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The Impact of 1930s Maps of Mortgage Risk on Modern Home Ownership*

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Abstract: This research estimates long-term impacts of "redlining" maps on rates of home ownership. In the 1930s, the Home Owners' Loan Corporation drew maps that split US cities into zones with 4 categories of mortgage risk. We exploit the grade discontinuities at the borders between zones to estimate effects of the grade assignments. Using newly-created shapefiles for 1940 Census blocks in Birmingham, Alabama, we match 1940 and 2010 Census blocks in Birmingham to grades and then build small neighborhoods of blocks that are close together and lie along both sides of grade borders. We compare outcomes between higher- and lower-graded blocks within neighborhoods. 2010 Households in lower-graded blocks are significantly less likely to live in an owner-occupied dwelling than their neighbors a couple blocks away in a higher-graded zone. However, the same is true in 1940, suggesting that estimates from 2010 severely overstate the effect of treatment. Extending the 2010 analysis to all US cities produces even smaller differences than in Birmingham.

Keywords: Housing, HOLC, Redlining, Homeownership, Spatial discontinuity, Mortgage risk, Racism, Discrimination, Urban economics

JEL Codes: R31, R38, G21, N92, J15

1. INTRODUCTION

This research estimates long-term impacts of "redlining" maps on rates of home ownership. In the 1930s, The Home Owners' Loan Corporation (HOLC) drew maps that graded mortgage risk in zones of American cities from A ("Best") to D ("Hazardous"). We match 1940 and 2010 Census blocks to HOLC grades and then build small neighborhoods of blocks that are close together and lie along both sides of HOLC zone borders. We estimate impacts of HOLC grades on home ownership with variation within neighborhoods. Estimates for 1940 show that pre-treatment differences across HOLC grade boundaries were large even very close to those boundaries and, thus, suggest that spatial discontinuity methods often used in studies of redlining severely overestimate effects.

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HOLC grades likely measured many things including access to services, land quality, population density, age of buildings, physical beauty of the space, racial and cultural prejudices against residents, racial homogeneity, and more. We attempt to separate effects of ratings from effects of these other variables using a spatial discontinuity design. HOLC grades vary discontinuously across HOLC zone boundaries (for example, the grade jumps from C to B suddenly). If unobserved factors that impact outcomes vary continuously across HOLC zone boundaries, then effects of the grade could be estimated consistently by comparing outcomes arbitrarily close to the boundary.

However, it is not obvious that other factors would vary continuously over the boundaries. Thus, we compare differences in outcomes across boundaries in 2010 to differences in 1940. The maps were created from 1935 to 1940, so using 1940 as a comparison group assumes that the treatment had insufficient time to significantly alter housing patterns by 1940. This assumption is strengthened by the fact that the maps were for internal use only. We use 1940 because the Census did not publish data at the block level in 1930. We know of no existing geocoded maps of 1940 Census blocks, so we create our own. We geocode maps of 1940 Census blocks for Birmingham, Alabama, by hand and digitized tables of block-level data (U.S. Census Bureau, 1941).

A contribution of this research is that we use data at the Census block level. To our knowledge, this is the first redlining study to use pre-treatment data at the block level rather than the tract level. We also implement a novel method of grouping areas into neighborhoods. The newly-geocoded map of 1940 Census blocks may also be of general use to researchers.

Racial discrimination is an important part of the redlining literature and of historical lending practices. However, we do not attempt to discriminate effects due to racial prejudice from effects due to actual mortgage risk. Nor do we estimate effects of being denied a mortgage because of race. However, zones graded as higher risk were more likely than others to be majority Black or to have high concentrations of minority residents. Thus, if lower HOLC grades in the 1930s decrease rates of home ownership today, that is important for racial justice. Furthermore, to the extent that HOLC grade differences were due to racial prejudice, effect of those grades today can also be attributed to that prejudice.

It has been almost a century since the HOLC drew its infamous maps. Why would we see effects today? The most obvious way for effects to propagate from the 1930s to today is through the accumulation (or non-accumulation) of family and household wealth in the form owned property. We should expect to find effects today if the people who live in affected neighborhoods today are descended from families that lived in those neighborhoods in the past. However, that is not the only possible mechanism. Household wealth spills over into the surrounding community (for example, through peer effects in school). Households that move into the neighborhood benefit from these spillovers, increasing the probability that they, too, can purchase homes.[1]

[1] An interesting study might follow over time the households and families of people who lived near the borders between HOLC zones when the maps were in use. These households experienced a shock to their wealth in the 1930s that might persist as differences in the wealth of their descendants.

