}$ is equal to the percent change in the share of the population aged 25 to 64 with at least a Bachelor's degree residing in the attendance zone for grade g at school s from 2005 to 2011. $POST_t$ is a dummy variable that takes the value of 1 for all years after 2010 and 0 otherwise. Appendix Table A2 contains summary statistics for all dependent variables used in the analyses and for my measure of gentrification.

X_{gst} contains demographic characteristics of the attendance zone belonging to grade g at school s from the 2005-2009 ACS and changes in those characteristics from the 2000 Census to the 2005-2009 ACS, which I include to control for pre-trends in neighborhood characteristics correlated with gentrification, vacant land, and changes in school outcomes in subsequent years. X_{gst} also contains the average area of a vacant parcel in the attendance zone in 2005 and a time-varying measure of the number of manufacturing and utilities facilities per thousand square meters in the attendance zone each year, both of which I include to improve the validity of my instrument, which is described in the next subsection. Lastly, X_{gst} contains the percent of the attendance zone's area in the expanded GEA to account for the fact that, given the policy context, the magnitude of the effects of gentrification in an attendance zone may depend on the share of the attendance zone belonging to the expanded GEA. Appendix Table A3 provides summary statistics for all variables included in X_{gst}.[13]

λ_s are school fixed effects, which I include to account for time-invariant school characteristics correlated with gentrification and changes in school outcomes, and γ_t are year fixed effects intended to address year-specific shocks to local public school outcomes common to all schools with attendance zones in the expanded GEA. α_1 is the parameter of interest and is an estimate of the average treatment effect, i.e. the (biased) effect of gentrification on outcomes for schools with attendance zones in the expanded GEA. I cluster standard errors at the school-grade (i.e. attendance zone) level, which is the level of treatment. School fixed effects address correlations in outcomes

[12] When outcomes are measured at the school level instead of the grade level, the outcome variable is Y_{st}.

[13] Note that some variables appear as both dependent variables in Appendix Table A2 and as school controls in Appendix Table A3. Whenever a school- or grade-level variable is the dependent variable, clearly it is not also included in the model as an independent variable.

within-schools, and clustering standard errors at the school-grade level addresses correlations in outcomes for 3rd graders, for example, at the same school over time.

5.2 Instrumental Variables

The primary threat to identifying the effect of gentrification on outcomes at local public schools within the expanded GEA is that neighborhoods within the expanded GEA where local public schools are good or improving may disproportionately attract new residential development and college-educated households. I address this source of bias in two ways. First, I include school fixed effects to account for time-invariant school characteristics correlated with changes in school-level outcomes and changes in the demographic composition of attendance zone residents from 2005 to 2011. If school quality is fixed over time, school fixed effects will remove this source of bias. However, if school quality changes over the time and if highly educated households are more likely to move to neighborhoods zoned for schools where quality is improving, OLS estimates will be biased upwards even with school fixed effects in the model. So, second, I employ an instrumental variables approach, using the share of the attendance zone's parcels that are vacant in 2005, the year before the 421-a property tax reform was announced, as an instrument for gentrification. I obtain IV estimates using the following two-stage least squares equation

$$Y_{gst} = \beta_0 + \beta_1 GENT_{gs} * POST_t + \beta_2 X_{gst} + \lambda_s + \gamma_t + \varepsilon_{gst}$$

where the first stage is given by

$$GENT_{gs} * POST_t = \delta_0 + \delta_1 VACANT_{gs} * POST_t + \delta_2 X_{gst} + \lambda_s + \gamma_t + \varepsilon_{gst}$$

and where $VACANT_{gs}$ is the share of parcels in the attendance zone for grade g at school s that are vacant in 2005. β_1 is the parameter of interest and is an estimate of the local average treatment effect, i.e. the effect of gentrification on outcomes for schools whose zones gentrified because they contained more land available to be developed before the announcement of the 421-a property tax reform.

For this instrument to be valid, the vacant share of parcels in an attendance zone in 2005 may only be correlated with changes in public school outcomes through gentrification. School fixed effects allow me to difference out any correlation between pre-period land availability and unobserved time-invariant school characteristics, but the exclusion restriction will be violated if land availability in 2005 is correlated with changes in school outcomes in subsequent years.

One way the exclusion restriction would be violated is if attendance zones with high land availability and low land availability differ with respect to time-varying patterns correlated with changes in school outcomes, i.e. if there are differential time trends unrelated to gentrification in outcomes for schools with attendance zones with relatively large shares of vacant land in 2005 compared to schools whose zones have less vacant land pre-refom. For example, if neighborhoods in attendance zones with high land availability in 2005 are declining, the schools to which they are assigned may experience a downward trend in test scores or school quality in subsequent years not because of gentrification but because of continued neighborhood decline. To address this concern, I include in X_{gst} both the levels of the following neighborhood characteristics from the 2005-2009 ACS and their changes from the 2000 Census to the 2005-2009 ACS: population aged 25 to 64, share of the population aged 25 to 64 with at least a Bachelor's degree, median household income, number of public elementary school enrollees, total housing units, share of housing units occupied, share of housing units built prior to 1940, and median rent. The 2005 levels and the 2000-to-2005 changes are intended to control for differences in pre-trends across school zones unrelated to gentrification but correlated with future changes in school outcomes.

The exclusion restriction may also be violated if industrial facilities are more likely to be built in attendance zones with greater shares of vacant land in 2005. The construction and operation of industrial facilities in subsequent years could impact academic performance at local public schools not through gentrification but through negative externalities like noise and pollution generated from the operation of these facilities. To address this potential sources of bias, I include in X_{gst} a time varying-measure of the number of manufacturing and utilities facilities per thousand square meters in each attendance zone in each year.

A final concern with my instrumental variables approach is that, conditional on the share of parcels that are vacant in 2005, attendance zones with larger vacant parcels on average have more land area on which to build new, multi-unit residential structures, resulting in larger structures that likely house more new residents. If so, an additional vacant parcel in an attendance zone may have a different on gentrification, i.e. the percent change in the share of the working age population with a Bachelor's degree, in attendance zones where that additional parcel is large relative to attendance zones where that additional parcel is small. To address this, I compute the average area of a vacant parcel in each attendance zone in 2005 and include this as a control variable in X_{gst}.

Figure 6 contains a visual representation of the unconditional reduced-form regression, showing the relationship between standardized math (panel A) and ELA (panel B) test scores and the percent of attendance zone parcels that are vacant in 2005. The negative and statistically significant relationship between test scores and 2005 land availability visible in the raw data indicates that my instrument is, in fact, correlated with test scores, my primary outcome of interest. In addition, Figure 7 contains a visual representation of the first stage. Panel A shows the spatial distribution of the share of vacant parcels in 2005 by elementary school attendance zone, and panel B shows the distribution of the percent change in the college-educated population share from 2005 to 2011 by attendance zone. Land availability and subsequent changes in the college-educated population share, while not perfectly correlated, are related. For example, the Bushwick neighborhood in Brooklyn and and the East Harlem neighborhood in Manhattan are two areas with relatively high pre-reform land availability that experience relatively large increases in the college-educated population share from 2005 to 2011.

6 Results

6.1 Test Scores

Table 3 contains OLS and IV estimates of the effect of gentrification on math and ELA test scores. The OLS estimates in the first column of Table 3 suggest that gentrification is not associated with changes in ELA test scores and is associated with small declines in math scores for 3rd through 5th graders in New York City. Specifically, a 10% increase the share of an attendance zone's population with a Bachelor's degree is associated with a 0.02 standard deviation decline in math scores. However, OLS results will be biased upwards if highly educated people are more likely to move into attendance zones within the expanded GEA where elementary school test scores are high or improving. To address this bias, I instrument for gentrification with the share of the attendance zone's parcels that are vacant in 2005, the year prior to the announcement of 421-a property tax reform. The IV estimates in the second column of Table 3 indicate that reform-induced gentrification in the expanded GEA, measured by a 10% increase in the college-educated population share, reduces math and ELA test scores by 0.14 and 0.09 standard deviations on average, respectively. The fact that the IV estimates are negative and larger in magnitude than the OLS estimates supports the hypothesis that college-educated households sort into school zones with higher test scores within the expanded GEA.[14]

The third and fourth columns of Table 3 show the OLS and IV estimates, respectively, after adding measures of time-varying, observable school and student characteristics to the model.[15] The magnitude of the OLS estimate for math scores drops by half, the magnitude of the IV estimate for math scores declines by about two-thirds, and both become statistically indistinguishable from zero. Similarly, the magnitudes of the OLS and IV estimates for ELA scores decline by over 80% and also become statistically insignificant. These facts suggest that changes in time-varying, observable school characteristics in X_{gst} explain most of gentrification's on effect test scores. To determine the mechanism(s) through which the test score effects operate, I regress each school characteristic on my measure of gentrification, holding all others constant. I discuss the results of this exercise in the following subsection.

