Pockets of Poverty: The Long-Term Effects of Redlining

Ian Appel* Jordan Nickerson†

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This paper studies the long-term effects of redlining policies that restricted access to credit in urban communities. For empirical identification, we use a regression discontinuity design that exploits boundaries from maps created by the Home Owners Loan Corporation (HOLC) in 1940. We find that "redlined" neighborhoods have 4.8% lower home prices in 1990 relative to adjacent areas. This finding is robust to the exclusion of boundaries that coincide with the physical features of cities (e.g., rivers, landmarks). Moreover, we show that housing characteristics varied smoothly at the boundaries when the maps were created. Evidence suggests lower property values may be driven by negative externalities associated with fewer owner-occupied homes and more vacant structures. Overall, our results indicate the effects of discriminatory credit rationing can persist decades after such practices are formally discontinued.

JEL Classification: E5, N3, R2, R31

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*Boston College, Carroll School of Management, 140 Commonwealth Avenue, Chestnut Hill, MA 02467; telephone: (617)552-1459. E-mail: Ian.Appel@bc.edu

†Boston College, Carroll School of Management, 140 Commonwealth Avenue, Chestnut Hill, MA 02467; telephone: (617)552-2847. E-mail: Jordan.Nickerson@bc.edu

History is rife with examples of discriminatory practices intended to limit access to finance. A particularly notorious case was credit rationing in US housing markets. Throughout much of the 20th century, both private lenders and federal agencies limited the availability of mortgage credit to racial and ethnic minorities. Such practices, which potentially reflect the preferences of intermediaries (Becker (1957)) or information asymmetry (Arrow (1973); Phelps (1972)), were eventually outlawed in the 1960s. Yet, many view discriminatory credit rationing as a fundamental cause of urban decay and disparate economic outcomes that exist today.[1]

Despite widespread speculation, little empirical evidence exists on the effects of discriminatory credit rationing. In this paper, we study the long-term consequences of redlining, the systematic restriction of mortgage credit to geographic areas. The effects of this practice are theoretically ambiguous. For example, redlining by some lenders may not affect aggregate credit availability of targeted areas if others increase supply in response to unmet demand. However, the equilibrium supply of credit may be reduced if redlining increases the uncertainty regarding house prices due to fewer past transactions (Lang and Nakamura (1993)). Redlining may also be economically rational if intermediaries can distinguish between the riskiness of groups but not individuals within them (Stiglitz and Weiss (1981)). In this case, differential lending behavior may decrease the value of pledgeable collateral used in future transactions or lead to changes in neighborhood characteristics that impose negative externalities (e.g., condition of the housing stock). Our goal is to test whether such local distortions persist over time and explain differences between neighborhoods decades after redlining was outlawed.

Our empirical setting uses neighborhood classifications from the residential security maps

1. In 2008, President Obama stated, "Legalized discrimination—where blacks were prevented, often through violence, from owning property, or loans were not granted to African American business owners, or black homeowners could not access FHA mortgages helps explain the wealth and income gap between black and white, and the concentrated pockets of poverty that persists in so many of today's urban and rural communities."

developed by the Home Owners Loan Corporation (HOLC), a Depression era government agency. These maps, which were completed in 1940, classify neighborhoods in major U.S. cities into four categories based on credit risk, the worst of which are shaded red. The race and ethnicity of residents played an important role in determining neighborhood ratings; Schill and Wachter (1995) note that areas with even a small minority population were generally deemed riskiest. Historical accounts indicate HOLC maps institutionalized redlining and may have influenced the practices of both the Federal Housing Administration (FHA) and private lenders (Jackson (1980)). This, in turn, led to significant disparity in mortgage markets in the decades following the Great Depression. For example, of the 2.7 million FHA-insured loans between 1935 and 1950, just 50,000 went to African Americans, half of which were under a military housing program (Commission on Civil Rights (1959)).

Studying the long-term effects of redlining poses an empirical challenge as HOLC ratings were not randomly assigned. Indeed, 1940 characteristics for neighborhoods with relatively low ratings differ considerably from those with higher ratings along a number of dimensions (e.g., minority population, house values, etc.). To address this challenge, we use a geographic regression discontinuity design (RDD) around the boundaries on the residential security maps. Specifically, we consider adjacent areas with different HOLC ratings that are located within a small distance (250–1000 meters) from the separating boundaries. Our identification assumption requires that unobservable neighborhood characteristics varied continuously around the boundaries when the HOLC maps were created. Anecdotal evidence supports this assumption. For example, Hillier (2005) notes that the boundaries did not correspond with administrative borders (e.g., wards or census tracts). Moreover, the classification of neighborhoods occurs at a relatively coarse level, and the maps often underwent several revisions, suggesting some disagreement over the precise location of neighborhood boundaries (Hillier (2005)). Nevertheless, we also conduct a number of empirical tests to rule out potential confounding factors.

Our results indicate redlining has long-term effects on neighborhoods that persist decades after such policies were banned. Specifically, we find 1990 house prices at the census block level are approximately 5% lower for neighborhoods with worse HOLC ratings relative to adjacent areas. This relative differential corresponds to a loss of approximately $7,500 per household, and the magnitude is consistent across the 250, 500, and 1000 meter bandwidths around the boundaries. Moreover, this finding is robust to the exclusion of boundaries that coincide with rivers, railways, and other landmarks, indicating the result is not driven by these potentially confounding geographic factors.

We next turn attention to initial neighborhood characteristics that potentially explain the relative differences in 1990 home values. This analysis uses block-level data from the 1940 census. While reduced form analysis indicates stark differences between the areas assigned the highest and lowest HOLC ratings, we find little evidence of discontinuities in neighborhood characteristics around the HOLC boundaries. Specifically, there are not statistically or economically significant discontinuities in relative 1940 home values, racial composition, households per structure, vacancy rates, or the percentage of homes that are in disrepair across the different bandwidths. These findings are consistent with the identifying assumption that treatment status discretely changes around the threshold while other characteristics vary smoothly.

We also conduct cross-sectional tests to examine how the effect of credit rationing varies with the intensity of credit demanded across cities. We hypothesize the effects of redlining are more pronounced for cities with high-demand for housing in the years before the practice was banned, and relatively muted for cities with high-demand for housing in the following years. Using state-level home price growth as a proxy for demand, we find results broadly consistent with these hypotheses. Specifically, the point estimates for cities with high housing demand from 1940 to 1960 are roughly double those with low demand. Conversely, point estimates for cities with high housing demand between 1960 and 1990 are about half the magnitude of those with low demand. Overall, these results provide additional support for our interpretation of the findings and also shed light on one reason for varying levels of long-term effects of redlining across different cities.

Finally, we examine other block-level 1990 neighborhood characteristics around the HOLC thresholds to provide evidence of the mechanism underlying this change in home prices. We first document that redlined areas have 5-7% more vacant homes, consistent with disinvestment from inner-cities leading to a deterioration of the housing stock. In addition, owner-occupied housing is lower by 3.3%, indicating an increase in the propensity to rent in redlined areas. Both of these changes in *neighborhood* characteristics impose negative externalities and potentially explain, at least in part, the drop in home prices. We do not, however, find changes in the characteristics of the *residents* which could potentially explain lower prices. Specifically, there is no difference in the racial composition of redlined areas, which could lead to "tipping points" (Card et al. (2008)), nor is there a difference in overcrowding, which potentially serves proxy for resident wealth.

Our work is related to a number of strands of literature. Broadly speaking, we contribute to the literature on the economics of discrimination. This line of literature seeks to understand disparate economic outcomes resulting from race, sex, and other characteristics. Becker (1957) proposes a preference-based model of discrimination in which agents are willing to forego a benefit in order to cater to certain groups. In contrast, Phelps (1972) and Arrow (1973) model statistical discrimination in which characteristics of groups are used to address information asymmetry problems and infer information about individuals. The subsequent literature has documented evidence of discrimination in a variety of contexts, including labor markets (Bertrand and Mullainathan (2004)), car sales (Ayres and Siegelman (1995)), and basketball referees (Price and Wolfers (2010)).

The role of discrimination in explaining disparate access to credit, however, is a long-standing controversy. Munnell et al. (1996) find that race plays an important role in the extension of mortgage credit to individuals, though this conclusion has been subject to considerable debate (Ladd (1998)). Other papers find little evidence of banks discriminating based on neighborhood characteristics after redlining was outlawed (e.g., Holmes and Horvitz

(1994); Tootell (1996)). In addition, Lang and Nakamura (1993) develop a theoretical model of redlining in which reductions in mortgage credit are self-perpetuating due to an information externality stemming from fewer past transactions. Our contribution to this literature is twofold. First, to the best of our knowledge, this paper is the first comprehensive analysis of redlining practices initiated by the federal government. Second, in contrast to other works which documents discrimination in credit markets, we instead focus on the long-term effects of discriminatory credit rationing. Our results indicate that the negative effects of such policies affect home prices and other characteristics of neighborhoods decades after they are discontinued.

This paper also contributes to the urban economics literature. Several papers in this literature shed light on the dynamics of home values within cities. Guerrieri et al. (2013) develop a model of endogenous gentrification and argue the poor neighborhoods bordering rich ones have the highest price elasticity in response to positive demand shocks. Landvoigt et al. (2015) find that cheap credit disproportionately affects home prices at the low end of the market. Other papers have explored differences in neighborhood home values based on targeted government policies (e.g., Busso et al. (2013)), housing stock (Rosenthal (2008)), and racial composition (Harris (1999)). We contribute to this line of literature by highlighting the role of historical credit rationing in explaining differences in property values across neighborhoods.

Finally, we contribute to the literature on the long-term effects of historic institutions pioneered by Porta et al. (1997) and Acemoglu et al. (2001) among others. Recent work in this area has studied long-term effects of financial institutions. For example, Pascali (2016) documents persistence in the banking development of Italian cities resulting from the Catholic church's usury ban during the Renaissance, and Brown et al. (2016) show that childhood exposure to developed credit markets on Native American reservations leads to improved financial outcomes later in life. Our paper also relates to studies of the long-term effects of discrimination. D'Acunto et al. (2015) find present-day German households located in areas with more historical Jewish persecution access fewer financial services.

I. Background

I.A. The origins and construction of HOLC maps

The creation of the HOLC in 1933 was one of the main policy responses to the foreclosure crisis during the Great Depression.[2] The HOLC was a publicly-financed "bad bank" that wrote new loans on 10% of owner-occupied homes in the U.S. over the course of just two years (Snowden (2010)). In doing so, the agency introduced a number of innovations to mortgage markets, including longer terms (15 years), fully amortized loans, and uniform appraisal standards (Schill and Wachter (1995)). In the pursuit of consistent appraisal standards, the HOLC was tasked with creating appraisal maps by the Federal Home Loan Bank Board (FHLBB), its parent agency.

HOLC assessments were rooted in the idea that the decline of urban neighborhoods is inevitable. This theory, popularized by FHA chief economist Homer Hoyt, argues that the wealthy migrate out of cities over time, leaving inner-cities inhabited by racial and ethnic minorities and causing home prices to drop (Hillier (2003)). HOLC's residential security maps institutionalized this ecological theory of urban neighborhoods. The maps classify neighborhoods into four categories of descending quality: A (green), B (blue), C (yellow), and D (red).

