Sorting into neighborhoods and schools: The role of density regulations

Amrita Kulka*

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Abstract

Despite fierce battles over rezoning, the role of land use regulations in forming neighborhoods remains understudied. In a neighborhood-based school system, density regulations determine the composition of peers in public schools by sorting wealthy households into low-density areas and less wealthy households into high-density areas. What is the extent of this sorting? How might children's test scores be affected if a small part of the school attendance area were rezoned to allow higher density? To answer these questions I first employ a boundary discontinuity design to study how mandated density affects neighborhood composition. Next, I estimate the effect of school peers' incomes on test scores using variation from a bussing policy. Putting these two effects together in a back of the envelope calculation suggests rezoning parts of school attendance areas can be highly beneficial to those expected to move there while only having small detrimental effects on the remaining children.

*Department of Economics, University of Wisconsin-Madison. Email: amrita.kulka2@wisc.edu

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1 Introduction

Minimum lot sizes[2] impose a minimum amount of housing that must be purchased to live in a particular neighborhood. They can lead to highly homogeneous residential neighborhoods of mostly large lots and low population density or small lots and high population density. In the process, neighborhoods arise that are unaffordable for some households. Since public education is traditionally tied to the neighborhood of residence, poorer households might be excluded from better schools purely because they are also in areas that are zoned in a more restrictive way - that is, high-income households sort into low-density neighborhoods and low-income households sort into high-density neighborhoods. Even if school resources are otherwise equal, we expect the quality of schools in differently zoned neighborhoods to be different because peers systematically differ. While there are theoretical results studying stratification by income stemming from minimum lot sizes, there is a lack of empirical work in this area. In this paper I take a first step towards filling this gap by analyzing the question of how land use regulations affect school outcomes of elementary school children. Given high levels of inequality in schools and in residential communities, understanding whether some of this inequality may come purely from imposed land use regulations is a question with highly relevant policy implications.

Figure 1 demonstrates the correlation between the quality of education and the strictness of land use regulation for Wake County, North Carolina, that I will be studying in this paper: The x axis represents the allowed density in dwelling units per acre (for example an x value of 1 implies an allowed density of 1 dwelling unit per acre (du/a), a very restrictive regulation) and the y axis represents the proportion of a school attendance area zoned according to each regulation. I find schools that perform at or above the 90th percentile of end of grade elementary school math test scores and schools that perform at or below the 10th percentile of end of grade elementary school math test scores. For each of these two groups, I calculate the total school attendance area and then graph the proportion of this aggregated area by density regulation. There is a clear correlation between lower dwelling units per acre and better school quality: The top performing schools (red bars) lie in attendance areas where almost 40% of the area is zoned with one dwelling unit per acre and the proportion zoned according to other regulations falls off steeply. On the other hand, the density of the worst performing schools approaches a uniform distribution across different density regulations. This descriptive evidence suggests that density regulations may play a role in determining educational outcomes.

2 Literature

This paper combines and draws from several strands of literature. The work on neighborhood choice mostly does not consider minimum lot sizes or other regulations as a restriction for households choosing their location, focusing instead on designing housing vouchers optimally and willingness to pay for school quality (Bayer, Ferreira and McMillan (2007), Black (1999), Davis et al. (2017), Galiani, Murphy and Pantano (2015)). Equilibrium models are mostly theoretical and disregard the effect of peers and neighbors (Calabrese, Epple and Romano (2007), Epple and Sieg (1999), Fernandez and Rogerson (1997)) and the school finance literature takes as given how individuals sort and adds the system of public education provision (Fernandez and Rogerson (2003), Hoxby (1996), Hoxby (2001), Kotera and Seshadri (2017)). In as far as zoning regulations have played a role in these types of models, they serve the sole function of providing a base for property taxes to be levied (Hanushek and Yilmaz (2015)).

The literature on the effects of land use regulations can be summarized by the finding that stricter land use regulations lead to an artificial reduction in housing supply and hence to higher property values. Glaeser and

[2] Used interchangeably for now with density regulations. For example, if the density regulation is 2 dwelling units per acre then the corresponding minimum lot size is 0.5 acres. This is a point for further consideration in future analysis.