6.2 School and Student Characteristics

Gentrification can affect elementary school test scores through multiple channels. Given the negative impact of gentrification on academic performance at local elementary schools, identifying the primary channel(s) is important for understanding the consequences of policies, like changes to the property tax code, that invite gentrification and is necessary for creating effective policies and

[14] Appendix Tables A4 and A5 contain OLS and IV estimates for the effect of gentrification on math and ELA test scores, respectively using binary measures of gentrification that take the value of 1 if an attendance zone experienced an increase in the college-educated population share from the 2005-2009 ACS to the 2011-2015 ACS that is in the top 40%, 30%, 20%, or 10% of attendance zones in my sample and 0 otherwise. The IV estimates are negative, like with the continuous measure, but the magnitudes are larger because the average college-educated population share change occurring in GENT=1 attendance zones with are large. For example, the IV estimate for the effect of gentrification on math test scores in column 2 of Table 3 implies that a 1% increase in the college-educated population share reduces math scores by 0.0135 standard deviations. This is not directly comparable to the IV estimates in Appendix Table A4 because attendance zones with changes in the top 30%, for example, experience a 62.4% increase in the college-educated population share on average. Once scaled appropriately, the estimate in Table 3 implies that 62.4% increase in the college-educated population share reduces math test scores by 0.84 standard deviations on average, which is much closer to 0.82, the IV estimate in column 2 in the top panel of Appendix Table A4. The rest of the findings presented in this paper are similarly robust to using a binary measure of gentrification.

[15] See the "school controls" section of Appendix Table A3 for the list of and summary statistics for variables added to the model.

programs aimed at mitigating them. To do so, I identify the effect of gentrification other (non-test score) school outcomes that could, in turn, affect academic achievement. Table 4 contains the OLS and IV estimates generated from this exercise.

Before interpreting the results, it is useful to compare the OLS and IV estimates to determine whether the direction of the bias for each variable aligns with expectations based on the types of schools highly educated households desire. OLS estimates of the effect of gentrification on average class size and approximate teacher salary are biased upwards, suggesting that highly educated households are more likely to move into neighborhoods zoned for schools with higher teacher salaries and larger average class sizes. In contrast, the OLS estimates of the effect of gentrification on the remaining school characteristics are biased downwards, indicating that highly educated households choose neighborhoods zoned for schools with lower per pupil expenditures (i.e. with fewer needy students, based on the New York City public school funding formula), with smaller shares of students who are poor (measured by the share of students eligible for free lunch), with fewer shares of students learning English, and with fewer shares of students enrolled in special education programs, with fewer Hispanic and Black students, and with lower absence rates. To the extent that higher teacher salaries, a less needy student body, and lower absence rates signal school quality, these comparisons support the idea that highly educated households choose neighborhoods with high quality schools and that OLS estimates of the effect of an increase in the college-educated population share on school outcomes are biased. Therefore, I discuss the IV estimates alone moving forward.

The IV estimates in Table 4 indicate that gentrification has no statistically significant effect (at the 5% level) on class sizes or school resources, measured by per pupil expenditures and approximate teacher salary, and student characteristics, measured by the percent of students eligible for free lunch, the percent of students who are English Language Learners, the percent of students enrolled in special education course, the number of Hispanic students, and the number of Black students.

The null effect for class sizes supports hypothesis that migrants into gentrifying areas are either childless or do not send their children to local schools or that the number of new students at local schools is roughly equal to the number of students who change schools. The null effects for per pupil expenditures and approximate teacher salary reflect the fact that public elementary school funding in New York City is need-based and therefore directly tied to student demographic characteristics, which I include as control variables, and suggests that, conditional on changes to the enrollment and the demographic composition of schools, gentrification has no separate effect on school funding as expected.

The null effects for student characteristics can be explained in two ways. First, students in New York City's public elementary schools who move to a new school zone may choose to either attend the school for which their new residence is zoned or may continue attending their current school until they complete 5th grade. So, even if gentrification leads to changes in the demographic composition of neighborhoods, corresponding changes in the demographic composition of students at local schools may not occur if students who move choose to continue attending their old schools. As discussed in section 2, 72% of students who change home addresses in New York City remain in the same school from year to the next, so, coupled with the fact that migrants into gentrifying ares are less likely to send children to local schools, it is unsurprising in this context that gentrification does not shift local public school demographic characteristics substantially (NYCIBO, 2017; NYCDOE, 2020a).

Finally, I identify the effect of gentrification on the absence rate at public elementary schools, conditional on changes to all other student and school characteristics. I find that a 10% increase in an attendance zone's college-educated population share leads to 0.4 percentage point increase in the absence rate, or a 5% increase at the mean. Taken together, the findings presented in this section indicate that an increase in the absence rate is the primary (observable) mechanism through which gentrification affects test scores at local public schools in New York City. There are a few ways that gentrification could increase absences, and I explore some of them in the next subsection.

6.3 Absence Rate Mechanisms

The findings presented thus far indicate that gentrification negatively impacts elementary school test scores primarily by increasing absences, conditional on changes to other observable school and student characteristics. As discussed in section 2, gentrification may affect absence rates and, consequently, academic achievement at local public schools though changes to neighborhoods and households. I investigate gentrification's relationship with three neighborhood characteristics in an attempt to isolate the mechanisms driving the increased absence rates: crime, air quality, and access to healthcare. While extremely important, household-level changes are not visible in the data available to me, so I can not study gentrification's impact on household stress and other household-level factors that may contribute to increased absence rates and declines in academic achievement. I leave this task to future research.

Table 5 shows the OLS and IV estimates of the effect of gentrification on crimes per thousand square meters in the following four crime categories: public disturbances, property crime, violent crime, and crime related to drugs and alcohol. The IV estimates suggest that a 10% increase in the share of an attendance zone's population with a college degree is linked to 0.09 fewer public disturbances per thousand square meters, or a 13% drop at the mean, but has no statistically significant effects on crimes in the other three categories. Overall, the negative and null effects in Table 5 suggest that changes in neighborhood crime are not key determinants of absence rate increases at schools in the expanded GEA.

Next, I examine the effect of gentrification on air quality, given that poor air quality is linked to increased absences and poor academic performance among elementary school children (Currie et al., 2009; Heissel, Persico, and Simon, 2019). The IV estimates in Table 6 indicate that a 10% increase in the share of the population with a Bachelor's degree reduces PM2.5 concentrations in attendance zones by 0.07 $\mu g/m^3$ on average, or a 1% decrease at the mean, and the effect is statistically significant at the 10% level only. Moreover, gentrification has no statistically significant effect on the percent of school days where the attendance zone's average PM2.5 concentration is greater than 12 $\mu g/m^3$, the standard set by the EPA for children. Taken together, these small and null effects suggest that, like changes in neighborhood crime, changes in neighborhood air quality are likely not the primary drivers of increased absence rates at public schools in the expanded GEA whose attendance zones gentrify.

Lastly, gentrification-induced changes in healthcare availability could affect absence rates at local public elementary schools. If access to healthcare declines in gentrifying areas, children may have to travel farther to see a doctor and may miss more school as a result. Moreover, sick children may be less likely to visit the doctor altogether if there are few healthcare facilities near home, which may lead to more school days missed due to illness. Table 7 shows the OLS and IV estimates of the effect of gentrification on access to healthcare, measured by the number of physician's offices, community health centers, hospitals and emergency centers, and social assistance services per thousand residents. I find that a 10% increase in the college-educated population share leads to 1.4 fewer physician's offices, 0.1 fewer community health centers, and 0.08 fewer hospitals and emergency centers per thousand residents, which correspond to 35%, 47%, and 39% declines, respectively, at the mean. In addition, I find no statistically significant effect of gentrification on the availability of social assistance services aimed at providing help to residents struggling with food, housing, or family care issues, which may arise for low-income families as rents rise in gentrifying areas. Note that healthcare and social assistance facilities are measured per thousand residents, so the finding that access to healthcare is lower in gentrifying areas may indicate either that healthcare facilities are less likely to locate in gentrifying areas *or* that the population of gentrifying areas is growing at a faster rate than the rate at which new healthcare facilities are added to communities. In either case, access to healthcare – in terms of physical proximity to healthcare facilities or in terms of the amount of time one expects to wait for care – decreases and could increase the amount of time sick children (or children with sick family members) are absent from school.

7 Conclusion

Gentrification is pervasive in the United States. While it has been linked to improvements in neighborhood amenities, its effects on local public schools are ambiguous, understudied, and important, given that education is a primary vehicle for upward mobility. If gentrification negatively impacts schools and students, it could hinder the ability of low-income students to move up the income ladder. Exploiting a change to the 421-a property tax exemption in New York City, which enables me to use an instrumental variables approach to address the endogeneity of gentrification, I find that a 10% increase in the college-educated population share from 2005 to 2011 reduces math and ELA test scores for 3rd through 5th graders by 0.14 and 0.09 standard deviations on average, respectively.