While neighborhood classifications accounted for a variety of factors including the age of its housing stock and distance from industrial areas, two of the chief determinants were the race and ethnicity of its inhabitants (Hillier (2005)). Green areas were, according to HOLC assessments, the most desirable neighborhoods. Such areas were characterized by their relatively new housing stock and "homogeneous" (i.e., white, upper class, and native-born) populations. In addition, such areas were often separated by "geographical, social, and eco-

2. See Wheelock (2008) for an overview of the mortgage market during the Depression and actions taken to address the wave of foreclosures.

nomic boundary lines" so as to "preserve the unity and quality of a neighborhood" (FHLBB (1936)). Blue regions shared many qualities with their green counterparts. However, such areas were in risk of decline over time due to "encroachment of business or infiltration of a less desirable class of people."[3] Yellow and red regions were the least desirable regions according to HOLC assessments. Yellow coded neighborhoods were "definitely declining" and exhibited a "trend in type of population to a lower grade." Red regions were deemed "hazardous" and a "good mortgage man would probably not consider any loans at all" (FHLBB (1936)). Schill and Wachter (1995) note that areas with even a small black population were generally given this lowest rating.

HOLC assessments contained information on the class/occupation of residents, racial and immigrant makeup, typical home characteristics, and the current and projected value of housing in the neighborhood. Figure 1 provides two examples of such reports from Akron, Ohio. Panel A provides the report for a neighborhood located in a northern suburb of the city. The assessment notes that the neighborhood consists primarily of executives and professionals. Furthermore, there are no racial or ethnic minorities, and the housing stock is relatively new and "highly restricted" due to its location near a lake. The expected trend is upwards for this neighborhood, and it was assigned the top grade. Panel B provides a report for a neighborhood in downtown Akron. This neighborhood was located near a rubber plant and was inhabited primarily by laborers. The consideration of race and ethnicity in HOLC assessments is evident. The report notes that the neighborhood was populated by "low class Jews" and the "present heavy negro encroachment [is] gradually increasing." The HOLC assigned this neighborhood a *D* rating.

Figure 2 provides an example of a residential security map from the Bronx borough of New York City. Three features of this map are of particular note and generalize to other maps in the sample. First, the significant white areas in the map indicate industrial/commercial areas, undeveloped land, waterways, or landmarks (e.g., Yankee Stadium, Fordham Univer-

3. Language used in HOLC guidelines and assessments is at times offensive. We quote it here to provide the historical context for our empirical setting.

sity, and public parks). Second, consistent with the area descriptions provided above, the highest rated areas on the western part of the borough are largely secluded, bordered by a park to the East and the Hudson River to the West. However, there are also instances (B10 and B11) of highly rated neighborhoods in the interior of the borough. Third, the classification of housing stock into grades occurs at a relatively coarse level, with boundary edges extending for considerable distances and largely determined by major thoroughfares. This final feature is crucial for the identification strategy used in this paper.

[INSERT FIGURE 2 HERE]

I.B. The use of HOLC maps

Despite the fact that the HOLC constructed the residential security maps, evidence suggests that they were not used by the agency in its own lending program. This is evident from the timing of when the maps were made: the HOLC completed the bulk of its mortgage relief efforts between August 1933 and June 1936, yet the maps were commissioned in 1936 and not completed until 1940. Furthermore, analysis of HOLC loans suggests the agency did not engage in redlining. If anything, HOLC loans disproportionately targeted areas with higher minority populations (Hillier (2003)). This fact, however, does not necessarily indicate that the HOLC did not discriminate; the agency engaged in "racial steering" (targeted towards individuals) when reselling foreclosed HOLC properties (Hillier (2003)).

The effect of the HOLC maps, if any, was therefore likely a result of its influence on other entities. While the HOLC was a temporary intervention during the 1930s, the Federal Home Administration (FHA) was intended to offer longer term solutions by fundamentally reshaping the mortgage market. This agency, authorized by the National Housing Act of 1934, offered mortgage insurance to incentive lending by private institutions. In fact, the FHA was granted a virtual monopoly in the mortgage insurance market as loans insured by the agency (but not private insurers) were exempt from federal and state safety-and-soundness regulations. For example, in 1939 loans in Connecticut were required to have a loan-to-value (LTV) ratio of 90% if insured by FHA and 66.7% if not. In some states (e.g., New York) private mortgage was banned altogether in the 1930s (Gordon (2005)).

While the FHA achieved significant success in increasing the level of home ownership in the US, its discriminatory policies are well documented (Jackson (1980); Gordon (2005)). As part of the underwriting process, FHA agents evaluated neighborhoods along eight weighted dimensions.[4] Jackson (1980) notes that the two largest factors (i.e., relative economic stability and protection from adverse influences) were "interpreted in ways that were prejudicial against heterogeneous environments." Moreover, the FHA Manual (1936) explicitly warned of "lower class occupancy and inharmonious racial groups."

Evidence suggests FHA policies were influenced by the HOLC neighborhood appraisals and, according to Jackson (1980), "perhaps the maps themselves."[5] Historians agree that the HOLC provided copies of its maps to the FHA as well as other government agencies (Hillier (2003)). The FHA maps used the same classification system as the HOLC– neighborhoods labeled *A*, *B*, *C*, or *D* in descending order of desirability (FHA Manual, 1938). Schill and Wachter (1995) note the FHA "emulated HOLC guidelines and discouraged lending in areas where blacks lived." Jackson (1980) writes that "the FHA cooperated with the HOLC and followed HOLC appraisal practices," and observes that 80% of FHA loans were issued to homes on outskirts of cities and suburbs, areas which were often given *A* or *B* ratings on the maps.

HOLC maps may also have influenced the actions of private mortgage lenders. To assist in the classification of neighborhoods, the HOLC consulted local realtors and bankers in each city. For example, in Los Angeles, 26 realtors assisted the agency in constructing its map (Hillier (2005)), and in Brooklyn the agency consulted representatives from at least 9 local financial institutions (Jaffe and Lautin (2014)). The maps were not made publicly available,

4. Relative economic stability (40%), protection from adverse influences (20%), freedom from special hazards (5%), adequacy of civic, social, and commercial centers (5%), adequacy of transportation (10%), sufficiency of utilities and conveniences (5%), level of taxes and special assessments (5%), appeal (10%)

5. Similar conclusions regarding the use of HOLC maps are reached by Dickerson (2016) and Gordon (2005), among others.

however, and the extent to which private sector lenders knew about them is debated by historians. Jackson (1980) notes than the results of a FHLBB survey asking bankers the most desirable areas to lend often returned answers such as "*A* and *B*" or "blue," while the least desirable areas returned answers such as "red and most yellow." Hillier (2003) argues that such answers may have reflected shorthand used by FHLBB employees conducting the interviews. In addition, there are anecdotes of real estate professionals seeking access to the maps, suggesting they contained valuable information.[6]

The practice of redlining proceeded relatively unencumbered for over two decades after the Great Depression. In 1962, President Kennedy issued an executive order that banned redlining by federal agencies.[7] The Fair Housing Act of 1968, part of the Civil Rights Act, banned housing discrimination on the basis of race, religion, national origin, or sex. Further reforms were made by the Equal Credit Opportunity Act (1974), Home Mortgage Disclosure Act (1975), and Community Reinvestment Act (1977). Yet, by many accounts, the effects of redlining were already entrenched in inner-cities by this time. Schill and Wachter (1995) note that such effects include economic disparities between urban and suburban neighborhoods, racial segregation in cities, and divestment and lower property values in predominately minority neighborhoods.

II. Data & Empirical Methodology

We obtain data from multiple sources regarding HOLC lending maps and housing characteristics. We briefly describe each data source.

6. Hillier (2003) provides the example of a letter from the business manager of the Chicago Real Estate Board to an HOLC official stating "Incidentally. . . I hope to be able to 'borrow' a map from your portfolio when you are not looking during your journey in Chicago."

7. Gordon (2005) notes that this led to dramatic changes in FHA policies. While just 2.5% of FHA loans went to non-whites in 1960, this increased to 12.5% in 1970 and 19.8% in 1980.

II.A. Data Description

To begin, we hand collect all availble residential security maps commissioned by the HOLC. The result is 58 maps which represent 48 unique MSAs. However, these historical maps do not include identifying information with respect to a geographic coordinate system. Therefore, we next georeference each map using a first order polynomial transformation and between six to nine control points consisting of street intersections and/or historical landmarks. Finally, we manually digitize each map by tracing the boundaries for every HOLC security lending region using geographic information system software (QGIS). The result is a collection polygon shapefiles containing the full set of latitude and longitude coordinates needed to characterize each HOLC lending region. The coded regions cover a collective area of 5,930 km^2.

The power of this study hinges on the ability to observe housing characteristics at a granular level, both historically as well as more recently. Ideally, this includes a snapshot of housing characteristics taken when the HOLC maps were commissioned. As such records do not exist, we turn to the 16^{th} Census of the United States which was taken in 1940. Specifically, we rely on the *Block Statistics Supplement to the First Series Housing Bulletin* which reports housing characteristics for all major cities at the census block-level (generally corresponding to a city block). The characteristics include the average monthly rent, as well as the percent of housing units segmented by vacancy status, tenant versus owner-occupied, head-of-household ethnicity, and state of disrepair. Furthermore, the reporting of rental rates does not restrict our sample to only tenant-occupied households. Instead, in the 1940 census a rental rate was estimated for owner-occupied households and were thus included in the statistic. Unfortunately, these records are not readily accessible in digital form. To this end, we first apply a custom OCR system specifically designed to exploit the format of the census records. Next, we hand verify any observations failing a cross-validation process using Mechanical Turk. The end result is a sample of more than 190,000 census block-level observations gathered from 2,325 census pages.

While this dataset contains housing characteristics, it does not contain geographic information for the census blocks, which we must collect separately. To do this, we first georeference 628 map images from the 1940 census in a similar manner to the HOLC maps. Each map depicts the relative location of roughly 350 census blocks. Thus, as a final step we record the relative location of each of our 190,000 census blocks on their respective map which we then convert to a latitude/longitude pair.

For data on housing characteristics from the recent period we rely on the 21st Census of the United States, taken in 1990. While there have been two additional census taken since, they do not contain housing characteristics of interest at the census block level. Fortunately, the path to obtaining usable data on housing characteristics in the 1990 census is relatively painless. We obtain a digital copy of both the block-level housing characteristics and the associated geographic information from the NHGIS, which is maintained by the Minnesota Population Center.

II.B. Summary Statistics

While the census data consists of all blocks within their respective city limits, our interest lies in the effect of the classification of neighborhoods by the HOLC. Therefore, we restrict our sample to census blocks that fall within an HOLC region. Following this restriction, the final sample consists of over 130,000 blocks for 1940 and over 217,000 blocks for 1990. The different number of observations reflects a change to the average size of a census block over time, not a change in the geographic area covered.

Panel A of Table 1 reports summary statistics for the full sample. Home values for 1990, the primary outcome of interest for this study, average $119k. While the 1940 Census does not provide information on home values, the average estimated rent was $34.51, or about $322 in 1990 dollars. There are, however, several directly comparable neighborhood characteristics for 1940 and 1990. Of particular note, the mean percentage of non-white residents increased by over 30 percentage points (6.3% to 40.7%), consistent with previous work documenting migration patterns in the twentieth century (e.g., Boustan (2010)). In addition, average vacancy rates increased by nearly 7 percentage points, and the number of households per structure doubled. In contrast, the percentage of overcrowded households is approximately equal during the two periods.