Gyourko (2002), Gyourko, Saiz and Summers (2008), Glaeser, Gyourko and Saks (2005), Glaeser and Ward (2009), Anenberg and Kung (2018) reach the conclusion that housing prices are higher than the marginal cost of building due to zoning in highly productive areas in the country. Banzhaf and Mangum (2018) consider that land use regulations lead to a two-price tariff where owners pay a ticket price for a neighborhood as well as a marginal price per square foot of land. This ticket price in some sense simulates communities formed based on a head tax in Tiebout (1956). Turner, Haughwout and van der Klaauw (2014) use a boundary discontinuity approach at the regulation boundary but estimate the effect on property values. Ganong and Shoag (2017), Hsieh and Moretti (2015) and Bunten (2017) show that regional income convergence and productivity have decreased due to the fact that land use regulations raise cost of housing.

Finally, I will use methods from and contribute to the research regarding the effects of segregation on children's outcomes in school. Card and Rothstein (2007) and Cutler and Glaeser (1997) examine the black-white achievement gap in school as a function of the level of segregation of cities. Card and Rothstein (2007) find that reducing segregation might reduce the achievement gap and that peer effects from residential neighborhoods matter more than peer effects at school. Hanushek, Kain and Rivkin (2009) rely on random cohort variation to explain the effect of peer composition on student outcomes. Angrist and Lang (2004) evaluate a desegregation program in Boston, focusing on the impact of desegregation on both the students sent to different schools as well as the receiving students. Guryan (2004) and Baum-Snow and Lutz (2011) study school outcomes after the introduction of bussing policies for the purposes of desegregation.

3 Approach

I am interested in the effect of density regulations on children's test scores. The main channel that I want to examine in this paper is how density regulations affect neighborhood composition which in turn affects test scores through peers at school. Density regulations are a mechanism for neighborhood formation. Given that public education is tied to neighborhoods, the composition of a neighborhood then has a direct impact on test scores by changing school peers. In this paper, I will estimate the effect of density regulations on neighborhood composition and the effect of peers on test scores separately using two empirical strategies and then combine the results in a back of the envelope calculation to answer the question of interest. I estimate the effect of density regulations on neighorhood composition using a boundary discontinuity approach and estimate the effect of peer composition on test scores using quasi-experimental variation from a bussing experiment.

4 Data

For this paper I compile a novel data set merging fine geographic level information on land use and on school outcomes for elementary school children (NCERDC administrative school data set). I focus on Wake County, North Carolina with its main city of Raleigh. I match census data on income, racial composition, tenure in housing and poverty levels to children's end of grade test scores in Math for grades 3-5 over time.

Figure 2 shows maps of Wake County elementary school attendance zone boundaries. Figure 2a overlays these boundaries with the density regulation for each lot. The darker the color, the more density is allowed and the smaller the lot sizes. White areas are non residential and hence not of interest here. Importantly, there is variation in density both within as well as across different elementary school attendance boundaries. If all elementary schools had some of the highest density available, then access would arguably be less of a problem. However, there are clearly some school boundaries where the highest allowed density is still quite low. Figure 2b shows the same map with elementary school attendance zone boundaries but this time it is overlaid with quintiles of the proportion of households with a household income below the poverty level. The highest poverty areas are red. The main thing to note is the overlap between the red areas in the top and the bottom map. This suggests a strong correlation of high density and poverty and low density and comparative wealth.

5 The effect of density regulations on neighborhood composition

To study the effect of density regulations on neighborhood composition, I conduct a boundary discontinuity design at the density regulation boundary. The goal is to isolate the effect of density regulations on different variables of neighborhood composition, most importantly, neighborhood income. The thought experiment is the following: In the cleanest possible scenario, I would compare two houses on either side of a street, where the regulation boundary coincides with the street, i.e. the house on one side of the street is regulated with a higher minimum lot size/ lower density and the house on the other side is regulated less strictly with a lower minimum lot size/ higher density. The households living in the two houses have the same access to all the neighborhood amenities like parks, cafes, restaurants, will be affected by the same neighbors and breath in the same air. I exclude boundaries that coincide with school attendance zone boundaries. Instead of houses on either side, I will be looking at census blocks due to the lack of availability of neighorhood information at the lot level.