I find no effect of gentrification on class sizes, school resources, and student demographic characteristics. However, I find that, conditional on all other changes to student and school characteristics, gentrification increases the absence rate at public elementary schools by 5% and that this effect explains most of the negative effects on test scores. I investigate changes to three neighborhood-level characteristics that may be contributing to the increase in absences and find that less access to healthcare in gentrifying areas, not changes in crime or pollution, is a possible mechanism for the increased absence rate.

My findings first and foremost support the idea that taking gentrification's effects on local public schools into account is critical when assessing the impacts of policies that invite it, since these effects are not positive as often assumed. Second, my findings suggest that, to support elementary school students and their families in gentrifying areas, policymakers should work to maintain and increase access to (affordable) healthcare. Lastly, more research is needed to uncover the household-level changes that students in gentrifying areas face, which may be another important pathway through which gentrification leads to higher absence rates and lower academic performance.

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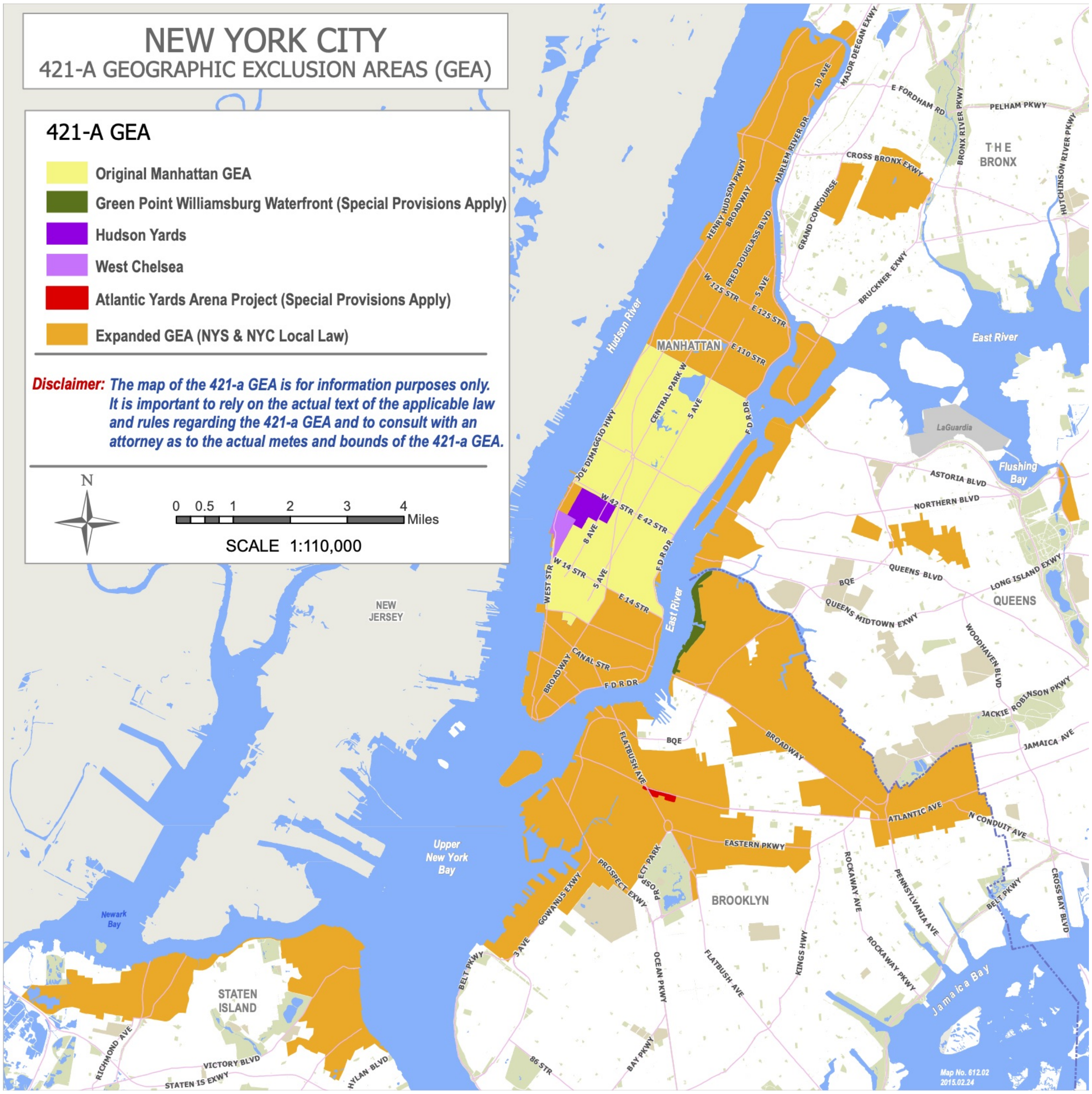
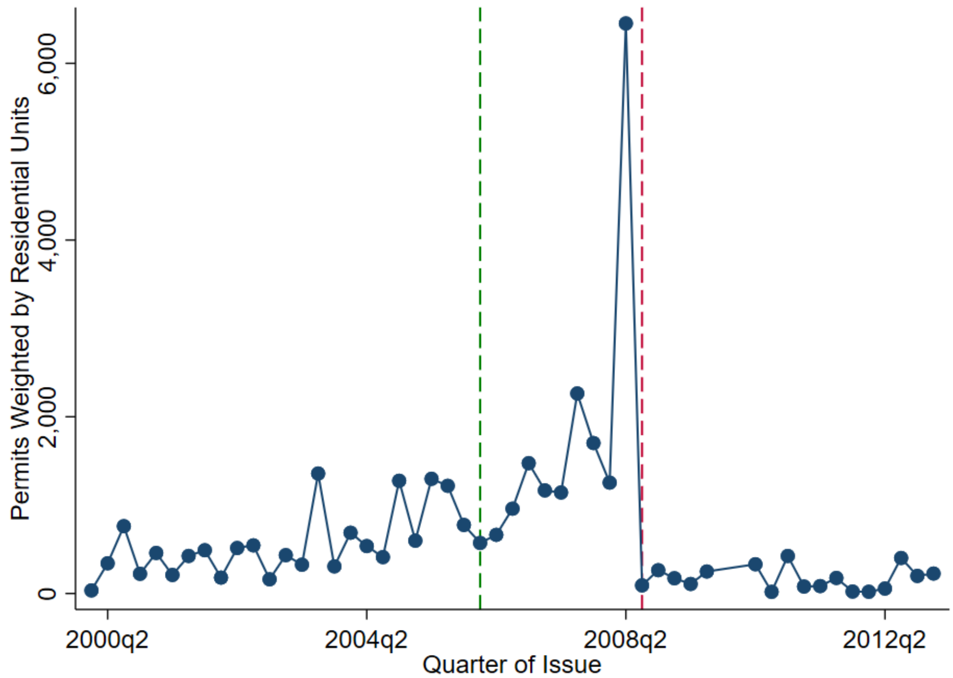
Figure 1: Geographic Exclusion Area



Source: New York City Department of Housing Preservation & Development

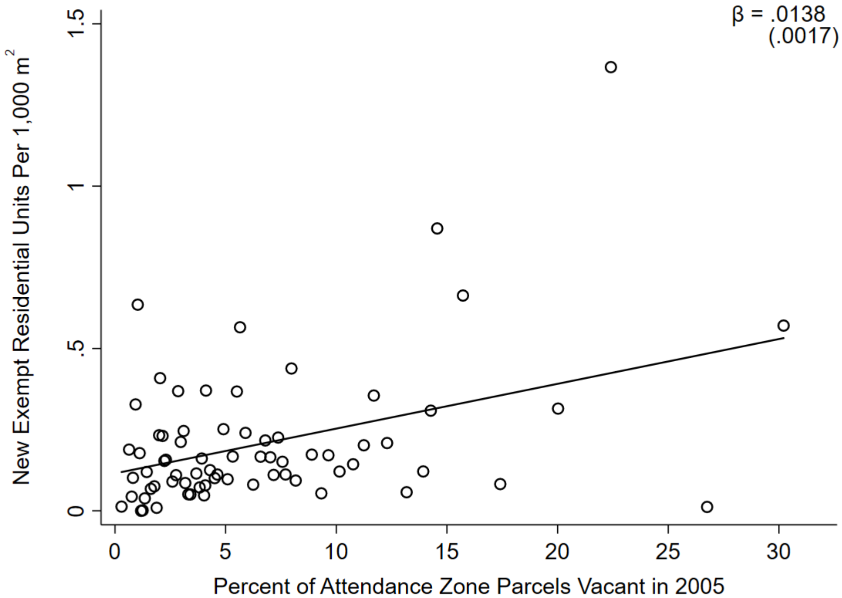
Figure 2: Weighted Tax-Exempt Permits Issued in Expanded GEA by Quarter of Issue