[INSERT TABLE 1 HERE]

Panel B of Table 1 provides average characteristics across HOLC ratings. The average rent in 1940 for *A*-rated areas was $70, about triple that of homes in *D*-rated areas. Levels of non-white residents are low (about 1%) across the top 3 grades, before increasing to 17.7% in *D*-rated areas. The percentage of homes with overcrowding and in disrepair are both inversely related to HOLC grades, but there is not a strong relationship for vacancy rates or households per structure in the 1940 data. The monotonic relationship between HOLC grades and home values remains in 1990. The average home value for *A*-rated neighborhoods was $230k compared to $136k, $107k and $89k for *B*, *C*, and *D* neighborhoods, respectively. The percentage of non-white residents is inversely rated to rating, though as mentioned above minority populations increased significantly across all categories relative to 1940. In fact, the minority population in *A*-rated areas in 1990 is approximately equal to that for *D*-rated areas in 1940. As with the 1940 data, there is an inverse relationship between HOLC grade and households per structure, but in contrast to the earlier period a similar relationship also exists for vacancies. Finally, there is a positive relationship between rating and the percentage of homes that are owner-occupied.

III. Empirical Methodology

The endogenous classification of neighborhoods by the HOLC makes it difficult to identify the effect of the agency's lending policy on future outcomes. Thus, we exploit geographic discontinuities that exist at the border between adjacent regions to draw causal inferences. The approach we outline below is similar to that of Dell (2010), who uses a regression discontinuity design based on historical geographic boundaries.

A traditional regression discontinuity design exploits discrete jumps in a policy function at specific thresholds in the forcing variable. In our empirical setting, these policy responses correspond to the different HOLC lending grades while the forcing variable is represented by the Euclidean distance to the boundary between adjacent HOLC regions. However, given the two-dimensional nature of our setting and the four HOLC regions, care must be taken when constructing the distance to a boundary. Figure 3 provides an illustration of this process.

[INSERT FIGURE 3 HERE]

The figure depicts four census blocks (A, B, C, D), which fall into three unique HOLC regions (red, yellow, and green). For each block, we first determine which HOLC region the block falls within.[8] We then set the magnitude of the forcing variable, *dist*, equal to the length in meters from the census block's centroid to the nearest HOLC region of a different grade.[9] The sign of *dist* is determined by the change in credit worthiness between the adjacent HOLC credit grades. Census blocks falling within a less credit worthy region relative to the adjacent region take on a negative value.

In the figure, the distance of block A, $dist_A$, is constructed as the length in meters to the yellow region and takes on a negative value. For all blocks which fall within the yellow region, the dashed line represents a shift in the classification scheme. Any point falling on the left of the dashed line (block B) is closer to the red region. These points are measured relative to this red/yellow boundary and take on positive values. In contrast, all points falling to the right of the dashed line (block C) are measured relative to the yellow/green boundary and take on negative values. Finally, a second variable is computed for each census block, *Region Comparison*. This variable identifies which region boundary the block's distance is computed relative to, and is denoted by the lesser of the adjacent HOLC regions with respect to credit worthiness.

8. We exclude any census blocks which fall outside of an HOLC region.

9. In all distance computations, we use the World Geodetic System 1984 (WGS84) with the longitudinal zone determined by the census block's centroid.

Following the construction of $dist$ for each census block, we estimate the causal effect of HOLC lending practices with the following:

$$Y_i = \alpha + \beta \mathbb{1}(dist_i < 0) + \sum_{n=1}^{N} \theta_n dist_i^n + \mathbb{1}(dist_i < 0) \times \sum_{n=1}^{N} \gamma_n dist_i^n + \phi_j + \varepsilon_i \tag{1}$$

where Y_i is the outcome of interest. In this specification β represents the change in the outcome variable due to a discrete change in the HOLC lending policy. We control for continuous changes in the outcome variable due to changes in the forcing variable ($dist$) with a N degree polynomial estimated separately for each side of the threshold. Finally, we include fixed effects for each value of $RegionComparison$, ϕ_j, to allow for average levels of the outcome variable to differ across the different boundaries.

IV. Long Run Effects of Redlining

In this section we study the long-term effects of the HOLC security maps on neighborhood dynamics. Our empirical design exploits differences between HOLC grades for adjacent neighborhoods. As with any RDD, there is a tradeoff between bias and noise when selecting the sample. Our preferred specification uses a bandwidth of 500 meters around the boundaries that separate different security grades. Recall, the summary statistics presented in Table 1 indicate differences in neighborhood characteristics across HOLC grades. To control for the underlying effect of these differences on home prices, we include a quadratic polynomial of $dist$. We also show the results are robust to using narrower (250 meters) and wider (1000 meters) bandwidths with linear and cubic spline functional forms, respectively.[10] For each specification, the polynomial order is chosen which minimizes the Bayesian information criterion.

10. Gelman and Imbens (2014) caution that high-order polynomials for the forcing variable may be misleading, but for our empirical setting the use of a third-order polynomial in the 1000 meter bandwidth yields similar estimates as local linear or quadratic controls for the forcing variable in the smaller bandwidths.

IV.A. Effect on 1990 Home Prices

The long-term effects of HOLC neighborhood classifications is illustrated by Figure 4. The figure shows the conditional mean of 1990 home value as a function of *dist*, the Euclidean distance from a census block's centroid to the nearest boundary between differing HOLC security grades. Negative distances represent census blocks that lie within an HOLC region with a lower grade relative to the adjacent region (e.g., B (blue) vs. C (yellow)). Panel A restricts the sample to census blocks that fall within 500 meters of a boundary and fits quadratic polynomials to both sides. Panel B extends the sample to include all census blocks within 1000 meters of a boundary and uses cubic polynomials for the fitted lines. All observations are scaled by the average house price of their respective MSA.

[INSERT FIGURE 4 HERE]

The figures share a number of common features. First, consistent with the summary statistics presented above, 1990 home prices are lower in neighborhoods assigned worse HOLC ratings relative to adjacent neighborhoods with better ratings. In addition, prices are positively correlated with the distance to the threshold for both lower- and higher-rated regions. Finally, both figures indicate a discrete jump in 1990 prices at the HOLC boundaries, thus providing reduced form evidence of long-term effects of HOLC ratings on home prices.

Table 2 formally tests for the presence of a discontinuity at the threshold. Columns (1)-(3) report results for the 250, 500, and 1000 meter bandwidths along with linear, quadratic, and cubic spline controls for the distance from the threshold, respectively. Consistent with Figure 4, the regression analysis indicates strong evidence of a jump in 1990 home prices at HOLC thresholds. The estimated magnitude of the difference in home prices at the boundary varies between 4.3% (1000 meter bandwidth) and 4.8% (500 meter bandwidth), and each specification is significant at the 1% level. Back of the envelope calculations indicate that the magnitude of this effect is approximately $7,500 per home in 1990 dollars.

[INSERT TABLE 2 HERE]

The interpretation of this result hinges on the assumption that other 1940 neighborhood characteristics that may influence long-term prices vary smoothly around the boundaries. Hillier (2005) notes that HOLC neighborhood classifications "did not rely on any existing set of boundaries," but were drawn so as to "incorporate homogeneous groups and types of housing." Furthermore, at least some maps (e.g., Philadelphia) underwent several substantive changes before they were finalized, consistent with the idea that neighborhood classifications are often based on subjective perceptions rather than well-defined, discrete boundaries. In fact, to this day, the identification of neighborhood boundaries that correspond to resident perceptions is a challenge for researchers (Coulton et al. (2013)).

Nonetheless, we take further steps to address potential confounding influences located precisely at HOLC boundaries. Our analysis focuses on the presence of rivers, train tracks, and other landmarks. These are particularly important aspects of urban environments for our analysis because isolation from "adverse influences" was one factor used to assign HOLC ratings. It is plausible that home values across such physical barriers diverged over time. Thus, the construction of the borders may simply coincide with physical features responsible for the discrete jump in home prices. We are particularly interested in features that existed prior to the construction of HOLC maps. In some instances, physical barriers between neighborhoods were constructed in response to redlining policies. However, this does not pose a challenge for our analysis because the barriers resulted from (rather than caused) neighborhood classifications.[11]

Table 3 reports the results of this analysis. Panel A excludes census blocks separated by the nearest boundary by a river or other waterways. Panel B considers both rivers and railways, and Panel C considers rivers, railways and other landmarks (e.g., parks, cemeteries, etc.). For the smallest bandwidth in Panel C, these exclusions amount to about 7% of the sample, while for the largest bandwidth the number of observations in the sample drops by nearly one quarter. The exclusion of these observations has little effect on the main

11. Jackson (1980) notes that in order to secure FHA funds, one developer in Detroit constructed a wall to separate the location of a new development from the adjacent area. The wall still stands today.

result. Specifically, the point estimates remain negative and statistically significant at the 1% level, though they are somewhat smaller in magnitude (3.9%-4.3% for Panel C). Figure IA.1 shows the conditional mean of 1990 home value as a function of distance to the boundary when excluding rivers, rails, and landmarks. The figure provides visual evidence that the discontinuity in home values remains after refining the sample in this manner.

[INSERT TABLE 3 HERE]

In sum, the results indicate redlining policies have long-term effects on real estate prices that are not explained by physical features of cities potentially corresponding with the boundaries. While the magnitude of the effect is somewhat modest, it is important to note that our analysis is limited to a single set of redlining maps produced in 1940. Historical accounts indicate redlining was practiced by both public and private institutions for decades after this, and it is likely that the specific areas targeted by such policies changed over time. Thus, the aggregate effects of redlining may be significantly larger than those documented in this setting.

IV.B. Examination of Pre-Treatment Effects

We next analyze housing characteristics from 1940, the year the HOLC maps were completed, to provide further evidence supporting a causal interpretation of the findings. The summary statistics presented in Table 1 indicate areas assigned different HOLC ratings differed along a number of dimensions (e.g., average rental rates, percentage of properties in disrepair, etc.). If such characteristics changed discretely at HOLC boundaries, this may explain differences in long-term house prices. However, if HOLC maps cause differences in home prices, 1940 housing characteristics should vary smoothly around the thresholds.[12] The results of our analysis are consistent with the latter interpretation. Consistent with

12. In theory, redlining may have had an immediate impact on some outcomes (e.g., prices) if the HOLC maps were immediately disclosed to all economic agents. We do not find evidence of this in the data.

a causal interpretation, we do not find evidence of discrete changes in 1940 neighborhood characteristics at HOLC thresholds.

[INSERT TABLE 4 HERE]

Table 4 reports the results of this analysis. Panel A shows the effect for block-level rental rates scaled by the average MSA rental rate. We use this outcome to measure relative valuations in adjacent HOLC regions because (unlike 1990) the block statistics from the 1940 census does not provide block-level data on home prices. Fortunately, the use of rental rates does not restrict our sample to only tenant-occupied households. Instead, rental rates were estimated for owner-occupied households and were thus included in the statistic. The coefficients for 250, 500, and 1000 meter bandwidths are both economically small and statistically indistinguishable from zero. Panel A of Figure 4 shows the conditional mean of 1940 rental rates as a function of distance to the HOLC boundaries. The graph is constructed in the same manner as Panel A of Figure 4; the bandwidth is 500 meters and quadratic polynomials are used for both sides of the threshold. However, in contrast to the earlier figure, there is no evidence of a discrete change in rental rates at the threshold. Figure IA.2 shows rental rates for the 1000 meter bandwidth and is also consistent with prices varying smoothly around HOLC thresholds.