The graphical analysis (not shown in this long abstract) suggests that the difference in minimum lot size at the boundary generates a discontinuity in neighborhood composition by generating different types of housing on either side. A more strictly regulated lot, i.e. a lot with a higher minimum lot size, should lead to a larger lot if the regulation is followed. This might lead to a larger house but it should certainly lead to a higher property value. This higher property value in and of itself should lead to households of different incomes moving in on either side, and a marginal person being priced out of the more regulated area.

My estimation strategy is as follows:

$$\begin{aligned} Y_b = \alpha_0 + \beta T + \alpha_1 dist_b + \alpha_2 dist_b \mathbb{1}\{\text{more regulated}\} + \alpha_3 dist_b^2 \\ + \alpha_4 dist_b^2 \mathbb{1}\{\text{more regulated}\} + \delta \mathbb{1}\{\text{rural}\} + \gamma_{city} + \theta_{bd} + \epsilon_b \end{aligned} \quad (1)$$

where b is the census block, Y_b is the outcome of interest at the census block level, D_b is distance in miles of block b to nearest regulation boundary. The distance to the boundary is the running variable - currently I control for the running variable using a quadratic polynomial that I estimate separately on either side of the boundary.

θ_{bd} is a set of boundary fixed effects, $T = \mathbb{1}\{\text{more regulated}\} * \Delta_{density}$ is the treatment indicator, an interaction of the block being on the more regulated side of the nearest boundary, $\mathbb{1}\{\text{more regulated}\}$, and $\Delta_{density}$ - the difference between the density regulation on either side of the boundary. The difference in the density is defined as: $\Delta_{density} = density_{\text{more regulated}} - density_{\text{less regulated}}$. This means that $\Delta_{density}$ will always be a negative number since the more regulated side has a lower density than the less regulated side. y_{city} is a city level fixed effect. Finally, $\mathbb{1}\{\text{rural}\}$ is an indicator for the census block being rural or not. The main outcome of interest Y_b that I examine is block level income.The interpretation of β is the effect on Y_b of a decrease in one dwelling unit per acre of mandated density.

Table 1 shows the results of estimating equation 1 where the dependent variable is the median household income by census block. It is helpful to consider when a density regulation is relevant and when it is not: The regulation imposes a floor on lot size. If all lots are larger than the minimum allowed lot size, then one might argue that the constraint is not binding for this neighborhood since all lots exceed the minimum lot size anyway. Consequently, we would expect to see less sorting at this boundary, if the regulation is imposing no constraint to begin with.

Table 1 column 1 estimates β for blocks where at least 30% of lots are exactly at the minimum lot size. The treatment coefficient can be interpreted as meaning that a block with a regulation allowing one less dwelling unit per acre than its neighbor has a median income of 248$ more than its neighbor (keeping in mind that Δ is defined as negative). Column 2 looks at the same outcome variable but for the sample of blocks where less than 30% of lots are binding. The coefficient is much smaller and switches sign but is also very imprecisely estimated. This supports the intuition that the effect of sorting should be larger at binding boundaries where the minimum lot size is more salient.

Columns 3 and 4 repeat the same exercise but this time consider blocks that either have at least 50% of binding lots (column 3) or less than 50% of binding lots (column 4). The same pattern as before emerges, with a statistically insignificant and smaller effect for the not binding sample and a statistically significant effect of $249 for the binding sample. The expectation of a larger effect for more binding boundaries (50% binding vs 30% binding) is not fulfilled here, both effects seem to be the same.