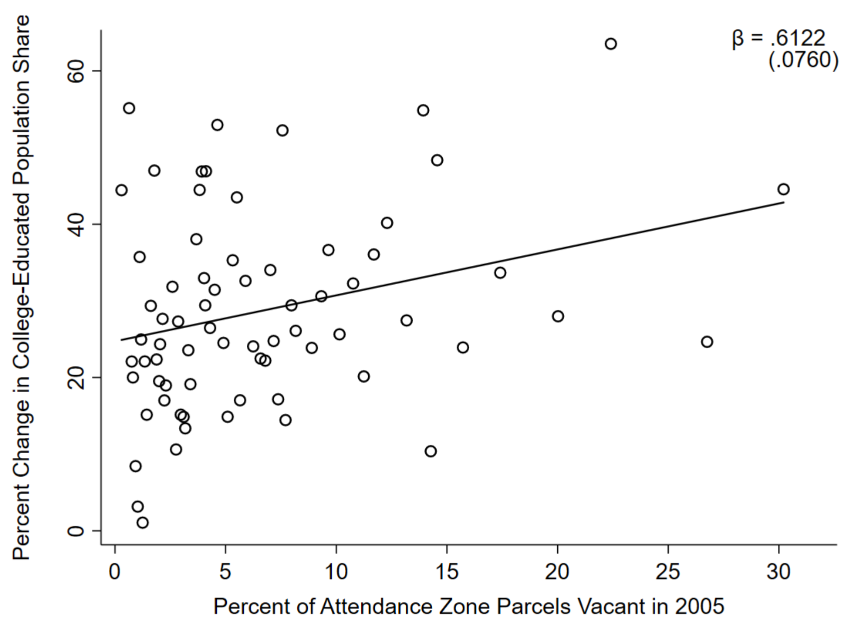
Notes: To create this graph, I merged the New York City Department of Finance's list of all properties receiving the 421-a tax exemption in the 2015-2016 fiscal year with the list of permits issued by the New York City Department of Buildings from 1989 to 2013. I use the 421-a properties list from the 2015-2016 fiscal year because, while exhaustive, this list does not state the length of benefits received and because 10 years is the minimum length available. I restrict the properties data to include all properties built in 2000 onward, and I restrict the permits data to include all permits issued in 2000 onward with permit type "NB" (new building) and with initial (as opposed to renewal) filing status. Lastly, I include permits issued for new construction on parcels located in elementary school attendance zones that are at least 75% contained in the expanded GEA only. I describe in subsection 4.1 how I determine which schools have attendance zones in the expanded GEA. The green line indicates the quarter in which the mayor of New York City created the task force charged with deciding how to reform the 421-a property tax exemption (Q1 2006), and the red line indicates the quarter in which the changes to the 421-a property tax exemption became effective (Q3 2008).

Figure 3: 2005 Land Availability and Subsequent Housing Stock and Demographic Changes

(A) New Tax-Exempt Residential Units by 2005 Land Availability

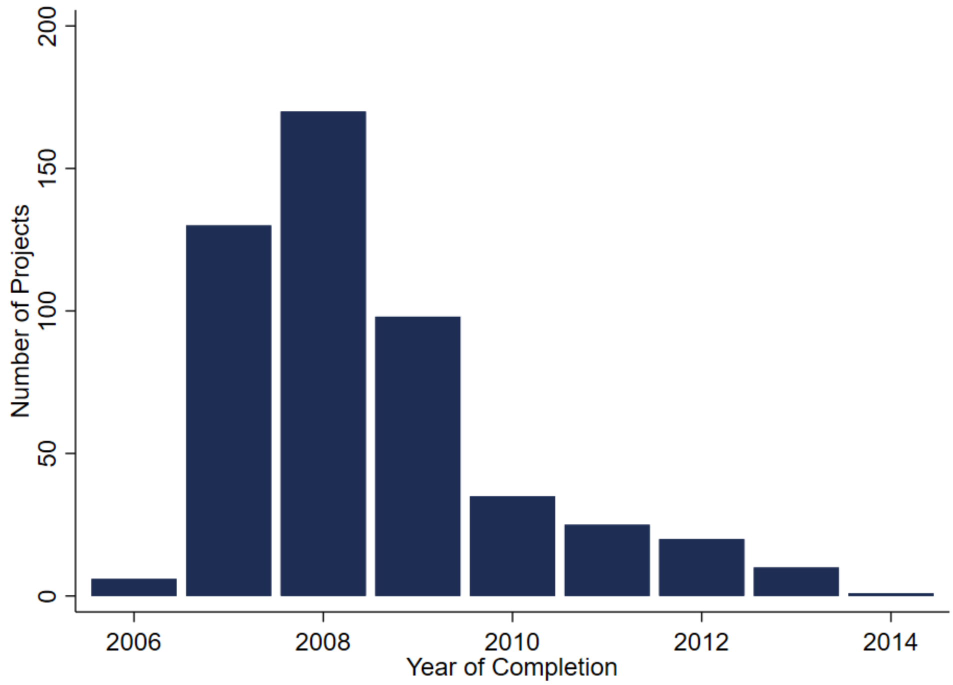


(B) Percent Change in College-Educated Population Share by 2005 Land Availability



Notes: This figure shows the relationship between pre-reform land availability and subsequent new, tax-exempt residential units (panel A) and changes in the college-educated population share (panel B) in attendance zones in my sample. Panel A shows a binned scatterplot of the number of new, tax-exempt residential units per thousand square meters built in attendance zones in my sample whose construction permits were issued between December 2006 and July 2008 by the percent of the attendance zone's parcels that were vacant in 2005. Panel B shows a binned scatterplot of the percent change in the attendance zone's working-age (25 to 64 year-old) college-educated population share from 2005 to 2011 by the percent of parcels vacant in 2005. Also shown are fitted lines and slope coefficients from bivariate regressions of residential units and college-educated population share changes on the percent of parcels vacant in 2005 using heteroskedasticity robust standard errors.

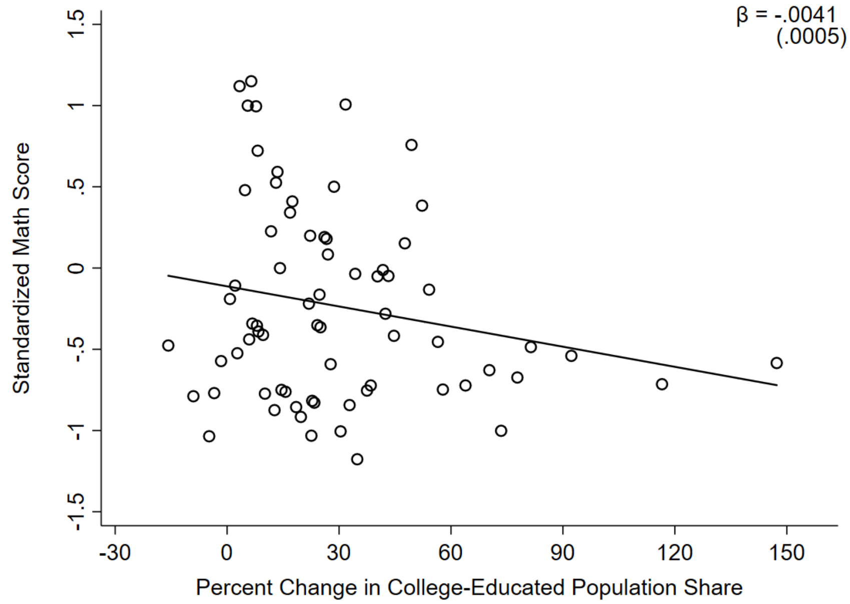
Figure 4: Tax-Exempt Projects Started Between December 2006 and June 2008 in Expanded GEA by Year of Completion