[INSERT FIGURE 5 HERE]

The remainder of Table 4 checks for discontinuities in various other neighborhood characteristics. There is no evidence of differences in the measures that potentially capture neighborhood quality such as vacancy rates or the percent of structures in disrepair. There is also no difference in the number of households per structure, suggesting that HOLC boundaries were not defined by the presence of large apartment buildings. Furthermore, HOLC boundaries do not correspond to discrete differences in the racial composition of neighborhoods. There is weak evidence of a difference in overcrowding, which potentially serves as a proxy for wealth. In particular, the coefficient for the percent of overcrowded homes is positive and marginally significant at the 10% level for the 250 meter bandwidth, indicating overcrowding is more likely for regions with *higher* HOLC ratings. The small magnitude of this effect (0.2%) combined with the fact that the wider bandwidths yield statistically insignificant results suggests this is not a significant concern for our empirical design. Panel B of Figure 5 provides visual evidence consistent with the findings in this table.

Overall, the results in this section are consistent with the identifying assumption that there is only a discrete change to the "treatment" status of observations around HOLC thresholds. We find very little evidence of discontinuities in relative home values or other neighborhood characteristics that potentially influence long-term price dynamics. However, an additional concern may be that HOLC maps merely reflect preexisting redlining practices used by other institutions and did not have an incremental effect on credit rationing. Indeed, historians have documented other instances of redlining prior to the HOLC.[13] While there is no historical account of the HOLC coordinating with local organizations to construct the residential security maps, it is possible that the local realtors were influenced by previous maps created by public or private organizations. We do not find evidence that such influence, if it in fact occurred, led to any differences in HOLC regions prior to their completion in 1940.

V. Conditional Effects across Cities

We next study differences in the effects of HOLC neighborhood classification across different cities. Our tests are motivated by the fact that the federal government took a number of actions in the 1960s and 1970s to outlaw redlining practices by both public and private entities (e.g., the Fair Housing Act of 1968). However, racial-based lending practices likely persisted from 1940 until this later period. This provides a unique setting to examine how

13. For example, Hillier (2003) notes that the Chicago Commission on Race Relations, formed following race riots in the summer of 1919, concluded that some lenders refused to make loans in minority neighborhoods.

the effect of credit rationing on home prices varies with the intensity of credit demanded across cities.

We accordingly hypothesize that the effects of redlining are more pronounced in cities with high demand for housing in the decades before redlining was banned. Additionally, Guerrieri et al. (2013) develop a model of endogenous gentrification and argue the poor neighborhoods bordering rich ones have the highest price elasticity in response to positive demand shocks. Thus, the increased demand present in cities with higher growth following the abolition of redlining practices in the 1960s should result in increased gentrification at HOLC boundaries, thus muting previously realized effects.

The results in Table 5 are broadly consistent with these hypotheses. Panel A splits the sample into cities located in states with above/below median house price growth between 1940 and 1960, a proxy for demand in the area. States with high demand during this period were disproportionately in the South (e.g., Texas, Louisiana, Alabama) and West Coast (e.g., California, Oregon, Washington). States with low demand were in the Northeast (e.g., Pennsylvania, New Jersey, Massachusetts, New York).[14] Cities with above-median demand over this period exhibit substantially larger discrete changes in home values at HOLC boundaries. Specifically, for the 500 and 1000 meter bandwidths, the point estimate is nearly twice as large for cities in states with higher growth relative to those with lower growth. The effect is less pronounced for the 250 meter bandwidth, though the point estimate for high growth states remains about 20% larger than that of low growth states.

[INSERT TABLE 5 HERE]

Panel B of Table 5 repeats the previous analysis when splitting the sample based on house price growth from 1960 to 1990. States with high demand during this period were disproportionally in the Northeast and West Coast, while states with low demand tended to be in the Midwest (e.g., Ohio, Michigan, Missouri). The panel indicates that the discrete change in home prices at HOLC boundaries is substantially lower in cities which have

14. The classification of states for both samples is reported in Internet Appendix Table 1

plausibly experienced more gentrification due to increased demand during this period. For each specification, the magnitude of the point estimate for cities with low demand are about double those with high demand.

VI. The Channel

In this section we examine other 1990 housing characteristics to shed light on the mechanism connecting redlining practices to home prices. We specifically consider changes to both housing characteristics and the individuals occupying the structures.

Redlining policies may have led to changes in the use of housing that potentially impose negative externalities. We first consider the presence of vacant homes in neighborhoods. Schill and Wachter (1995) note that the FHA lending was biased towards the suburbs and led to disinvestment from inner-cities. This disinvestment may have, in turn, eventually led to the deterioration of the housing stock and, perhaps, the abandonment of homes altogether. Gerardi et al. (2015) argue such disinvestment can negatively affect adjacent home prices through a "disamenity effect," which is more pronounced for homes in poor condition. To examine this hypothesis, we turn to 1990 housing vacancy rates. Panel A of Table 6 reports the results of this analysis. The dependent variable is the percentage of homes that are vacant for each census block. The results indicate redlining is associated with a 0.38-0.52 percentage point increase in this measure, statistically significant at the 1% level for each of the specifications. The magnitude of this effect is about 5-7% relative to the 1990 sample mean.[15] The result suggests negative externalities resulting from disinvestment may play a role in explaining the long-term effects of redlining on home prices.

[INSERT TABLE 6 HERE]

We next examine whether there is a long-term effect of redlining, which restricted credit needed to buy a new home, on the presence of renters in neighborhoods. While this credit

15. We find similar results when considering only structures classified as "boarded up".

constraint was presumably relaxed with the passage of the Fair Housing Act of 1968, both rental rates and neighborhood dynamics may be persistent resulting in a continued effect of redlining after it was outlawed. Unlike owners, renters lack a stake in the community and prior literature argues renters potentially impose negative externalities through home maintenance, civic engagement, and investment in local amenities (DiPasquale and Glaeser (1999)). Such externalities are presumably impounded into prices and may, at least partially, explain the long-term effects on home values. Panel B of Table 6 reports the results of this analysis. We document a decrease in owner-occupied housing of nearly 2 percentage points, or about 3.3% relative to the sample mean of 58%. The effect is statistically significant at the 1% level across each of the specifications. Figure 6 provides visual evidence of a discontinuity for both vacancy and rental rates.

[INSERT FIGURE 6 HERE]

Finally, we examine possible changes to the physical characteristics of housing stock. Recall, the results presented in Table 4 find no difference in the housing units per structure in 1940. However, it is possible that the choice of unit density in future construction is affected by the access to credit. If so, it is plausible that a restriction of credit due to redlining policies resulted in a difference in the types of structures being built (e.g. single-unit homes versus apartment towers). We test this hypothesis by examining the units per structure reported in 1990. Panel C reports no difference in the number of households per structure, mirroring the finding in Table 4 for 1940. This result indicates that there is no difference in the construction of apartment buildings in lower rated regions according to HOLC classifications.

Finally, we turn our attention to whether changes to the characteristics of neighborhood inhabitants might explain the decrease in house prices. For instance, it is possible that redlining policies led to an influx of minorities or people with lower socioeconomic status. This may have caused the neighborhood to reach a tipping point which lead to lower home prices (Card et al. (2008)). We do not, however, find evidence consistent with this explanation. Unfortunately we do not observe block-level measures of wealth in the data. Instead, we use overcrowding, or the percentage of housing units with at least 1.51 persons per room, as a proxy for wealth. Panel A of Table 7 reports the effect for this outcome. Overall, the results presented in the panel indicate that redlining does not have a long-term effect on overcrowding. Note, the point estimates for overcrowding are negative and marginally significant for the widest bandwidth. However, this specification suggests overcrowding is *less likely* to occur in areas with worse HOLC security grades. Finally, we examine the demographic makeup of residents near HOLC boundaries. Panel B indicates the difference in the percentage of minority residents is both economically small and statistically indistinguishable from zero. Overall, we find no evidence of a change to the racial composition of neighborhoods at HOLC boundaries.

[INSERT TABLE 7 HERE]

VII. Conclusion

This paper examines the long-term effects of redlining in mortgage markets. Using a regression discontinuity around neighborhood boundaries on the HOLC's residential security maps, we find such policies are associated with a 5% decrease in 1990 house prices. This result is not driven by the physical features of cities, and neighborhood characteristics varied smoothly around the boundaries when the maps were created in 1940. Furthermore, the strength of the effect varies with the intensity of credit demanded across cities: it is particularly strong in cities with high demand during the period when redlining was practiced but weaker for cities with high demand in subsequent years. We also document a 5-7% increase in vacant houses and a 3% decrease in owner-occupation, suggesting negative externalities associated with these neighborhood characteristics potentially explain the decrease in house values.

Overall, our findings shed light on the consequences of discriminatory credit rationing.

However, the results likely understate the aggregate effects of discrimination in housing markets. In addition to redlining, minority homeowners were subject to other discriminatory practices in mortgage markets for much of the 20th century, including racially restrictive covenants, zoning laws, and the threat of violence (Cutler et al. (1999)). There is even evidence that discrimination in mortgage markets continues to this day. For example, recent work finds evidence of predatory "reverse redlining" in which subprime lenders targeted areas with more minorities (e.g., Calem et al. (2004); Rugh and Massey (2010)); Agarwal et al. (2014) argue such predatory lending raised default rates during the financial crisis. While our paper does not directly speak to the effects of the over-extension of credit, it suggests such distortions in credit markets may have lasting effects. Thus, we believe further investigation of this issue offers a promising avenue for future research and has important policy implications.