Columns 5-8 do the same analysis as columns 1-4 but on a sample of blocks within 0.2 miles from the boundary. Overall, the smaller the bandwidth, the more the effect of regulation should be picked up, because the observations on either side are more similar to each other. The effect size doubles in column 5, suggesting sorting on income of $504 for a decrease in one dwelling unit per acre. Compared to column 6, the effect is slightly larger for the more binding boundaries. Comparing with the non-binding boundaries the pattern is the same as before: effects of sorting at the boundaries where minimum lot size does not seem to be a constraint are imprecise and small.

It is worthwhile to put these effects into context of existing results on sorting. One of the few existing results on income sorting into neighborhoods comes from Bayer, Ferreira and McMillan (2007). They find sorting on income of $2800 with a bandwidth of 0.2 miles from the school attendance zone boundary. Comparing this to the results that I find for the same distance (column 5 of Table 1), a decrease in dwelling units per acre of about 5-6 leads to a similar amount of sorting. Remembering that the density regulations go up to 25 du/a, this suggests that imposing minimum lot sizes can easily lead to similar or greater sorting effects than sorting that occurs due to different preferences of households for local public goods. Imagine now, the most extreme possible difference in Wake County, going from 1 du/a to 25 du/a. In this case sorting on income at such a boundary would be predicted to be between $12,500 and $15,000, which amounts to the difference between the 25th and 45th percentile of the income distribution in Wake County. If there were only two school districts and one of them was regulated with 1 du/a and the other with 25 du/a then simply the regulation would exclude the left tail of the income distribution from living in the strictly regulated district and attending that school.

6 The effect of neighborhood composition on test scores

Having estimated the effect of minimum lot sizes on neighborhood income, if I can estimate the effect of school peers' incomes on test scores then I can conduct a back of the envelope calculation of the effect of minimum lot sizes on test scores through the channel of changing neighborhood income and thereby the income of school peers. The biggest problem with estimating peer effects is the sorting of families into neighborhoods and schools, so that peers are not random. I estimate the effect of peers following the generalized fixed effects value added model of Hanushek, Kain and Rivkin (2009). The authors use this strategy to estimate the peer effects of the proportion of black students on test scores. The identifying variation comes from deviations in the proportion of black peers from the school's average by grade and year.

I use a similar strategy here to identify the effects of peers' average income on test scores of child i. I use administrative school data from North Carolina (NCERDC). This data contains records for all children going to North Carolina public schools going back to 1998. For each elementary school child in Wake County, I use the end of grade math test scores for grades 3-5, the available background characteristics as well as the home census block group. This allows me to link the school data to land use data and neighborhood characteristics. I am further able to match students to their math teacher and hence the teacher's pay and also to their classroom to get information on class size. For now, I focus on the years 2009-2013 which match best with the availability of school attendance boundary information.

Following Hanushek, Kain and Rivkin (2009), I estimate the following empirical model for student i in grade g in year y:

$$T_{igy} = \alpha_0 + \beta_1 \bar{Y}_{igy} + \alpha_1 T_{i,g-1,y-1} + X'_{igy}\beta_2 + S'_{igY}\delta + \psi_s + \rho_g + \tau_y + \eta_{sg} + \pi_{sy} + \phi_{gy} + \epsilon_{igy} \tag{2}$$

where T_{igy} is the end of grade elementary school math test score, $\bar{Y}_{igy}$ is the average income of i's peers, X_{igy} is a vector of time-varying and constant student and family characteristics, S_{igy} is a vector of time varying school resources (class size and teacher pay) and $T_{i,g-1,y-1}$ is the lagged end of grade elementary school math test score. ψ_s, ρ_g and τ_y are school, grade and year fixed effects respectively, capturing time invariant systematic differences. The coefficient of interest is β_1, the effect of school peers' average income on test scores. The variation that is left after controlling for the different sets of fixed effects is variation within school by cohort. Previous research has assumed that this variation is random - there are natural differences in cohort composition at a particular school that help to identify the causal effect of peers. In Wake County, random variation additionally comes from extensive bussing of school children based on different objectives. School attendance zones, including bussing zones, are redrawn annually to achieve the objectives of the school board, generating some variation in peers every year at every school. From the perspective of a student already at a given school, this randomizes the set of peers a little bit every year even after parents have selected into a school.