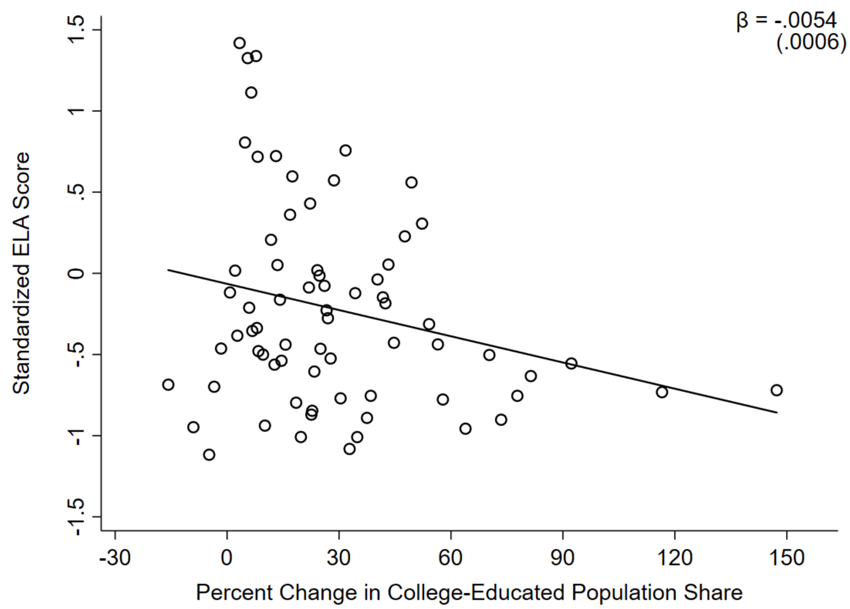
Notes: To create this graph, I merged the New York City Department of Finance's list of all properties receiving the 421-a tax exemption in the 2015-2016 fiscal year with the list of permits issued by the New York City Department of Buildings from 1989 to 2013. I use the 421-a properties list from the 2015-2016 fiscal year because, while exhaustive, this list does not state the length of benefits received and 10 years is the minimum length available. I restrict the properties data to include all properties built in 2000 onward, and I restrict the permits data to include all permits issued between December 2008 and June 2008 with permit type "NB" (new building) and with initial (as opposed to renewal) filing status. Lastly, I include permits issued for new construction on parcels located in elementary school attendance zones that are at least 75% contained in the expanded GEA only.

Figure 5: Standardized Test Scores and Gentrification

(A) Standardized Math Scores by Percent Change in College-Educated Population Share



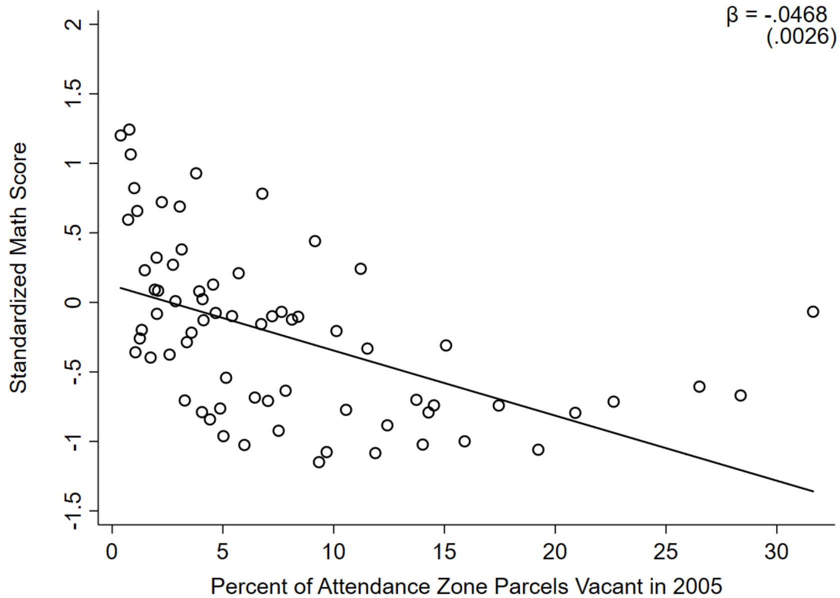
(B) Standardized ELA Scores by Percent Change in College-Educated Population Share



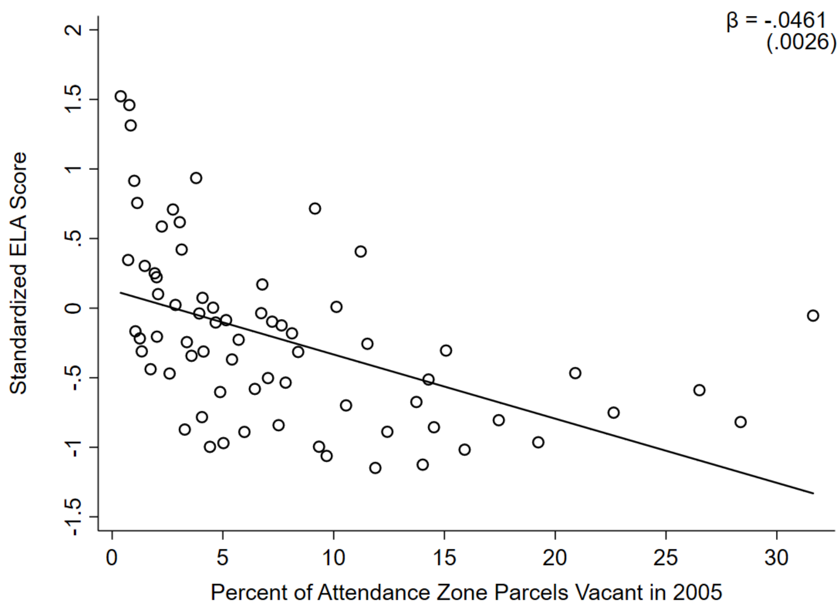
Notes: This figure shows the relationship between gentrification and standardized math (panel A) and ELA (panel B) scores. Panel A (B) shows a binned scatterplot of post-reform, i.e. 2011 to 2017, standardized 3rd through 5th grade math (ELA) scores for school-grade pairs with attendance zones in the expanded GEA by the percent change in the college-educated population share from 2005-2009 to 2011-2015 ACS. Also shown are fitted lines and slope coefficients from bivariate regressions of scores on college-educated population share changes using heteroskedasticity robust standard errors.

Figure 6: Reduced Form

(A) Standardized Math Scores by 2005 Land Availability



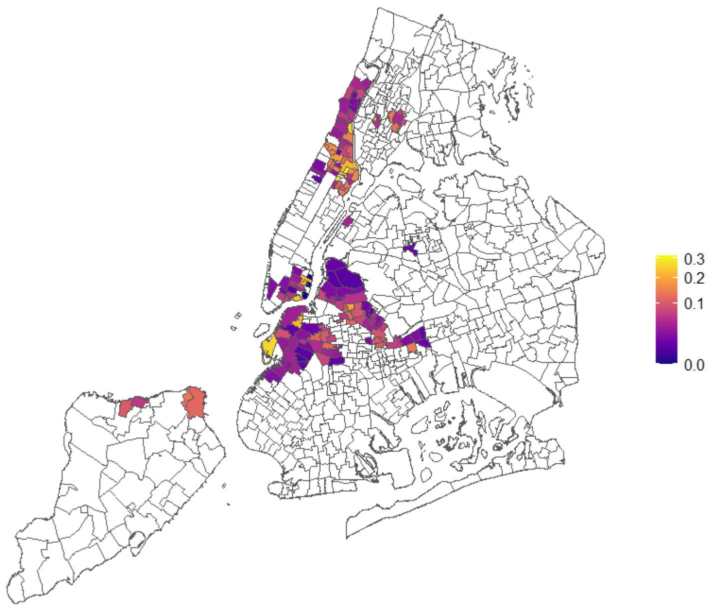
(B) Standardized ELA Scores by 2005 Land Availability



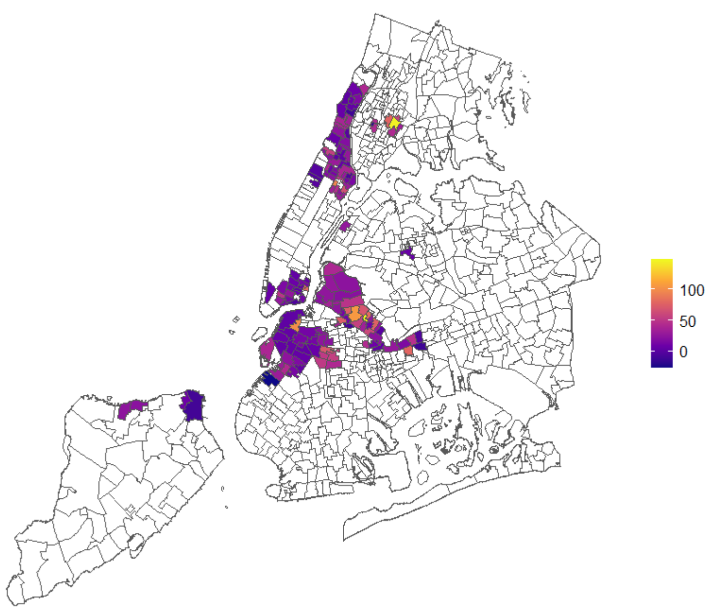
Notes: This figure shows the relationship between pre-reform land availability and standardized math (panel A) and ELA (panel B) scores. Panel A shows a binned scatterplot of standardized math scores by the percent of the attendance zone's parcels that were vacant in 2005. Panel B shows a binned scatterplot of standardized ELA scores by the percent of parcels vacant in 2005. Also shown are fitted lines and slope coefficients from bivariate regressions of scores on the percent of parcels vacant in 2005 using heteroskedasticity robust standard errors.