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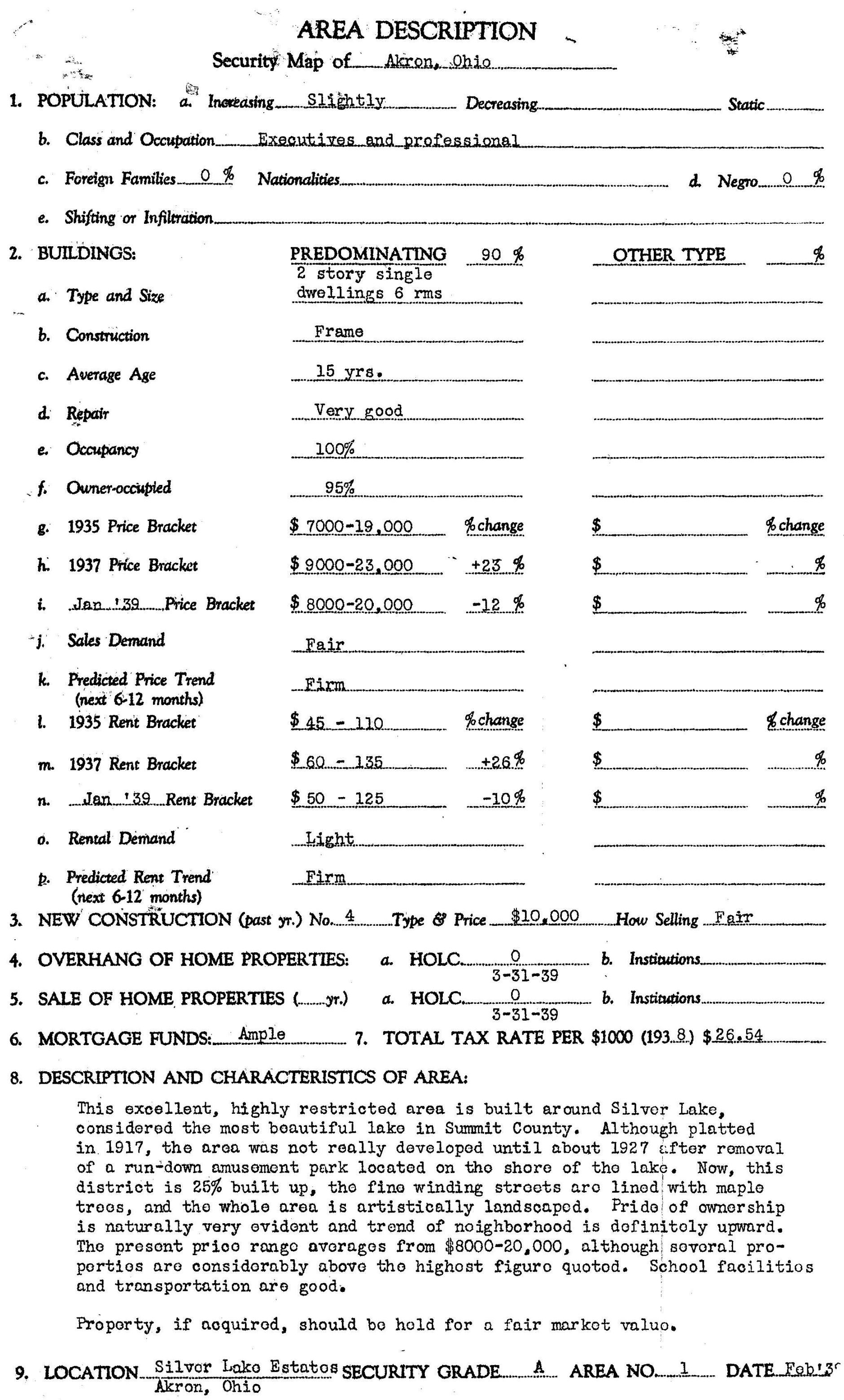
Panel A: HOLC Area Description, Security Grade *A*



AREA DESCRIPTION

Security Map of Akron, Ohio

1. POPULATION: *a.* *Increasing* Slightly *Decreasing* ____ *Static* ____

b. *Class and Occupation* Executives and professional

c. *Foreign Families* 0 % *Nationalities* ____ *d.* *Negro* 0 %

e. *Shifting or Infiltration* ____

2. BUILDINGS:	PREDOMINATING	90 %	OTHER TYPE	%
a. *Type and Size*	2 story single dwellings 6 rms			
b. *Construction*	Frame			
c. *Average Age*	15 yrs.			
d. *Repair*	Very good			
e. *Occupancy*	100%			
f. *Owner-occupied*	95%			
g. *1935 Price Bracket*	$ 7000-19,000	*% change*	$	*% change*
h. *1937 Price Bracket*	$ 9000-23,000	+23 %	$	%
i. Jan '39 *Price Bracket*	$ 8000-20,000	-12 %	$	%
j. *Sales Demand*	Fair			
k. *Predicted Price Trend (next 6-12 months)*	Firm			
l. *1935 Rent Bracket*	$ 45 - 110	*% change*	$	*% change*
m. *1937 Rent Bracket*	$ 60 - 135	+26 %	$	%
n. Jan '39 *Rent Bracket*	$ 50 - 125	-10 %	$	%
o. *Rental Demand*	Light			
p. *Predicted Rent Trend (next 6-12 months)*	Firm			

3. NEW CONSTRUCTION (*past yr.*) No. 4 *Type & Price* $10,000 *How Selling* Fair

4. OVERHANG OF HOME PROPERTIES: *a.* HOLC 0 3-31-39 *b.* *Institutions* ____

5. SALE OF HOME PROPERTIES (____ *yr.*) *a.* HOLC 0 3-31-39 *b.* *Institutions* ____

6. MORTGAGE FUNDS: Ample 7. TOTAL TAX RATE PER $1000 (193 8) $26.54

8. DESCRIPTION AND CHARACTERISTICS OF AREA:

This excellent, highly restricted area is built around Silver Lake, considered the most beautiful lake in Summit County. Although platted in 1917, the area was not really developed until about 1927 after removal of a run-down amusement park located on the shore of the lake. Now, this district is 25% built up, the fine winding streets are lined with maple trees, and the whole area is artistically landscaped. Pride of ownership is naturally very evident and trend of neighborhood is definitely upward. The present price range averages from $8000-20,000, although several properties are considerably above the highest figure quoted. School facilities and transportation are good.

Property, if acquired, should be held for a fair market value.

9. LOCATION Silver Lake Estates Akron, Ohio SECURITY GRADE A AREA NO. 1 DATE Feb '39

FIGURE 1. HOLC Area Descriptions

This figure presents two area descriptions commissioned by the HOLC for Akron, OH. The neighborhood in Panel A received an *A* rating, and the neighborhood in Panel B received a *D* rating.

Panel B: HOLC Area Description, Security Grade *D*

AREA DESCRIPTION

Security Map of Akron, Ohio

1. POPULATION: a. Increasing Yes Decreasing ______ Static ______

   b. Class and Occupation Rubber workers and laborers

   c. Foreign Families 25 % Nationalities Predominantly Jewish d. Negro 35 %

   e. Shifting or Infiltration of colored - fairly rapid

2. BUILDINGS:

	PREDOMINATING 95 %		OTHER TYPE %	
a. Type and Size	2 story single family 6 rooms			
b. Construction	Frame			
c. Average Age	30			
d. Repair	Fair only			
e. Occupancy	96%			
f. Owner-occupied	50%			
g. 1935 Price Bracket	$ 1500-2500	% change	$	% change
h. 1937 Price Bracket	$ 1600-2800	+10 %	$	%
i. Jan. '39 Price Bracket	$ 1500-2500	- 9 %	$	%
j. Sales Demand	Slow			
k. Predicted Price Trend (next 6-12 months)	Downward			
l. 1935 Rent Bracket	$ 10 - 20	% change	$	% change
m. 1937 Rent Bracket	$ 11 - 23	+13 %	$	%
n. Jan. '39 Rent Bracket	$ 10 - 20	-12 %	$	%
o. Rental Demand	Good			
p. Predicted Rent Trend (next 6-12 months)	Static to downward			

3. NEW CONSTRUCTION (past yr.) No. 0 Type & Price ______ How Selling ______

4. OVERHANG OF HOME PROPERTIES: a. HOLC 12 3-31-39 b. Institutions ______

5. SALE OF HOME PROPERTIES (___yr.) a. HOLC 1 3-31-39 b. Institutions ______

6. MORTGAGE FUNDS: Very little, if any 7. TOTAL TAX RATE PER $1000 (1938) $ 28.90

8. DESCRIPTION AND CHARACTERISTICS OF AREA:

Laid out about 1905; known as main Jewish shopping district; paved streets; good transportation; convenient to schools, churches, and stores; located just south of Perkins Park; level terrain. Most of the area lying south of Bartges Street has soft foundation due to nearby Summit Lake (southern boundary).

Homes located on Norka, Raymond and the south end Snyder, Schock, Metzger and Bowery Street are out of "plumb" owing to the shifting foundation. Heavy traffic along Wooster Avenue, Thornton and Bowery Streets. District affected by odors, smoke, and dirt from nearby Goodrich Rubber Company plant. Acquired property if not sold immediately will suffer from vandalism.

Declining district, heavily populated by low class Jews -- all stores on Wooster Avenue (traversing artery) are Jewish-owned. Present heavy negro encroachment gradually increasing.

9. LOCATION Akron, Ohio SECURITY GRADE D AREA NO. 4 DATE Feb. '39

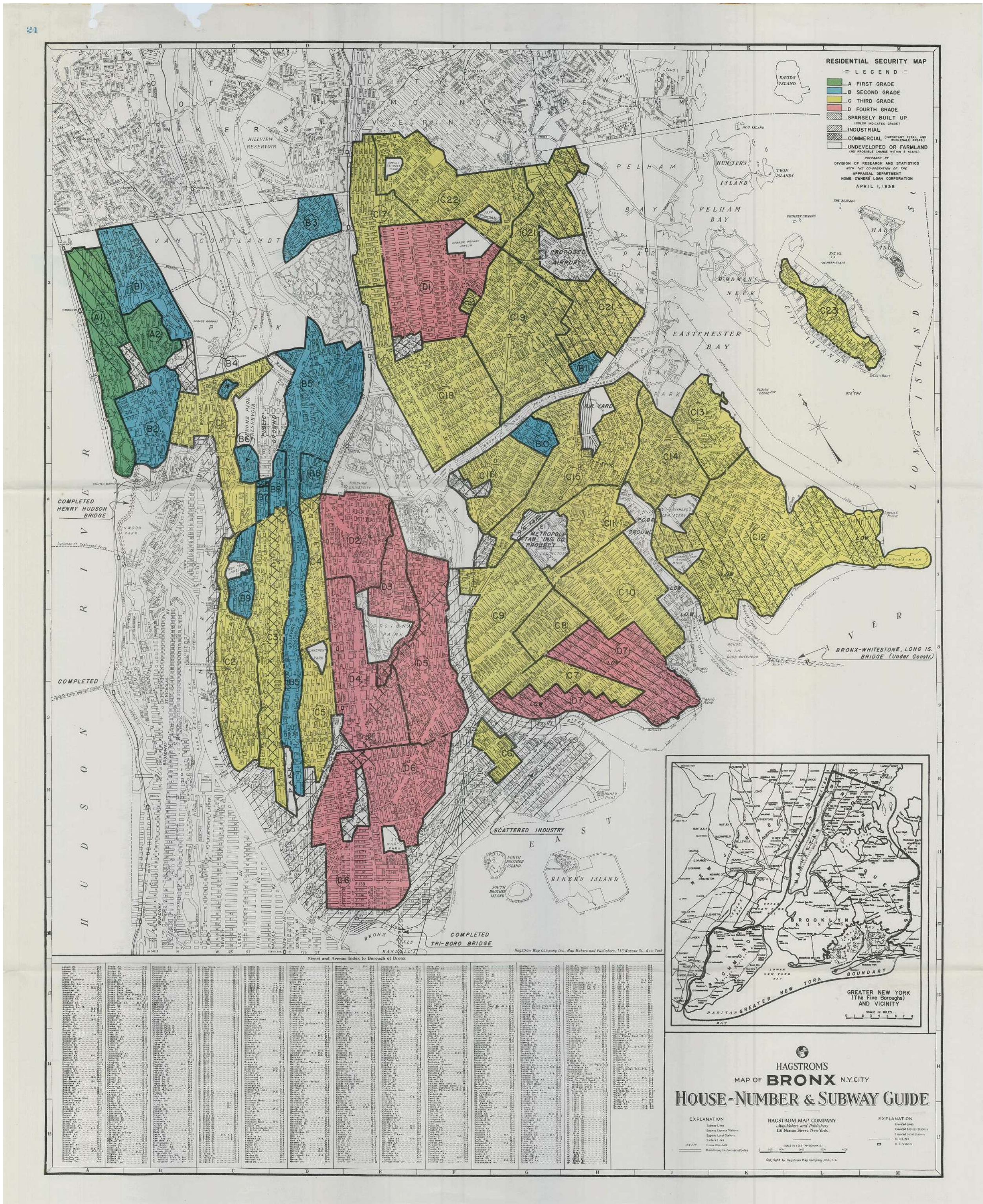


FIGURE 2. HOLC Residential Security Map

This figure presents the residential security map commissioned by the HOLC for Bronx County, New York. Areas are classified into four grades as described in the text. The full sample consists of 58 such maps covering 48 MSAs.