2. BACKGROUND ON THE HOLC AND REDLINING

The HOLC was a federal agency established in 1933 to expand home-buying opportunities through mortgage refinancing. Although the organization existed to improve opportunities for home ownership, there is some evidence that their practices systematically disadvantaged minorities. The HOLC drew maps that graded zones in US cities by mortgage risk. Lending practices based on these maps are often referred to as "redlining" because the lowest-rated zones were marked in red. These zones received less favorable treatment from the HOLC, the Federal Housing Administration (FHA), and private lenders. The term also gets used more generally for any practice of refusing services to persons due to the characteristics of the neighborhoods in which they reside.

The evidence for racial discrimination in HOLC and FHA practices is substantial. The 1938 FHA underwriting manual, for example, instructed FHA agents to consider adverse influences in their appraisal of a property; the adverse influences cited included surrounding neighborhoods that had "incompatible racial or social groups" (Federal Housing Administration, 1938, section 937). Notes written by HOLC auditors to justify their ratings also frequently cite the presence of undesirable racial and ethnic groups or immigrants. The notes on a neighborhood next to Birmingham-Southern College lauded the "proximity to schools, churches, parks, and community centers" before warning about "proximity to negro property on eastern and northern sides of area" (Nelson et al., 2023).

Existing research suggests that, in later decades, neighborhoods that were redlined experienced higher rates of racial segregation, crime, adverse health risks, and educational deficiencies and decreased home values and home ownership rates (Aaronson et al., 2021a,b; Anders, 2023; Appel and Nickerson, 2016; Asher, 2021). Scholarly discourse and public understanding often attribute these disparities to the HOLC (Fishback et al., 2024).

However, recent research questions whether lending companies actually referenced the HOLC maps to make decisions about loaning to a particular individual or whether the maps merely reflected preexisting trends in lending patterns (Fishback et al., 2024; Xu, 2022). Fishback et al. (2024) and Xu (2022), most notably, argue that the HOLC maps had little causal effect on long-term outcomes; instead, they attribute long-run disparities to practices by the FHA. To reach this conclusion, both Fishback et al. and Xu use unique data collection strategies to conduct their research, as the FHA destroyed almost all of their original records that described the locations in which they had insured mortgage loans (Fishback et al., 2024; Xu, 2022). Xu, for example, is a case study of Chicago, Illinois, as "this is only known available single-family mortgage map" created by the FHA (Xu, 2022, p. 250). The present research provides additional evidence that HOLC maps mostly reflected preexisting disparities.

3. DATA AND METHODS

Our methodology exploits the spatial discontinuity in treatment with HOLC grades at the boundaries between HOLC zones.

We first assign grades to blocks and then build small "neighborhoods" of blocks that contain blocks of different grades that are close together. We compare outcomes between areas with different HOLC grades within neighborhoods and aggregate those comparisons across neighborhoods.

Getting unbiased estimates of causal effects of HOLC grades requires that the placement of HOLC boundaries within neighborhoods is as good as random. In practical terms, though, the bias will be negligible if pretreatment factors vary continuously across the boundaries within neighborhoods and our neighborhoods are sufficiently small.

As a check on those conditions, we check for differences in outcomes across grade boundaries within neighborhoods around the time of treatment in 1940. If there are substantial pretreatment differences, we should not be confident that differences in later years are effects of treatment with HOLC grades. While it is tempting to subtract pretreatment differences from later differences and call that an estimate of the treatment effect, such a difference-in-differences approach is suspect. For example, if housing inequality increased in general over the 1900s, we would expect differences across boundaries to increase even without treatment with HOLC grades.

3.1. Outcome: Home ownership in Census block

We use three different samples of Census blocks: all 2010 blocks, 2010 blocks in Birmingham, Alabama, and 1940 blocks in Birmingham.

We construct "pre-treatment" measures with data at the block level from the 1940 Census. The Census published maps of blocks and corresponding tables of block-level data, and we copied the maps from a version digitized by Google and available through the HathiTrust Digital Library (U.S. Census Bureau, 1941). Due to the intensive nature and cost of manual geocoding, our 1940 data are limited to Birmingham, Alabama, which provides a case study for our research objectives. In contrast, our 2010 data encompass all U.S. cities that were rated by the HOLC. The completed geocoded map and the corresponding table of housing data are available in our online replication package.

The post-treatment sample uses data at the block level from the 2010 decennial Census Summary File 1 for 2010 (U.S. Census Bureau, 2010) accessed through IPUMS NHGIS (Manson et al., 2024). To aid in comparing the 2010 and 1940 data, we also perform the analyses using only the 2010 blocks that are in Birmingham. The area covered by Birmingham Census blocks in 1940 is smaller than the area of available blocks for 2010, but limiting the 2010 blocks to just the convex hull of 1940 blocks has a trivial impact on estimates, so we report results for all 2010 Birmingham blocks that can be assigned a grade and neighborhood.