Figure 7: First Stage

(A) Share of Vacant Parcels in 2005 by Attendance Zone



(B) 2005 to 2011 Percent Change in College-Educated Population Share by Attendance Zone



Notes: This figure shows New York City's 3rd grade public school attendance zones for the 2012-2013 school year with the shaded zones belonging to my sample. Panel A shows the spatial distribution of the share of vacant parcels in 2005 by attendance zone, and panel B shows the spatial distribution of the percent change in the college-educated share of the population residing in the attendance zone between the 2005-2009 and the 2011-2015 ACS.

Table 1: Means of Attendance Zone Characteristics Pre- and Post-Reform

	POST=0	POST=1	Difference	p-value
Demographics				
Population	9,840	10,254	414	0.008
Population aged 25-64	5,619	6,092	473	0
Percent of pop. aged 25-64 with Bachelor's degree	31.9	39.1	7.2	0
Median household income	45,808	51,453	5,645	0
Public elementary school enrollees	574	561	-13	0.1169
Total housing units	4,035	4,340	305	0
Percent of housing units built before 1940	53.7	50.6	-3.1	0
Median rent	940	1,135	195	0
Reported Crime				
Public disturbances	0.72	0.64	-0.08	0
Property crime	0.49	0.53	0.04	0.0002
Violent crime	0.38	0.37	-0.01	0.3260
Drugs and alcohol	0.19	0.14	-0.05	0
Pollution				
PM2.5 concentration	11.8	9.4	-2.4	0
Percent days PM2.5 $\geq$ 12	34.4	22.1	-12.3	0
Access to Healthcare and Social Assistance				
Offices of physicians	2.94	4.88	1.94	0
Community health centers	0.17	0.25	0.08	0
Hospitals and emergency centers	0.16	0.24	0.08	0
Social assistance services	0.84	1.02	0.18	0
N	2,098	2,825		

Notes: Each observation is a grade-, school-, and year. All monetary values are expressed in 2015 dollars. Demographic data in the POST=0 and POST=1 columns come from the 2005-2009 and 2011-2015 ACS 5-year estimates, respectively. Averages of crime, pollution, and healthcare/social assistance data from 2006-2010 and from 2011-2017 are reported in the POST=0 and POST=1 columns, respectively. Crime counts are reported per thousand square meters. Public disturbances include destruction of property/property damage, illegal weapon possession, prostitution, public disturbance, simple assault/menacing, and trespassing. Property crime includes arson, burglary, fraud, larceny, and theft. Violent crime includes abduction, aggravated assault, murder, rape/sexual abuse, and robbery. Drugs and alcohol include possession of a controlled substance, possession of a hypodermic instrument, possession of marijuana, sale of a controlled substance, sale of marijuana, and unlawful sale of alcohol. PM2.5 concentration is reported in micrograms per cubic meter of air. Counts of healthcare and social assistance facilities come from Infogroup are reported per thousand attendance zone residents, using 2005-2009 population estimates for data from 2006-2010 and using 2011-2015 population estimates for data from 2011-2017.

Table 2: Means of School and Grade Characteristics Pre- and Post-Reform

	POST=0	POST=1	Difference	p-value
Math z-score	-0.332	-0.232	0.100	0.0002
ELA z-score	-0.332	-0.220	0.112	0
School enrollment^s	604	578	-26	0.0007
Grade enrollment	83	83	0	0.9971
Average class size	22	24	2	0
Per pupil expenditures^s	18.0	19.6	1.6	0
Approximate teacher salary^s	76.8	92.3	15.5	0
Full-time equivalent teachers^s	47.2	41.6	-5.6	0
Percent free lunch eligible^s	77.5	73.2	-4.3	0
Percent special education^s	17.0	16.1	-0.9	0.0088
Percent English Language Learners^s	9.3	12.3	3.0	0
Percent Hispanic	49.7	51.5	1.8	0.0321
Percent Black	36.7	30.3	-6.4	0
Percent white	6.7	9.5	2.8	0
Percent Asian	6.5	7.5	1.0	0.0384
Percent other race	0.4	1.2	0.8	0
Absence rate^s	8.0	7.5	-0.5	0
N	2,098	2,825		

Notes: Each observation is a grade-, school-, and year. Data in the POST=0 and POST=1 columns are averages over the 2005-2010 and 2011-2017 school years, respectively. All variables are defined at the grade-level except variables with *s* superscripts, which are defined at the school-level. Math and ELA z-scores and are defined relative to all public elementary schools in New York City. Per pupil expenditures and approximate teacher salary are expressed in thousands of 2015 dollars. Per pupil expenditures is defined as the school's total general education expenditures divided by total general education enrollment. Approximate teacher salary is defined as the school's total expenditures on teachers divided by the number of full-time equivalent teachers. Other race is defined as any race/ethnicity other than Hispanic, Black, white, or Asian. The absence rate is computed by averaging daily absence rates, defined as the number of enrolled students divided by the number of absent students on a given day multiplied by 100, over the entire school year.

Table 3: Math and ELA Test Scores, OLS and IV Estimates

	Math Z-Score			
	OLS	IV	OLS	IV
GENT * POST	-0.0018***	-0.0135**	-0.0009	-0.0049
	(0.0007)	(0.0061)	(0.0006)	(0.0046)
School Controls	N	N	Y	Y
Zone Controls	Y	Y	Y	Y
School FEs	Y	Y	Y	Y
Year FEs	Y	Y	Y	Y
Observations	4,923	4,923	4,923	4,923
Adjusted R^2	0.76	0.73	0.78	0.78
Kleibergen-Paap F Stat.		9.44		9.94
	ELA Z-Score			
	OLS	IV	OLS	IV
GENT * POST	-0.0008	-0.0094**	-0.0001	0.0013
	(0.0006)	(0.0049)	(0.0005)	(0.0037)
School Controls	N	N	Y	Y
Zone Controls	Y	Y	Y	Y
School FEs	Y	Y	Y	Y
Year FEs	Y	Y	Y	Y
Observations	4,923	4,923	4,923	4,923
Adjusted R^2	0.77	0.76	0.80	0.80
Kleibergen-Paap F Stat.		9.44		9.94

Notes: Robust standard errors clustered at the school-grade level are in parentheses. * $p<0.1$, ** $p<0.05$, *** $p<0.01$.

Table 4: School Characteristics, OLS and IV Estimates

	Avgerage Class Size		Per Pupil Expenditures		Approx. Teacher Salary	
	OLS	IV	OLS	IV	OLS	IV
GENT * POST	0.0040	-0.0254	-0.0011	0.0198	-0.0340	-0.3435*
	(0.0046)	(0.0292)	(0.0025)	(0.0183)	(0.0268)	(0.2028)
School Controls	Y	Y	Y	Y	Y	Y
Zone Controls	Y	Y	Y	Y	Y	Y
School FEs	Y	Y	Y	Y	Y	Y
Year FEs	Y	Y	Y	Y	Y	Y
Observations	4,923	4,923	4,923	4,923	4,923	4,923
Adjusted R^2	0.39	0.38	0.83	0.83	0.64	0.61
Kleibergen-Paap F Stat.		9.93		9.93		10.06
	Percent Free Lunch		Percent ELL		Percent Special Education	
	OLS	IV	OLS	IV	OLS	IV
GENT * POST	-0.0083	0.1223	0.0121**	0.0388	-0.0250***	0.0271
	(0.0131)	(0.1010)	(0.0061)	(0.0339)	(0.0058)	(0.0359)
School Controls	Y	Y	Y	Y	Y	Y
Zone Controls	Y	Y	Y	Y	Y	Y
School FEs	Y	Y	Y	Y	Y	Y
Year FEs	Y	Y	Y	Y	Y	Y
Observations	4,923	4,923	4,923	4,923	4,923	4,923
Adjusted R^2	0.84	0.84	0.94	0.94	0.83	0.82
Kleibergen-Paap F Stat.		9.93		10.07		9.33
	Hispanic Enrollment		Black Enrollment		Absence Rate	
	OLS	IV	OLS	IV	OLS	IV
GENT * POST	0.0133	0.2058*	0.0072	0.1298	-0.0002	0.0382***
	(0.0239)	(0.1108)	(0.0110)	(0.0982)	(0.0013)	(0.0135)
School Controls	Y	Y	Y	Y	Y	Y
Zone Controls	Y	Y	Y	Y	Y	Y
School FEs	Y	Y	Y	Y	Y	Y
Year FEs	Y	Y	Y	Y	Y	Y
Observations	4,923	4,923	4,923	4,923	4,923	4,923
Adjusted R^2	0.93	0.93	0.90	0.89	0.90	0.85
Kleibergen-Paap F Stat.		10.56		10.56		9.45