Table 2 shows the results of estimating equation 2. The dependent variable is the standardized math test score. Average peer income is in \$1000. The preferred specification (column 3) includes time constant and time varying controls and suggests that an increase in peers' average income of \$1000, increases math scores by a precisely estimated 0.00227 standard deviations (coefficient is comparable to other peer effects estimates for an increase in \$10,000).

7 Back of the envelope calculation

Putting both parts together in a back of the envelope calculation (not shown in this long abstract) suggests that children's test scores are affected negatively when a part of the school attendance area is rezoned to allow higher density. Nevertheless, even after taking into account that the number of children from the rezoned areas is likely to increase, the effects remain quite small - on the order of 0.003 standard deviations decrease in math test scores per year per child. On the other hand there are considerable benefits of moving a child from a school attendance area with peers' average income of around 60-80% of area median income (the income range targeted by inclusionary zoning policies) to an affordable dense area in the suburbs. The effects alone of having peers from richer neighborhoods can lead to increases in math test scores of over 0.1 standard deviations per year and child.

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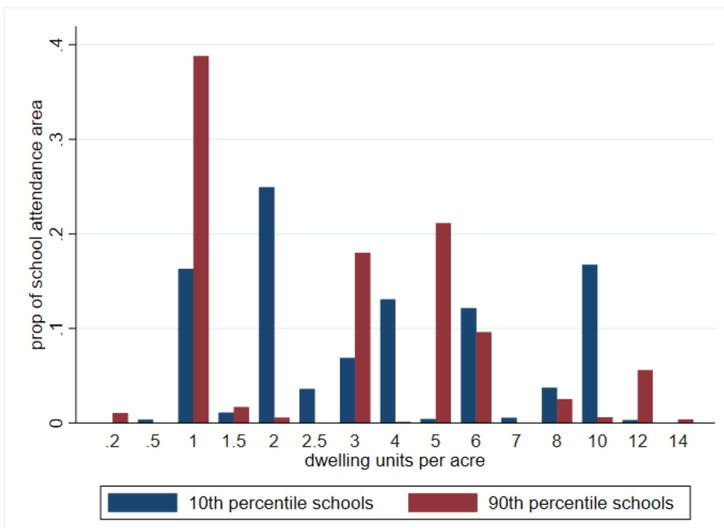
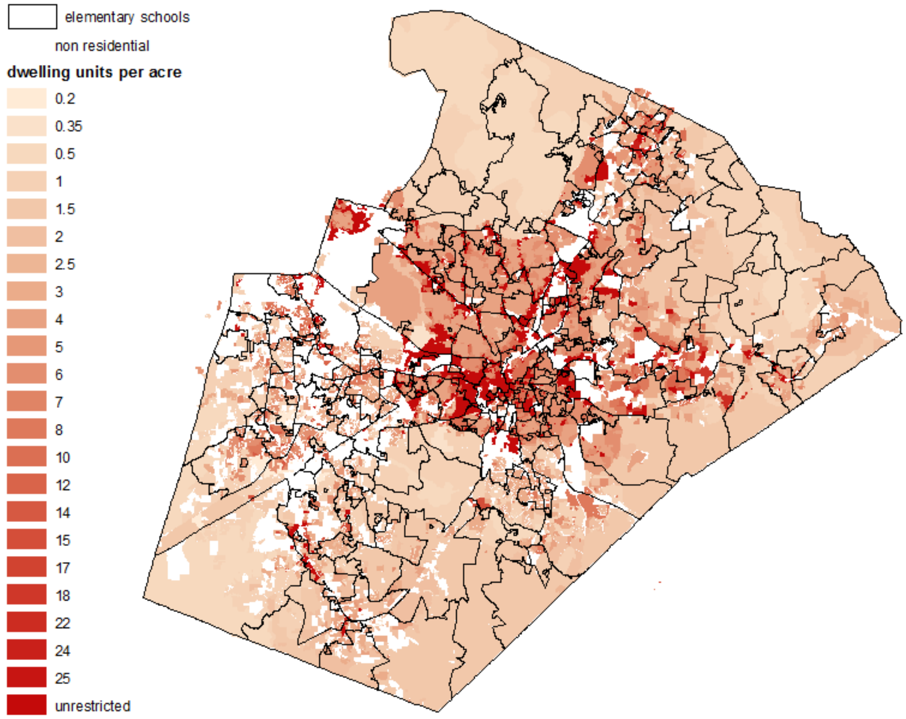
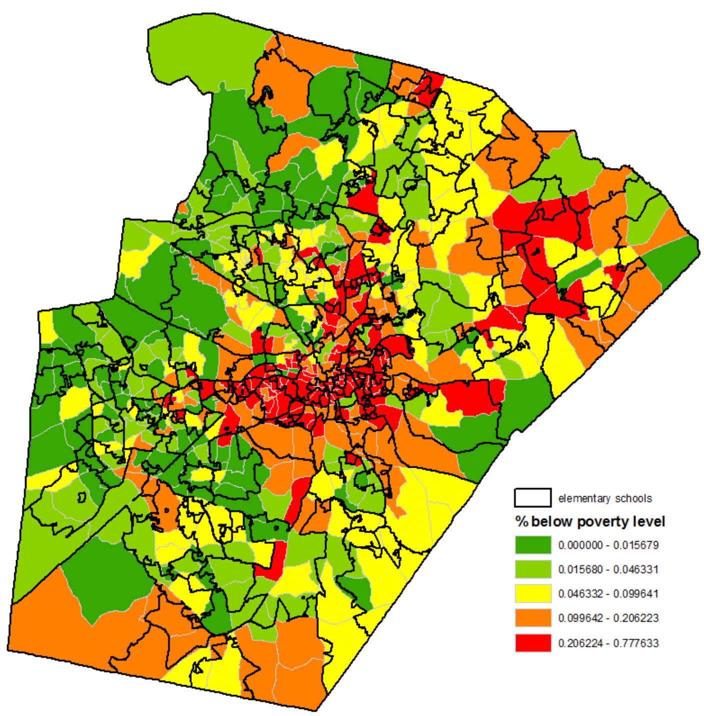