The outcome measure is the proportion of households in a block that live in a home that is owned by a member of the household. Specifically, we divide the number of owner-occupied housing units in a block by the total number of occupied housing units in the block. A housing unit is a space that is intended as a separate living space. For example, an apartment is usually a housing unit, and an apartment complex contains multiple housing units. We drop from the sample any block with 0 reported residents.

3.2. Treatment: HOLC maps of mortgage risk

We combine the block-level Census data with geocoded versions of HOLC maps from the University of Richmond's "Mapping Inequality" database (Nelson et al., 2023). Mapping Inequality includes 7,499 HOLC zones in 152 US cities across 29 states. The HOLC gave each zone a grade: A "Best," B "Still Desirable," C "Definitely Declining," or D "Hazardous." We compare areas with A grades to areas with B grades, areas with B grades to areas with C grades, and areas with C grades to areas with D grades.

Approximately 10% of zones have some overlap with another zone. These areas of overlap are small relative to the areas of the zones. If the overlapping zones have the same grade, we combine them into a single zone. If they have different grades, we remove the area of overlap from both zones.

3.3. Assigning grades to blocks

For a block to be included in our sample, we need to assign an HOLC grade to it. If at least 80% of a block's area is contained within HOLC zones of a particular grade, the block gets that grade.[2] Otherwise, the block is removed from the sample.

3.4. Neighborhoods

Neighborhoods are specific to a Census year and pair of consecutive grades. In other words, we form neighborhoods and conduct the analysis separately for "A" versus "B", "B" versus "C", and "C" versus "D" grades. The process for grouping blocks into neighborhoods is the same for each grade pair, so we present only the process for "C"- and "D"-graded blocks for brevity.

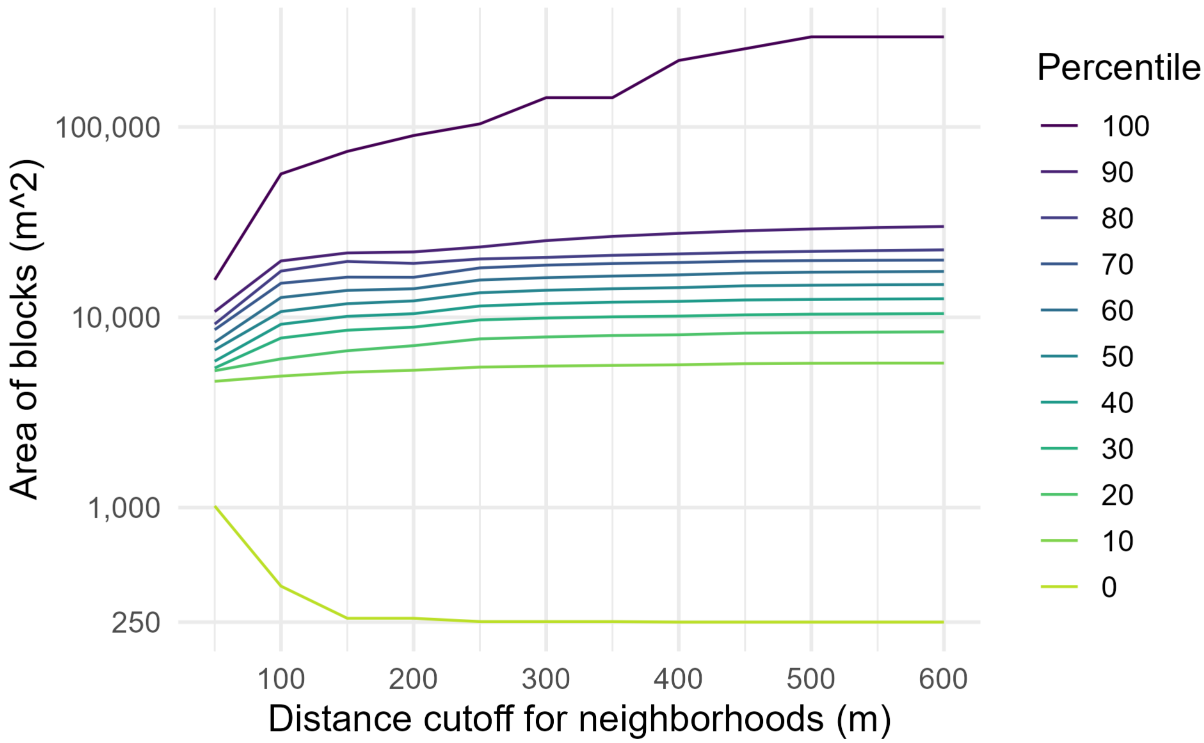
3.4.1. Distance between blocks

To form C-D neighborhoods, we start by finding the closest C block to each D block and the closest D block to each C block. For each possible pair of one C block and one D block, we calculate the maximum Hausdorff distance between them:

- For each point on the boundary of the C block, we find the distance to the closest point in the D block.
- For each point on the boundary of the D block, we find the distance to the closest point in the C block.
- The maximum Hausdorff distance is the greatest of these distances.