Notes: Per pupil expenditures and approximate teacher salary are expressed in thousands of 2015 dollars. Robust standard errors clustered at the school-grade level are in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Table 5: Reported Crime, OLS and IV Estimates

	Public Disturbances		Property Crime	
	OLS	IV	OLS	IV
GENT * POST	-0.0004	-0.0090**	0.00003	0.0018
	(0.0004)	(0.0041)	(0.0002)	(0.0024)
School Controls	N	N	N	N
Zone Controls	Y	Y	Y	Y
School FEs	Y	Y	Y	Y
Year FEs	Y	Y	Y	Y
Observations	4,923	4,923	4,923	4,923
Adjusted R^2	0.92	0.86	0.93	0.93
Kleibergen-Paap F Stat.		9.44		9.44
	Violent Crime		**Drugs & Alcohol**	
	OLS	IV	OLS	IV
GENT * POST	-0.0003*	0.0008	0.0004***	0.0018
	(0.0002)	(0.0014)	(0.0001)	(0.0014)
School Controls	N	N	N	N
Zone Controls	Y	Y	Y	Y
School FEs	Y	Y	Y	Y
Year FEs	Y	Y	Y	Y
Observations	4,923	4,923	4,923	4,923
Adjusted R^2	0.94	0.94	0.81	0.79
Kleibergen-Paap F Stat.		9.44		9.44

Notes: Robust standard errors clustered at the school-grade level are in parentheses. * $p<0.1$, ** $p<0.05$, *** $p<0.01$.

Table 6: Pollution, OLS and IV Results

	PM2.5 Concentration		Percent Days PM2.5 $\geq$ 12	
	OLS	IV	OLS	IV
GENT * POST	0.0021*	-0.0069*	0.0149	-0.0305
	(0.0013)	(0.004)	(0.0093)	(0.0221)
School Controls	N	N	N	N
Zone Controls	Y	Y	Y	Y
School FEs	Y	Y	Y	Y
Year FEs	Y	Y	Y	Y
Observations	4,923	4,923	4,923	4,923
Adjusted R^2	0.99	0.98	0.97	0.97
Kleibergen-Paap F Stat.		9.44		8.97

Notes: Robust standard errors clustered at the school-grade level are in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

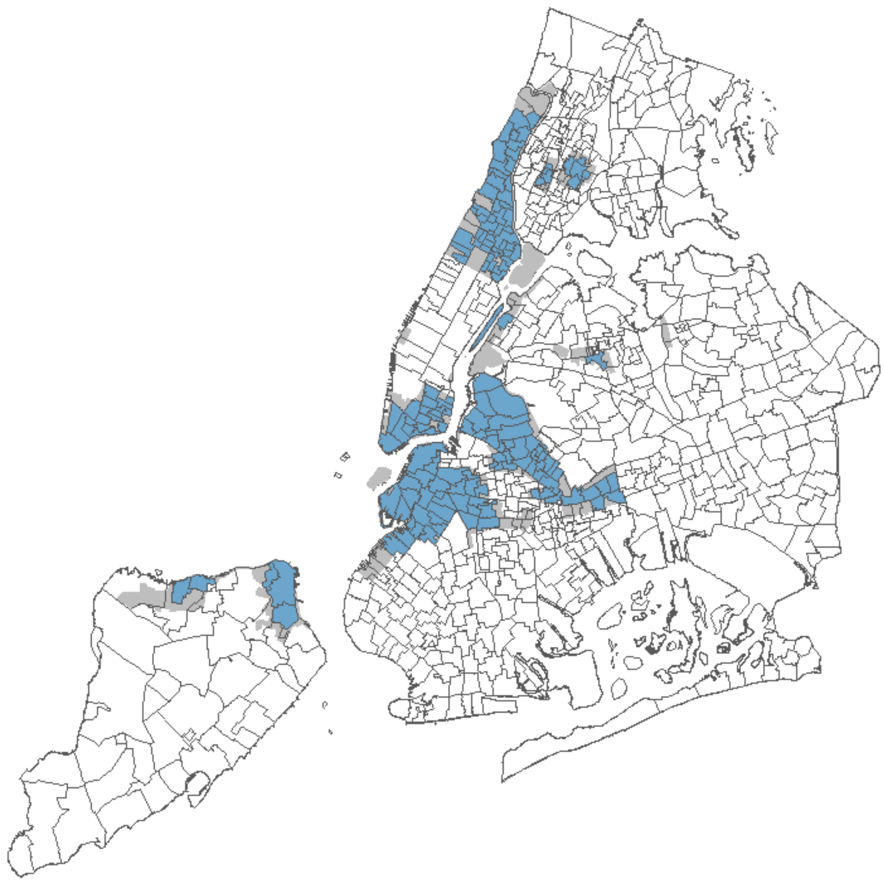
Table 7: Access to Healthcare and Social Assistance, OLS and IV Estimates

	Offices of Physicians		Community Health Centers	
	OLS	IV	OLS	IV
GENT * POST	0.0151**	-0.1408**	-0.0013***	-0.0102***
	(0.0073)	(0.0702)	(0.0004)	(0.0033)
School Controls	N	N	N	N
Zone Controls	Y	Y	Y	Y
School FEs	Y	Y	Y	Y
Year FEs	Y	Y	Y	Y
Observations	4,923	4,923	4,923	4,923
Adjusted R^2	0.81	0.79	0.79	0.69
Kleibergen-Paap F Stat.		9.44		9.44
	Hospitals & Emergency Centers		Social Assistance Services	
	OLS	IV	OLS	IV
GENT * POST	0.00003	-0.0081***	-0.0008	0.0040
	(0.0004)	(0.0032)	(0.0010)	(0.0077)
School Controls	N	N	N	N
Zone Controls	Y	Y	Y	Y
School FEs	Y	Y	Y	Y
Year FEs	Y	Y	Y	Y
Observations	4,923	4,923	4,923	4,923
Adjusted R^2	0.66	0.59	0.82	0.81
Kleibergen-Paap F Stat.		9.44		9.44

Notes: Robust standard errors clustered at the school-grade level are in parentheses. * $p<0.1$, ** $p<0.05$, *** $p<0.01$.

Appendix Figures and Tables

Figure A.1: Attendance Zones in Expanded Geographic Exclusion Area



Notes: This figure shows New York City's 3rd grade public school attendance zones for the 2012-2013 school year. The gray shaded region is the expanded GEA, and the blue shaded attendance zones are those included my sample. All attendance zones outside of the expanded GEA are excluded from my sample. An attendance zone in or partially in the expanded GEA is excluded from my sample if less than 75% of its area is inside the expanded GEA or if it serves more than one school in the same school year.

Table A.1: Observations by Grade and Year

School Year	Grade 3	Grade 4	Grade 5	Total
2005-2006	141	140	138	419
2006-2007	141	140	138	419
2007-2008	141	140	138	419
2008-2009	141	141	139	421
2009-2010	140	141	139	420
2010-2011	146	146	145	437
2011-2012	138	136	135	409
2012-2013	132	132	132	396
2013-2014	132	131	130	393
2014-2015	132	132	130	394
2015-2016	133	133	132	398
2016-2017	133	133	132	398
Total	1,650	1,645	1,628	4,923

Notes: This table shows the number of observations (attendance zones) in my sample by grade and year. The number of observations in my sample decreases over time due to school closures and schools becoming "unzoned" or choice schools with no (or, in some cases, multiple) attendance zone(s) assigned to them. To check the robustness of my findings, I reestimated all models using a balanced panel, i.e. the subsample of school-grade pairs that appear in my original sample every year, and the results are unchanged.