Figure 1: School quality and density regulations



(a) Elementary schools and density



(b) Elementary schools and poverty

Figure 2: Elementary school attendance zones and land use

Table 1: Household income

	(1) 30% binding	(2) not binding	(3) 50% binding	(4) not binding	(5) 30% binding	(6) not binding	(7) 50% binding	(8) not binding
$\mathbb{1}\{\text{regulated}\} * \Delta_{density}$	-248.6**	40.14	-249.4*	-151.2	-503.9***	366.0	-593.9**	-21.17
	(80.39)	(177.5)	(109.7)	(102.7)	(126.4)	(265.2)	(186.5)	(158.3)
distance to boundary	≤0.5mi	≤0.5mi	≤0.5mi	≤0.5mi	≤0.2mi	≤0.2mi	≤0.2mi	≤0.2mi
distance	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic	quadratic
boundary f.e.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
city f.e.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4450	2042	2417	4075	2328	1202	1243	2287

Standard errors in parentheses

$^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

all specifications control for the block being rural or urban

Table 2: Peer effects

	(1) std. math score	(2) std. math score	(3) std. math score	(4) std. math score
average peer income	0.00112	0.00116^{+}	0.00227**	0.00219**
	(0.000696)	(0.000695)	(0.000753)	(0.000780)
proportion black peers				-0.0365
				(0.0695)
changing controls	Yes	Yes	Yes	Yes
constant controls	No	Yes	Yes	Yes
school resources	No	No	Yes	Yes
school f.e.	Yes	Yes	Yes	Yes
year f.e.	Yes	Yes	Yes	Yes
grade f.e.	Yes	Yes	Yes	Yes
all f.e. interactions	Yes	Yes	Yes	Yes
Observations	70830	70830	61567	61567

Standard errors in parentheses

changing controls: lagged test score, free lunch, age, disability, English proficiency

constant controls: black, hispanic, female

school resources: log teacher pay, class size

$^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$