[2] This 80% overlap does not have to come from a single HOLC zone. For example, the HOLC could have drawn two C-graded zones close together, and a block that overlaps substantially with both would be included with a grade of C. However, census blocks are quite small relative to HOLC zones, so this is rare.

Figure 1: Distribution of block sizes in the 2010 B-C sample as a function of the distance cutoff for neighborhoods



The distance is small when every point in both blocks is close to some point in the other block. If the distance is greater than some cutoff, we drop that pairing. If a block has no remaining pairings, we drop it from the sample.

The distance cutoff is arbitrary, so we report results for cutoffs from 100 m to 600 m in 50 m intervals. Smaller cutoffs have the benefit of reducing bias due to factors that vary with distance to the boundary but reduce the number of data. Using smaller distance cutoffs also tends to drop larger blocks. This is good because non-residential blocks tend to be larger but bad because it likely makes the sample more urban. Figure 1 shows the distribution of block sizes in the 2010 B-C sample as a function of the distance cutoff. The A-B and C-D samples are similar. That tradeoff has questionable value at higher cutoffs and at very low cutoffs becomes a big problem. With a distance cutoff of 600 m, the median block size in our B-C sample is 14862.5 m^2. Suppose such blocks were squares in a grid. A rectangle of two blocks would have a maximum Hausdorff distance of 172.4 m. Other shapes and layouts usually increase that distance. If we set the distance cutoff to 150 m, these median-sized blocks get dropped from the sample.

Using the Hausdorff distance is also somewhat arbitrary. For example, we could use the minimum distance between any two points in the two blocks. Using the Hausdorff distance has the benefit of guaranteeing that everyone who lives in one block lives close to everyone in the other block.

3.4.2. Forming neighborhoods

Neighborhoods are groupings of blocks such that every block is in exactly 1 neighborhood, every C block has its closest D block in the same neighborhood, every D block has its closest C block in the same neighborhood, and the neighborhood cannot be split into two neighborhoods that meet the above conditions (i.e., neighborhoods are as small as possible).

We use the following algorithm to form neighborhoods.

- Randomly select one block ("initial block") and assign it to a neighborhood.
- The initial block becomes the "current block".
- Find the block of the opposite grade that is closest to the current block and assign it to the neighborhood.
- That closest block becomes the "current block" (if there are multiple, they all get processed as the current block in sequence).
- Find the closest block for the new current block and add it to the neighborhood.
- Continue assigning blocks to this neighborhood until the closest block is already assigned to the neighborhood.
- If, at any step, the closest block is already assigned to a different neighborhood, merge the neighborhoods.
- Randomly select an unassigned block and do the process again.
- Stop when all blocks are assigned.

We have not proved that there is only one possible set of neighborhoods, but applying the algorithm with three different random seeds produced identical neighborhoods.

Figure 2 maps 1940 Birmingham Census blocks over color-coded HOLC zones. The space in the middle with no HOLC grade is downtown Birmingham. The figure includes a popout detail that shows the set of blocks in that area that end up in our final C-D sample and the neighborhoods into which they are grouped. The thicker colored lines are neighborhood boundaries.

3.5. Alternatives

An alternative would be to start with pairs of C and D zones that touch and define a neighborhood as the set of blocks that are on the border between those zones. However, boundaries of grade zones are not nicely lined up with block edges. Thus, there is often not clearly a C block on one side and D block on the other. Rather, there might be a C block that straddles both sides of the boundary. It is possible that the HOLC's intent was to have zones end at the sorts of boundaries that make up block edges (like streets), but we would have to manually adjust the HOLC shapefiles to match this intent—a subjective process.

Figure 2: Map of 1940 Birmingham blocks and HOLC zones with a detail popout to show neighborhoods