Table A.2: Summary Statistics for Key Variables Used in Regressions

Variable	Mean	SD	Min	Max	N
Dependent Variables					
Math z-score	-0.274	0.946	-2.98	4.00	4,923
ELA z-score	-0.268	0.956	-2.73	3.39	4,923
Average class size	23.1	4.1	11.0	35.0	4,923
Per pupil expenditures^s	18.9	3.2	11.7	49.5	4,923
Approximate teacher salary^s	85.7	23.7	10.1	440.3	4,923
Percent free lunch eligible^s	75.0	21.8	0	100	4,923
Percent special education^s	16.5	12.1	0.5	62.0	4,923
Percent English Language Learners^s	11.0	6.8	0	44.2	4,923
Hispanic enrollment	44	40	0	297	4,923
Black enrollment	23	21	0	150	4,923
Absence rate^s	7.7	2.2	1.6	14.8	4923
Public disturbances	0.67	0.46	0.07	3.22	4,923
Property crime	0.51	0.36	0.04	3.03	4,923
Violent crime	0.37	0.26	0.03	1.77	4,923
Drugs & alcohol	0.16	0.18	0	1.31	4,923
PM2.5 concentration	10.4	2.3	2.7	14.4	4,923
Percent days PM2.5 $\geq$ 12	27.3	11.2	0	48.0	4,923
Offices of physicians	4.05	15.39	0	312.36	4,923
Community health centers	0.22	0.38	0	4.97	4,923
Hospitals and emergency centers	0.21	0.42	0	6.46	4,923
Social assistance services	0.94	0.84	0	9.15	4,923
Gentrification Measure and Instrument					
Percent Δ in share with Bachelor's * POST	16.6	25.7	-26.3	150.0	4,923
Share of parcels vacant in 2005 * POST	0.043	0.063	0	0.316	4,923

Notes: Each observation is a grade-, school-, and year. All variables are defined at the grade-level except variables with s superscripts, which are defined at the school-level. All monetary values are expressed in 2015 dollars. Math and ELA z-scores are defined relative to all public elementary schools in New York City. Per pupil expenditures and approximate teacher salary are expressed in thousands of 2015 dollars. Per pupil expenditures is defined as the school's total general education expenditures divided by total general education enrollment. Approximate teacher salary is defined as the school's total expenditures on teachers divided by the number of full-time equivalent teachers. The absence rate is computed by averaging daily absence rates, defined as the number of enrolled students divided by the number of absent studies on a given day multiplied by 100, over the entire school year. Crime counts are reported per thousand square meters, and the PM2.5 concentration is reported in micrograms per cubic meter of air. Counts of healthcare and social assistance facilities are reported per thousand attendance zone residents. POST is an indicator equal to 1 for all years after 2010 and 0 otherwise.

Table A.3: Summary Statistics for Control Variables Used in Regressions

Variable	Mean	SD	Min	Max	N
School Controls					
Average class size	23.1	4.1	11.0	35	4,923
Per pupil expenditures^s	18.9	3.2	11.7	49.5	4,923
Approximate teacher salary^s	85.7	23.7	10.1	440.3	4,923
Percent free lunch eligible^s	75.0	21.8	0	100	4,923
Percent special education^s	16.5	12.1	0.5	62.0	4,923
Percent English Language Learners^s	11.9	6.8	0	44.2	4,923
Percent Hispanic	50.7	28.7	0	100	4,923
Percent Black	33.1	27.4	0	98.7	4,923
Percent Asian	7.1	17.2	0	97.6	4,923
Percent other race	0.9	1.8	0	22.4	4,923
Absence rate^s	7.7	2.2	1.6	14.8	4,923
Zone Controls					
2000-2005 Δ population aged 25-64	486	690	-1,336	6,507	4,923
2000-2005 Δ share of pop. aged 25-64 with Bachelor's	0.104	0.063	-0.022	0.247	4,923
2000-2005 Δ median household income	4,072	6,766	-10,258	28,695	4,923
2000-2005 Δ public elementary school enrollees	-176	206	-999	285	4,923
2000-2005 Δ total housing units	221	438	-409	49,26	4923
2000-2005 Δ share of housing units occupied	-0.022	0.031	-0.19	0.074	4,923
2000-2005 Δ share of housing units built before 1940	0.109	0.099	-0.091	0.495	4,923
2000-2005 Δ median rent	136	122	-537	512	4,923
2005 population aged 25-64	5,642	3,369	543	19,305	4,923
2005 share of pop. aged 25-64 with Bachelor's	0.321	0.202	0.061	0.847	4,923
2005 median household income	46,127	23,440	19,021	145,744	4,923
2005 public elementary school enrollees	571	292	102	1,833	4,923
2005 total housing units	4,042	2,429	407	15,469	4,923
2005 share of housing units occupied	0.906	0.043	0.773	0.996	4,923
2005 share of housing units built before 1940	0.542	0.198	0.009	0.927	4,923
2005 median rent	942	316	415	2,202	4,923
2005 average vacant parcel area	506	651	0	6,513	4,923
Manufacturing and utilities facilities	0.01	0.02	0	0.23	4,923
Percent of attendance zone in expanded GEA	97.4	5.7	75.2	100	4,923

Notes: Each observation is a grade-, school-, and year. All variables are defined at the grade-level except variables with s superscripts, which are defined at the school-level. All monetary values are expressed in 2015 dollars. Math and ELA z-scores are defined relative to all public elementary schools in New York City. Per pupil expenditures and approximate teacher salary are expressed in thousands of 2015 dollars. Per pupil expenditures is defined as the school's total general education expenditures divided by total general education enrollment. Approximate teacher salary is defined as the school's total expenditures on teachers divided by the number of full-time equivalent teachers. Other race is defined as any race/ethnicity other than Hispanic, Black, white, or Asian. The absence rate is computed by averaging daily absence rates, defined as the number of enrolled students divided by the number of absent students on a given day multiplied by 100, over the entire school year. Average vacant parcel area is reported in square meters, and manufacturing and utilities facilities are reported per thousand square meters.

Table A.4: Math Test Scores, OLS and IV Estimates, Binary Measure of Gentrification

Panel A: IV Estimates	p60	p70	p80	p90
GENT * POST	-0.6616**	-0.8171**	-1.121**	-1.242**
	(0.2841)	(0.3553)	(0.5572)	(0.5610)
Percentile value	27.2	34.6	45.0	65.9
Average % Δ in college-educated share for GENT=1	54.6	62.4	73.2	92.8
School Controls	N	N	N	N
Zone Controls	Y	Y	Y	Y
School FEs	Y	Y	Y	Y
Year FEs	Y	Y	Y	Y
Observations	4,923	4,923	4,923	4,923
Adjusted R^2	0.74	0.73	0.71	0.73
Kleibergen-Paap F Stat.	19.42	10.24	6.57	7.90

Panel B: OLS Estimates	p60	p70	p80	p90
GENT * POST	-0.1051**	-0.0594	-0.0525	-0.1464**
	(0.0479)	(0.04889)	(0.0576)	(0.06071)
Percentile value	27.2	34.6	45.0	65.9
Average % Δ in college-educated share for GENT=1	54.6	62.4	73.2	92.8
School Controls	N	N	N	N
Zone Controls	Y	Y	Y	Y
School FEs	Y	Y	Y	Y
Year FEs	Y	Y	Y	Y
Observations	4,923	4,923	4,923	4,923
Adjusted R^2	0.76	0.76	0.76	0.76

Notes: The outcome variable in all specifications in the grade-, school-, and year-specific math Z-score. GENT is an indicator equal to 1 if an attednance zone experiences a change in the college-educated population share in the top 40%, 30%, 20%, or 10% of attendance zones in my sample. Robust standard errors clustered at the school-grade level are in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Table A.5: ELA Test Scores, OLS and IV Estimates, Binary Measure of Gentrification

Panel A: IV Estimates	p60	p70	p80	p90
GENT * POST	-0.4618**	-0.5703**	-0.7827*	-0.8671**
	(0.2338)	(0.2932)	(0.4265)	(0.4414)
Percentile value	27.2	34.6	45.0	65.9
Average % Δ in college-educated share for GENT=1	54.6	62.4	73.2	92.8
School Controls	N	N	N	N
Zone Controls	Y	Y	Y	Y
School FEs	Y	Y	Y	Y
Year FEs	Y	Y	Y	Y
Observations	4,923	4,923	4,923	4,923
Adjusted R^2	0.77	0.76	0.75	0.76
Kleibergen-Paap F Stat.	19.42	10.24	6.57	7.90

Panel B: OLS Estimates	p60	p70	p80	p90
GENT * POST	-0.0776*	-0.0223	-0.0183	-0.0244
	(0.0439)	(0.044)	(0.0504)	(0.0559)
Percentile value	27.2	34.6	45.0	65.9
Average % Δ in college-educated share for GENT=1	54.6	62.4	73.2	92.8
School Controls	N	N	N	N
Zone Controls	Y	Y	Y	Y
School FEs	Y	Y	Y	Y
Year FEs	Y	Y	Y	Y
Observations	4,923	4,923	4,923	4,923
Adjusted R^2	0.78	0.78	0.78	0.78

Notes: The outcome variable in all specifications in the grade-, school-, and year-specific ELA Z-score. GENT is an indicator equal to 1 if an attednance zone experiences a change in the college-educated population share in the top 40%, 30%, 20%, or 10% of attendance zones in my sample. Robust standard errors clustered at the school-grade level are in parentheses. * $p<0.1$, ** $p<0.05$, *** $p<0.01$.