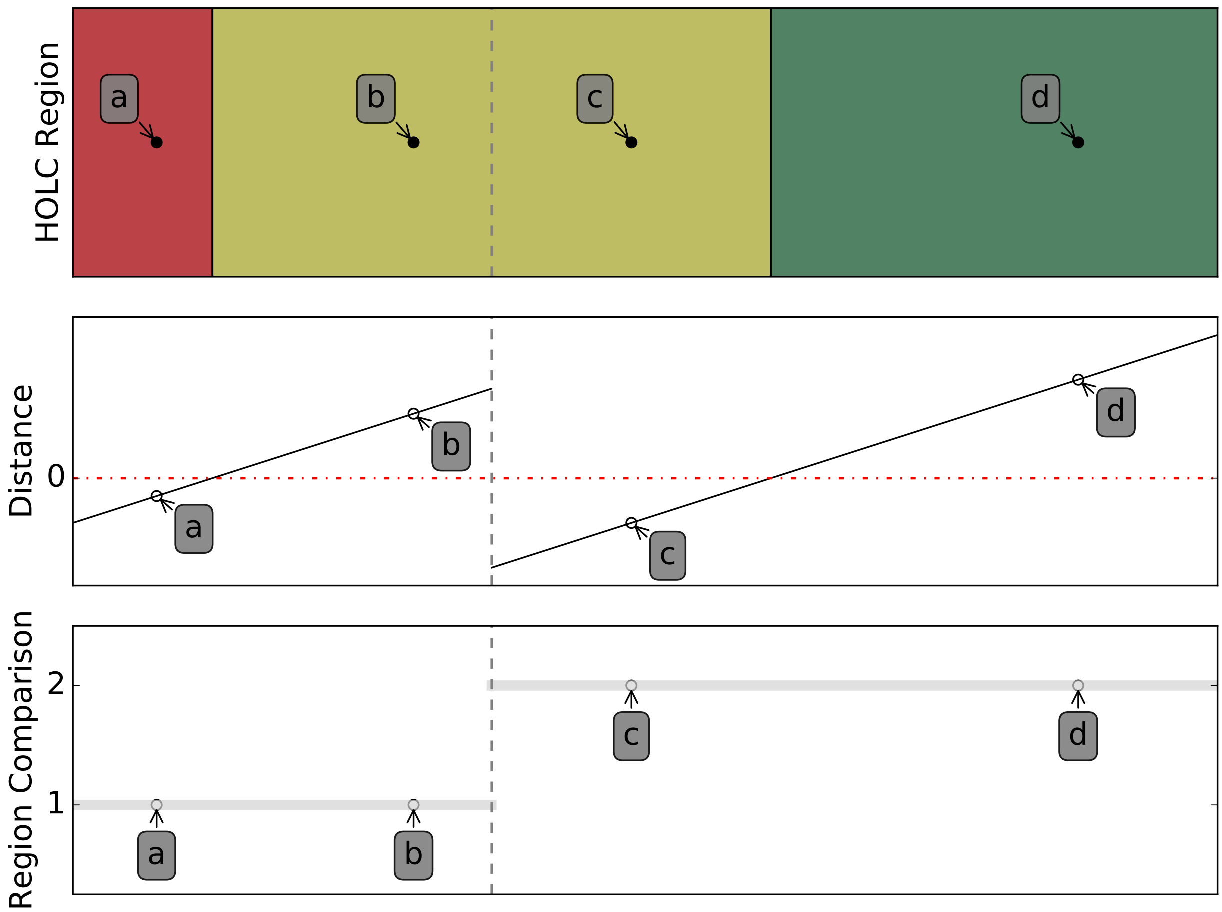


FIGURE 3. Construction of Distance to Boundaries

This figure illustrates the construction of *dist* used throughout the analysis. For each point within a region, *dist* is computed relative to the nearest region of a different security grade. All points not falling within an HOLC region are excluded. For points in a region of a lower quality relative to the closest adjacent region, *dist* takes on a negative value. $TransitionRegion$ is set equal to the lower quality grade of a point's region and the closest adjacent region.

Panel A: 1990 House Prices, 500 Meter Bandwidth

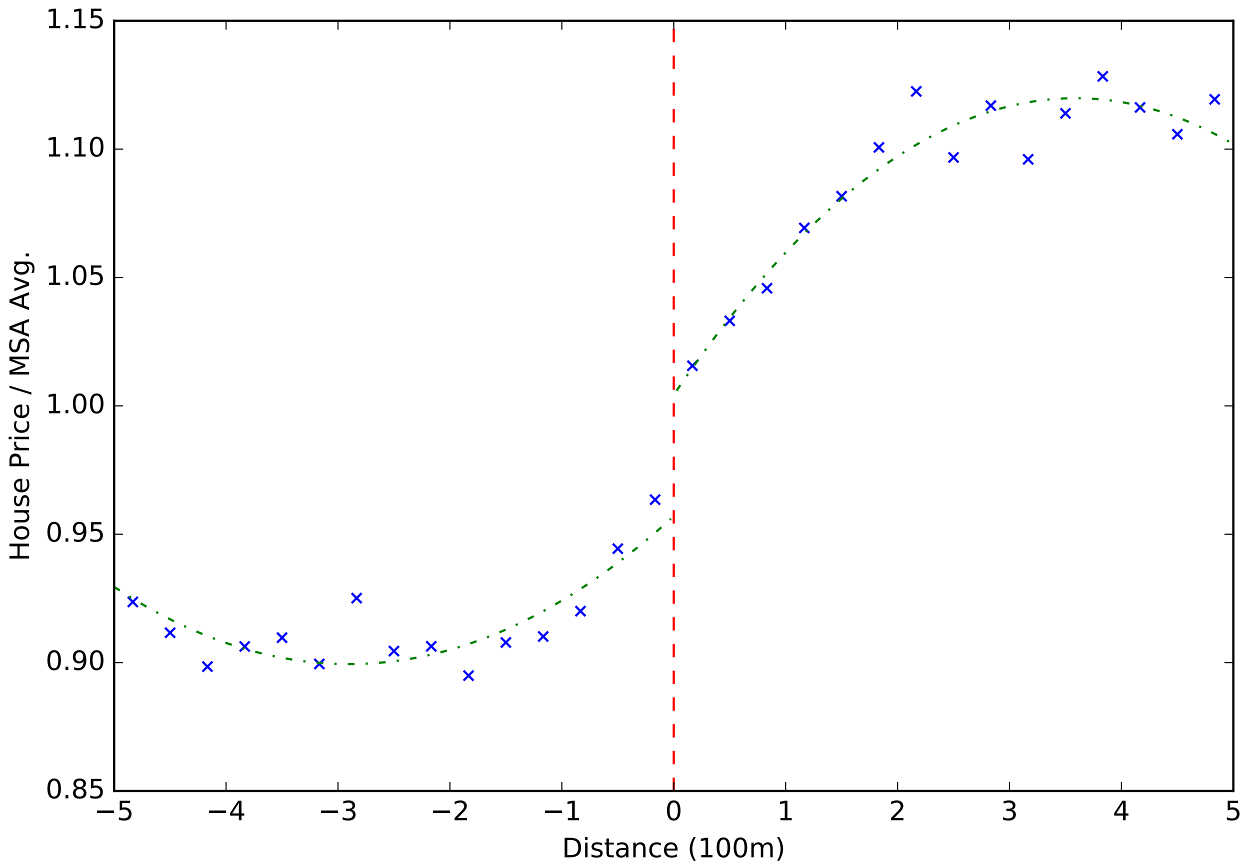
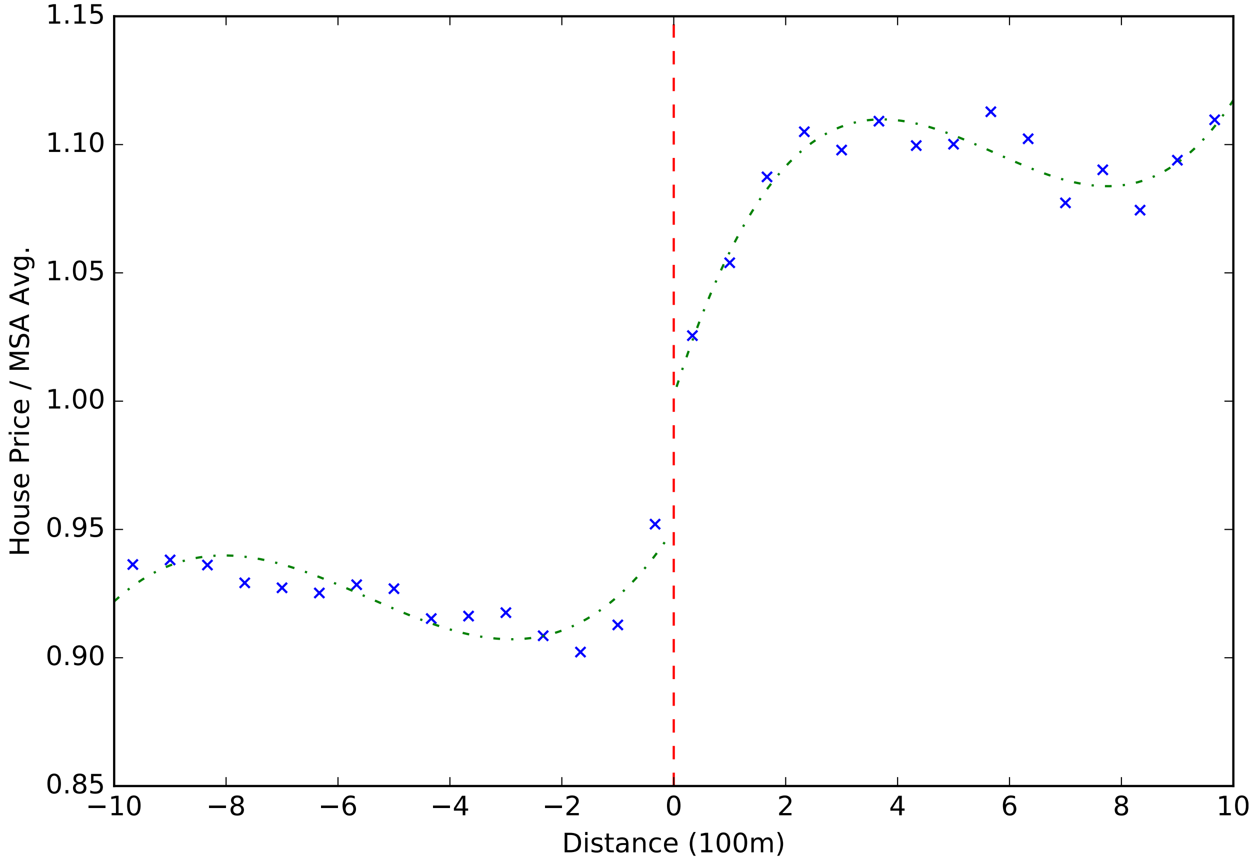


FIGURE 4. Effect on 1990 House Prices

This figure shows the change in 1990 house prices (scaled by MSA average) near the HOLC boundaries. Panel A restricts the sample to all observations within 500 meters of HOLC boundaries and fits second-order polynomials for each side of the threshold. Panel B expands the sample to all observations within 1000 meters of an HOLC boundaries and fits third-order polynomials.