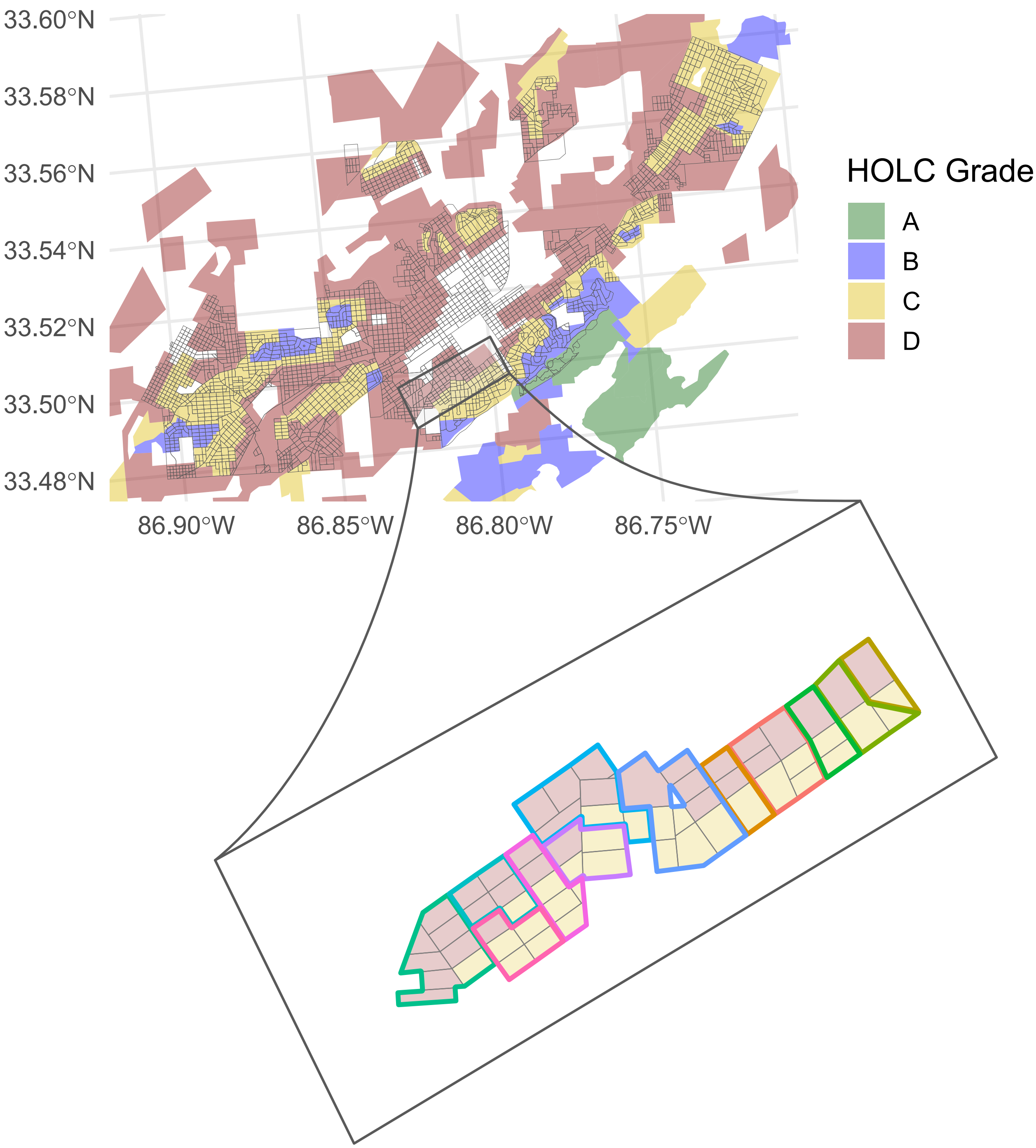


Table 1: Counts of households by sample with a distance cutoff of 500 meters

	Full 2010 sample	2010 Birmingham	1940 Birmingham
Blocks			
B vs A	24,276	89	20
C vs B	69,913	918	332
D vs C	69,410	2,172	1,138
Neighborhoods			
B vs A	3,005	11	5
C vs B	8,064	81	53
D vs C	7,540	201	183
Occupied housing units			
B vs A	624,370	1,497	495
C vs B	2,313,784	10,858	6,664
D vs C	2,158,342	18,161	22,894

We could get around the subjectivity by first assigning grades to blocks and then using the boundaries between groups of blocks of different grades to define neighborhoods. However, this can produce very large neighborhoods.

We could also pair blocks with their nearest neighbor. However, if block 2 is the nearest to block 1, it is often the case that block 1 is not the nearest to block 2. Furthermore, the fact that blocks are often laid out in grids means that a block will often have ties for nearest neighbor between multiple blocks. Our approach creates the smallest groupings such that every block is grouped with all of its nearest neighbors.

3.6. Sample counts

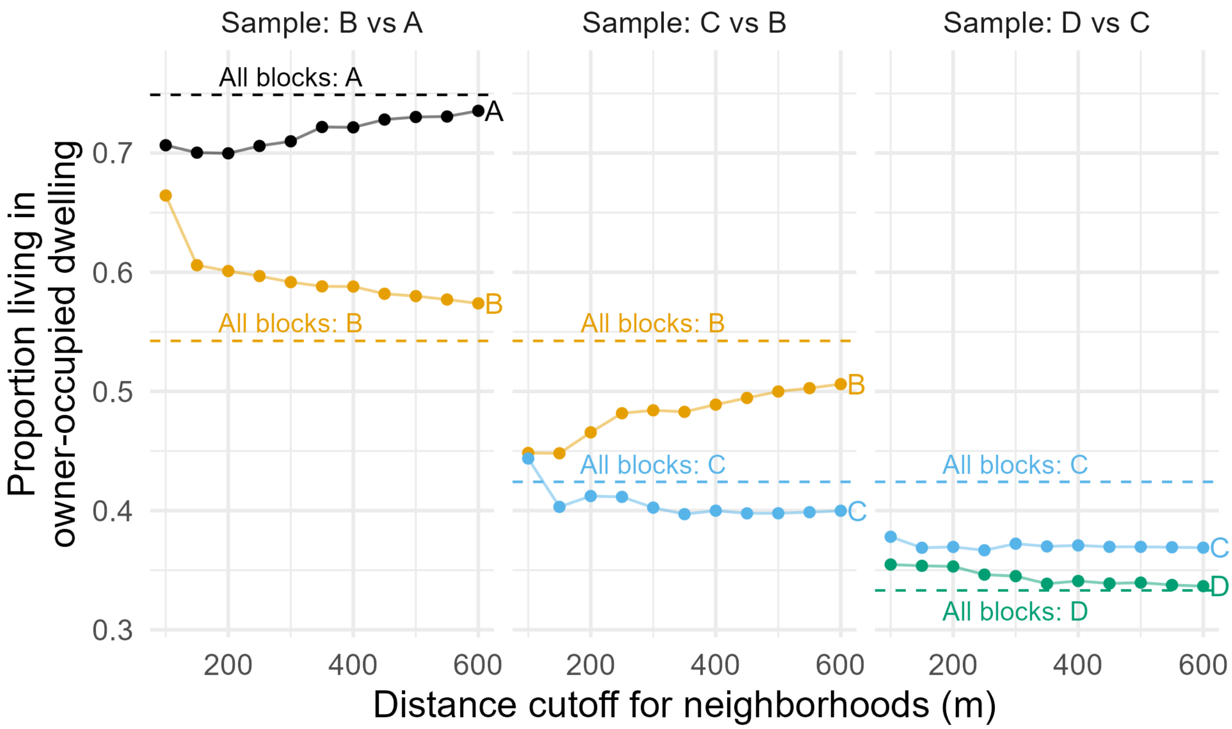
Table 1 gives counts of households, blocks, and neighborhoods in each of our samples (using a distance cutoff of 500 meters). There are few neighborhoods in the A-B comparison samples for Birmingham, so we omit reporting those estimates.

3.7. Typical levels of home ownership

Figure 3 shows the proportion of households in each of our nationwide 2010 samples that lived in an owner-occupied dwelling as attached points. Horizontal dashed lines are proportions within the full set of blocks that were assigned a grade regardless of whether they were close enough to other blocks to make it into a neighborhood sample.

How representative are our neighborhood samples? In most cases, the rates of home ownership in our samples become more similar to the rates in all graded blocks as we use a larger distance cutoff. All else equal, we would like our samples to be representative of the set of all blocks, but our spatial discontinuity design means we estimate partial effects within the sets of blocks near HOLC boundaries, which may not be representative of all blocks. Differences between blocks that received an HOLC grade (mostly urban) and blocks that

Figure 3: Proportion of 2010 USA households living in an owner-occupied dwelling by neighborhood distance cutoff



Notes: Horizontal dashed lines are proportions within the full set of blocks that were assigned a grade regardless of whether they were close enough to other blocks to make it into a sample.

never got HOLC ratings (mostly rural) may be even more important than the differences shown here between our final samples and the set of all graded blocks

For a given sample, the rates of home ownership tend to fall between the rates for the relevant grades within the full set of blocks. As we might expect, B-graded blocks that are close to A-graded blocks (first panel) have higher rates of home ownership than B-graded blocks do overall. On the other hand, being close to C-graded blocks (second panel) drives down the rates of home ownership among B-graded blocks. Surprisingly, the middle panel shows that people in C-graded blocks near B-graded blocks are actually slightly *less* likely to live in an owned home than people in other C-graded blocks. This result deserves additional study.

Note that the values in Figure 3 are aggregates across all cities in the sample. Our estimates below instead compare home ownership only *within* neighborhoods.

3.8. Estimation procedure

Using the block-level data, we regress the outcome (the proportion of occupied housing units that are owner-occupied) on an indicator for having the lower grade (e.g. D for a C-D comparison) and fixed effects for neighborhood. Observations are weighted by the number of occupied housing units in the block. Standard errors are "clustered" by neighborhood (corrected for arbitrary correlation of errors within neighborhoods).