Panel B: 1990 House Prices, 1000 Meter Bandwidth



Panel A: 1940 House Prices

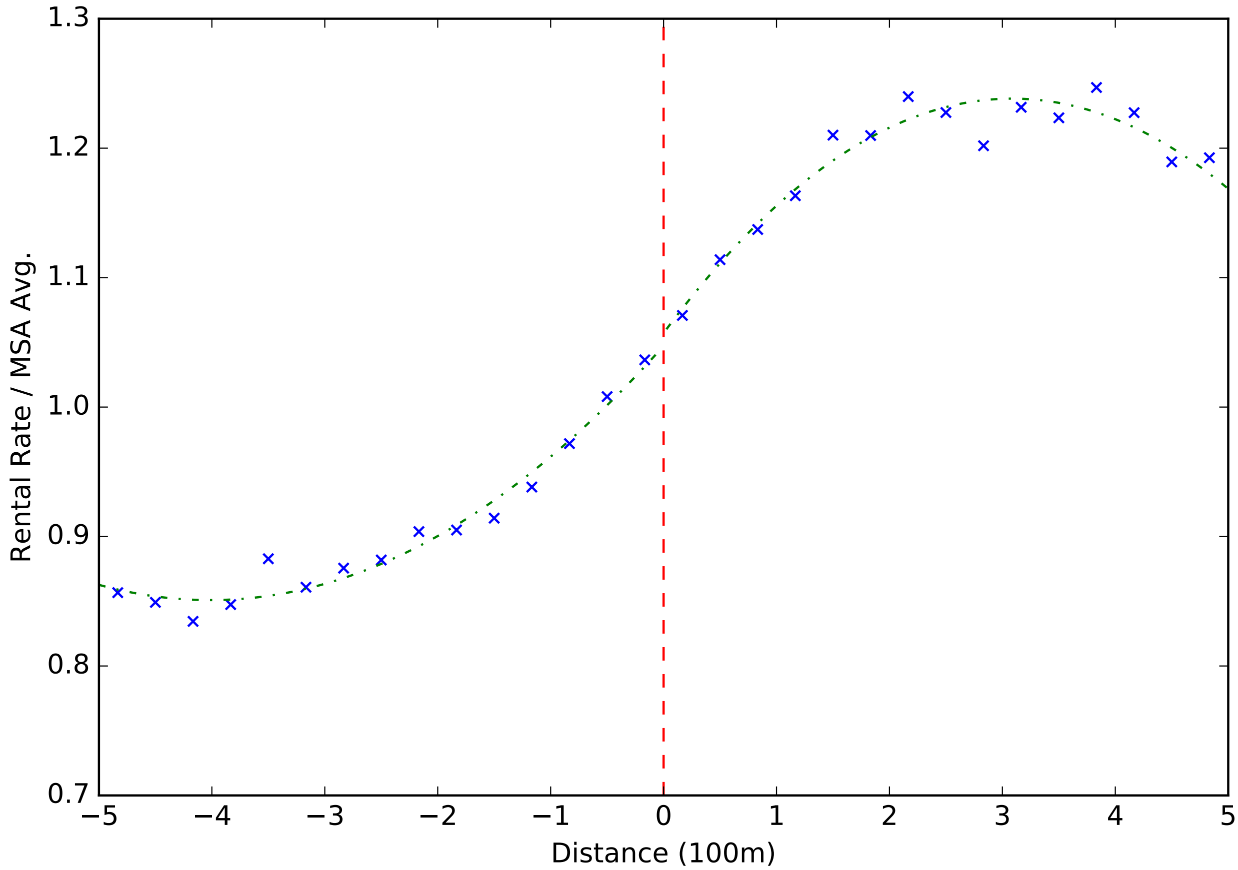
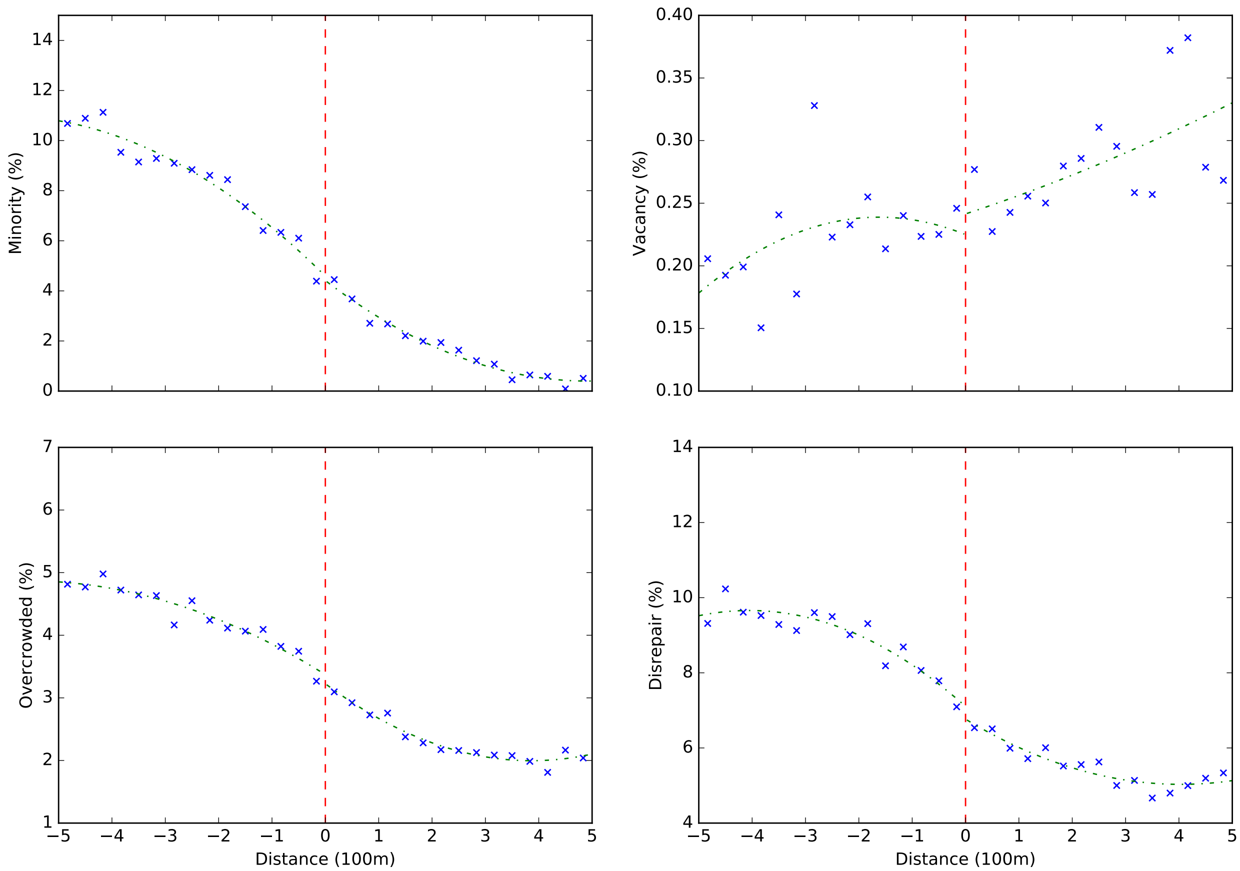


FIGURE 5. 1940 Housing Characteristics

This figure shows the relation between the distance to HOLC boundaries and 1940 housing characteristics. The sample includes include all observations within 500 meters of HOLC boundaries. Panel A reports the rental rate (scaled by MSA average). Panel B reports the percent of households with a non-white head (*Minority*), households reported vacant (*Vacancy*), households with at least 1.51 persons per room (*Overcrowded*), and households reported as requiring repair (*Disrepair*). Second-order polynomials estimated separately for each side of the threshold are reported by the dashed lines.

Panel B: Other 1940 Housing Characteristics



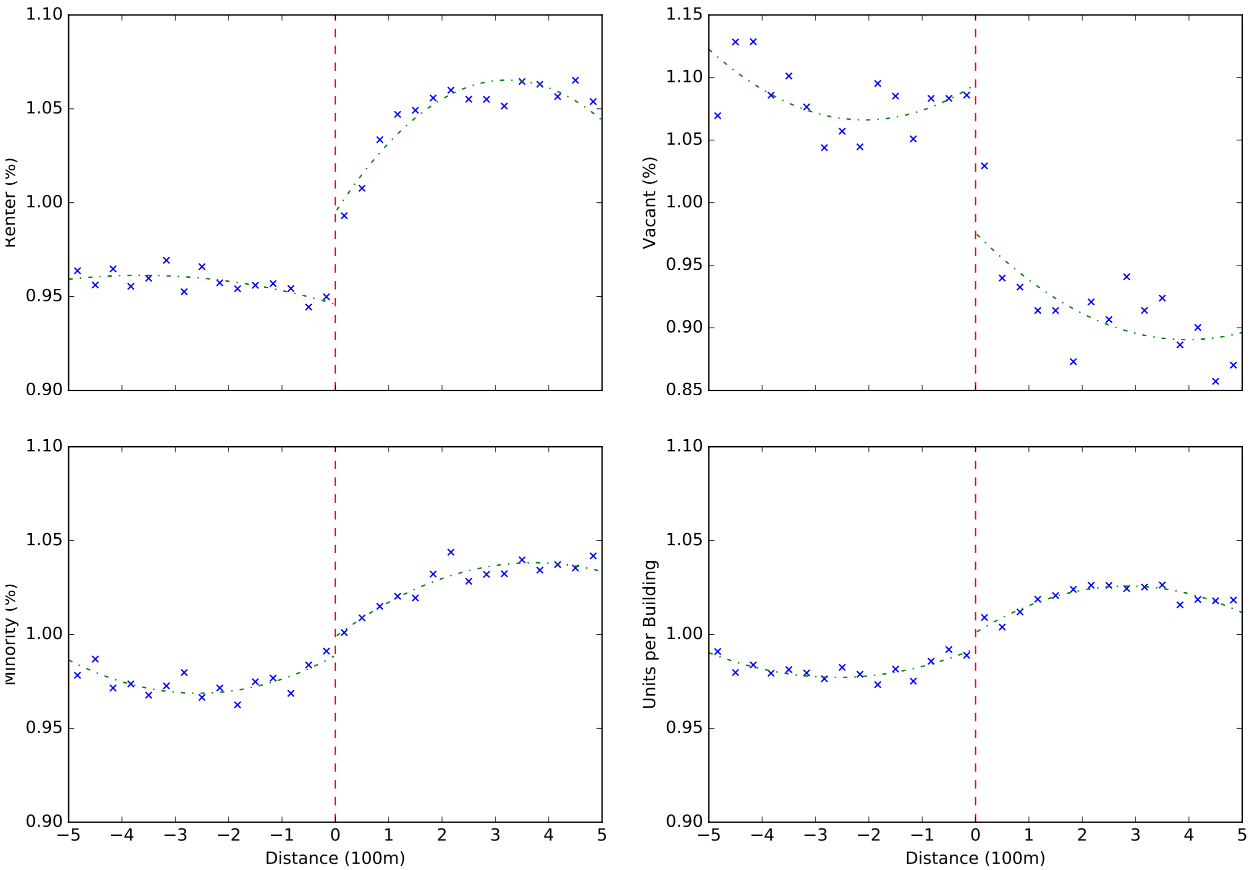


FIGURE 6. Effect on 1990 Housing Characteristics

This figure shows the relation between the distance to HOLC boundaries and 1990 housing characteristics. The sample includes all observations within 500 meters of HOLC boundaries. The outcomes are the percent of households reported vacant (*Vacancy*), households that are owner-occupied (*Owner-Occupied*), households with at least 1.51 persons per room (*Overcrowded*), and households with a non-white head (*Minority*). Second-order polynomials estimated separately for each side of the threshold are reported by the dashed lines.