In addition to the clustered standard errors, we tested a randomization inference procedure that approximates the sampling distribution of the estimator under the null hypothesis that HOLC grade has no effect and assuming that HOLC grade was randomly assigned to blocks within neighborhoods. We do not report the results of these simulations because there is no substantive difference between the p-values calculated from such simulations and those implied by the estimates we report below.

4. RESULTS

4.1. Full 2010 sample

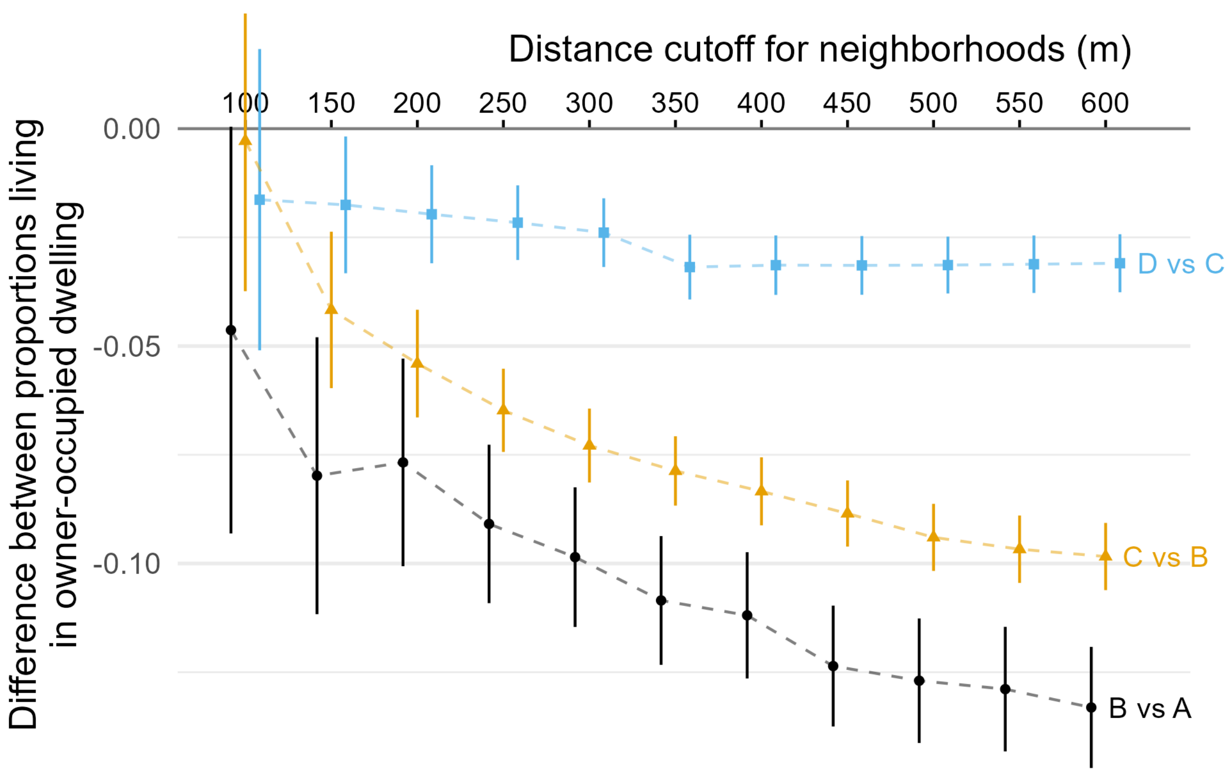
The estimates for the full 2010 sample are in Figure 4, which also demonstrates how the estimates differ with the distance cutoff for neighborhoods. Vertical bars are 95% confidence intervals using standard errors clustered at the neighborhood level.

Take the third triangle-shaped point from the left, for example (in the "C vs B" group). This point says that when we construct neighborhoods with the distance cutoff of 200 m, households in C-graded blocks are about 5 percentage points less likely to live in an owner-occupied dwelling than people in B-graded blocks in the same neighborhood.

4.2. Birmingham in 1940 and 2010

Estimates for just Birmingham in 1940 and 2010 are in Figures 5 and 6, respectively. Vertical bars are 95% confidence intervals using standard errors clustered at the neighborhood level. Birmingham has few A-graded blocks and few A-B neighborhoods, so we omit the noisy A-B

Figure 4: 2010 USA: Regression estimates of effects of living in a lower-grade neighborhood on home ownership by neighborhood distance cutoff



Notes: Vertical bars are 95% confidence intervals using standard errors clustered at the neighborhood level. Sample: all 2010 blocks.

Figure 5: Birmingham 1940: Regression estimates of effects of living in a lower-grade neighborhood on home ownership by neighborhood distance cutoff

Notes: Vertical bars are 95% confidence intervals using standard errors clustered at the neighborhood level. Sample: blocks in Birmingham in 1940.

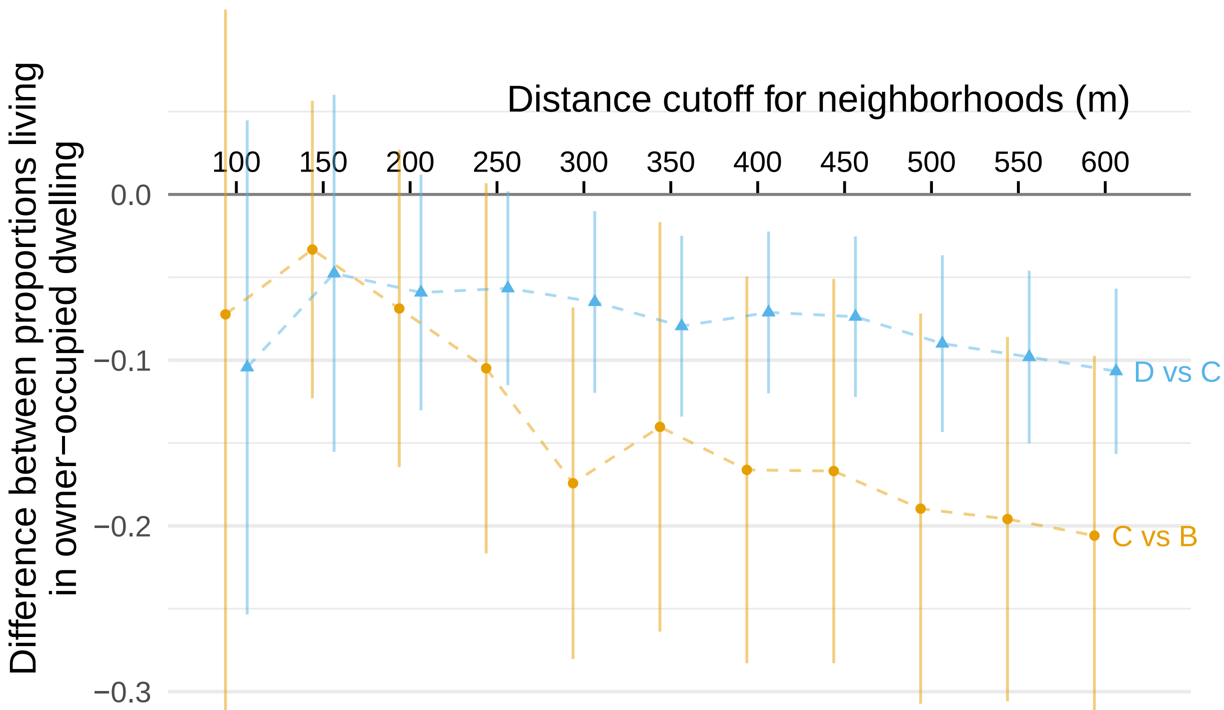
comparisons from the figures. The omitted point estimates are negative and much larger in magnitude than those for the other grade pairs. Note that the vertical axis range is larger than in Figure 4.

5. DISCUSSION

This study compares rates of home ownership in areas that received lower grades from the HOLC to nearby areas that received higher grades. Estimates using the full 2010 sample are negative as expected. Among people living today near the boundaries between regions given different grades by the HOLC, people on the lower-ranked side are less likely to live in a resident-owned home than their neighbors on the other side of the boundary are. Like Aaronson et al. (2021a) and Aaronson et al. (2021b), we find larger differences between higher-rated areas (e.g. C versus B) than between lower-rated areas (D versus C). We estimate substantial differences between 2 and 13 percentage points.

However, we also find large "pretreatment" differences in outcomes in 1940 Birmingham. Households living in a lower-graded block in 1940 were about 10 percentage points less likely to live in an owner-occupied home than their close neighbors in a block with the next higher grade. This fact undermines the argument for using a spatial discontinuity design: either

Figure 6: Birmingham 2010: Regression estimates of effects of living in a lower-grade neighborhood on home ownership by neighborhood distance cutoff



Notes: Vertical bars are 95% confidence intervals using standard errors clustered at the neighborhood level. Sample: blocks in Birmingham in 2010.

pretreatment differences between regions with different grades do not vary continuously over the grade boundaries or a Census block is not a sufficiently small bandwidth for the discontinuity analysis. Further research could use a smaller bandwidth by using data at the residence level.

More fundamentally, future research might be more useful by focusing on the outcomes experienced by people who lived in neighborhoods that received different grades (and their descendants) rather than on long-term differences between neighborhoods.

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