TABLE 1–Summary Statistics

Panel A: Full Sample					
	N	Mean	Median	p10	p90
1940 Characteristics:					
Estimated Rent ($)	124468	34.51	30.75	17.17	55.00
Non-White (%)	132876	6.31	0.00	0.00	10.00
Vacant (%)	132892	0.24	0.00	0.00	0.00
Overcrowded (%)	132807	3.46	0.00	0.00	10.39
Disrepair (%)	132708	7.49	0.00	0.00	25.00
Households/Structure	132866	2.24	1.25	1.00	3.20
1990 Characteristics:					
Estimated Value ($1,000)	200018	119.03	72.50	25.70	273.50
Non-White (%)	218057	40.74	23.36	0.00	100.00
Vacant (%)	217960	7.13	4.17	0.00	17.65
Overcrowded (%)	217384	3.35	0.00	0.00	9.52
Owner-Occupied (%)	217384	58.70	62.50	12.22	98.44
Households/Structure	217607	4.424	1.309	1.000	8.189

Panel B: Mean By HOLC Grade				
	HOLC Security Grade			
	A	B	C	D
1940 Characteristics:				
Estimated Rent ($)	70.15	45.47	33.95	23.73
Non-White (%)	0.51	0.45	1.22	17.68
Vacant (%)	0.52	0.30	0.23	0.19
Overcrowded (%)	0.39	1.21	2.59	6.52
Disrepair (%)	1.88	3.46	6.23	12.59
Households/Structure	1.68	2.22	2.12	2.48
1990 Characteristics:				
Estimated Value ($1,000)	230.23	136.07	107.49	89.41
Non-White (%)	16.97	28.65	40.76	58.43
Vacant (%)	3.85	4.93	6.80	10.68
Overcrowded (%)	0.35	1.49	3.63	5.39
Owner-Occupied (%)	84.78	68.94	55.92	47.01
Households/Structure	2.88	4.03	4.46	5.14

This table reports summary statistics for the sample. Panel A reports the aggregate statistics for the full sample. Panel B reports the sample mean partitioned by HOLC security grade.

TABLE 2–1990 House Prices

	(1)	(2)	(3)
$\mathbb{1}(dist < 0)$	-0.047***	-0.048***	-0.043***
	(-3.75)	(-4.26)	(-3.90)
Bandwidth	250	500	1000
Order Polynomial	1	2	3
N	74,468	121,464	164,883
R^2	0.181	0.188	0.194

This table reports the estimates of the discrete change in relative 1990 house values (scaled by the MSA average) at the boundary between HOLC regions. We estimate

$$Y_i = \alpha + \beta \mathbb{1}(dist_i < 0) + \sum_{n=1}^{N} \theta_n dist_i^n + \mathbb{1}(dist_i < 0) \times \sum_{n=1}^{N} \gamma_n dist_i^n + \phi_j + \varepsilon_i$$

where Y_i is the outcome of interest, $dist_i$ is the distance of a census block to the HOLC boundary, and ϕ_j are region fixed effects. We control for continuous changes in the outcome variable with a N degree polynomial of *dist* on each side of the threshold that minimizes the Bayesian information criterion. Negative distances indicate a lower HOLC rating relative to adjacent areas. Reported t-statistics in parentheses are heteroscedasticity-robust and clustered by MSA. ***p<0.01

TABLE 3–1990 House Prices: Confounding Geographic Effects

	(1)	(2)	(3)
		Panel A: Excluding Rivers	
$\mathbb{1}(dist < 0)$	-0.048***	-0.048***	-0.041***
	(-3.79)	(-4.28)	(-3.97)
N	73,846	119,391	160,021
R^2	0.181	0.189	0.195
		Panel B: Excluding Rivers & Rails	
$\mathbb{1}(dist < 0)$	-0.046***	-0.049***	-0.043***
	(-3.49)	(-4.10)	(-3.99)
N	71,915	113,295	146,236
R^2	0.179	0.184	0.189
		Panel C: Excluding Rivers, Rails & Landmarks	
$\mathbb{1}(dist < 0)$	-0.043***	-0.045***	-0.039***
	(-3.34)	(-3.76)	(-3.35)
N	69,530	102,270	118,307
R^2	0.180	0.186	0.191
Bandwidth	250	500	1000
Order Polynomial	1	2	3

This table reports the estimates of the discrete change in relative 1990 house values (scaled by the MSA average). Panel A excludes HOLC boundaries that coincide with rivers. Panel B excludes boundaries coinciding with rivers and railroad tracks, and Panel C further excludes those coinciding with landmarks (e.g., parks). We estimate

$$Y_i = \alpha + \beta \mathbb{1}(dist_i < 0) + \sum_{n=1}^{N} \theta_n dist_i^n + \mathbb{1}(dist_i < 0) \times \sum_{n=1}^{N} \gamma_n dist_i^n + \phi_j + \varepsilon_i$$

where Y_i is the outcome of interest, $dist_i$ is the distance of a census block to the HOLC boundary, and ϕ_j are region fixed effects. We control for continuous changes in the outcome variable with a N degree polynomial of *dist* on each side of the threshold that minimizes the Bayesian information criterion. Negative distances indicate a lower HOLC rating relative to adjacent areas. Reported t-statistics in parentheses are heteroscedasticity-robust and clustered by MSA. ***p<0.01

TABLE 4– 1940 Housing Charactersitics

	(1)	(2)	(3)
Panel A: Estimated Rental Rates			
$\mathbb{1}(dist < 0)$	-0.016	-0.010	-0.009
	(-1.34)	(-0.85)	(-0.75)
N	45,015	70,405	90,934
R^2	0.295	0.311	0.330
Panel B: Vacancy Rates			
$\mathbb{1}(dist < 0)$	-0.013	-0.016	0.000
	(-0.42)	(-0.46)	(0.01)
N	47,883	75,130	96,969
R^2	0.002	0.002	0.002
Panel C: Percent Overcrowded			
$\mathbb{1}(dist < 0)$	0.179*	0.143	0.117
	(1.92)	(1.27)	(0.92)
N	46,023	72,079	92,934
R^2	0.072	0.084	0.094
Panel D: Households per Structure			
$\mathbb{1}(dist < 0)$	0.066	-0.014	-0.016
	(0.29)	(-0.06)	(-0.07)
N	47,877	75,119	96,956
R^2	0.001	0.001	0.001
Panel E: Percent Minority			
$\mathbb{1}(dist < 0)$	0.075	0.154	-0.147
	(0.20)	(0.43)	(-0.33)
N	46,032	72,094	92,959
R^2	0.064	0.088	0.109
Panel F: Percent in Disrepair			
$\mathbb{1}(dist < 0)$	0.459	0.331	0.229
	(1.55)	(0.93)	(0.61)
N	45,991	72,028	92,882
R^2	0.032	0.040	0.048
Bandwidth	250	500	1000
Order Polynomial	1	2	3

Table 4, Continued – 1940 Housing Characteristics

This table tests for discrete changes in housing characteristics at HOLC boundaries in 1940. The outcomes are the estimated rental rate scaled by the average rental rate of the MSA, the percent of households with a non-white head (*Minority*), households reported vacant (*Vacancy*), households with at least 1.51 persons per room (*Overcrowded*), and households requiring repair (*Disrepair*). We estimate

$$Y_i = \alpha + \beta \mathbb{1}(dist_i < 0) + \sum_{n=1}^{N} \theta_n dist_i^n + \mathbb{1}(dist_i < 0) \times \sum_{n=1}^{N} \gamma_n dist_i^n + \phi_j + \varepsilon_i$$

where Y_i is the outcome of interest, $dist_i$ is the distance of a census block to the HOLC boundary, and ϕ_j are region fixed effects. We control for continuous changes in the outcome variable with a N degree polynomial of *dist* on each side of the threshold that minimizes the Bayesian information criterion. Negative distances indicate a lower HOLC rating relative to adjacent areas. Reported t-statistics in parentheses are heteroscedasticity-robust and clustered by MSA. *p<0.10

TABLE 5–Cross-Sectional Effects across Cities

Panel A: Median Splits: House Price Growth (1940-1960)						
	(1)		(2)		(3)	
	Above	Below	Above	Below	Above	Below
$\mathbb{1}(dist < 0)$	-0.051***	-0.042**	-0.072***	-0.034**	-0.061***	-0.030**
	(-3.36)	(-2.11)	(-4.28)	(-2.26)	(-4.34)	(-2.16)
Bandwidth	250	250	500	500	1000	1000
Order Polynomial	1	1	2	2	3	3
N	28,241	43,674	44,888	68,407	58,342	87,894
R^2	0.162	0.191	0.164	0.197	0.166	0.205
Panel B: Median Splits: House Price Growth (1960-1990)						
	(1)		(2)		(3)	
	Above	Below	Above	Below	Above	Below
$\mathbb{1}(dist < 0)$	-0.023	-0.073***	-0.036**	-0.067***	-0.027*	-0.064***
	(-1.39)	(-4.58)	(-2.04)	(-5.05)	(-1.96)	(-5.25)
Bandwidth	250	250	500	500	1000	1000
Order Polynomial	1	1	2	2	3	3
N	39,253	32,662	61,857	51,438	80,535	65,701
R^2	0.191	0.169	0.201	0.172	0.210	0.175

This table repeats the analysis from Table 2 for mutually exclusive subsets of the sample. Panel A partitions the sample at the median state level house price growth from 1940 to 1960. Panel B considers the state level house price growth from 1960 to 1990. The classification of states is reported in Internet Appendix Table IA.1. For both panels, we estimate

$$Y_i = \alpha + \beta \mathbb{1}(dist_i < 0) + \sum_{n=1}^{N} \theta_n dist_i^n + \mathbb{1}(dist_i < 0) \times \sum_{n=1}^{N} \gamma_n dist_i^n + \phi_j + \varepsilon_i$$

where Y_i is the outcome of interest, $dist_i$ is the distance of a census block to the HOLC boundary, and ϕ_j are region fixed effects. We control for continuous changes in the outcome variable with a N degree polynomial of *dist* on each side of the threshold that minimizes the Bayesian information criterion. Negative distances indicate a lower HOLC rating relative to adjacent areas. Reported t-statistics in parentheses are heteroscedasticity-robust and clustered by MSA. ***p<0.01, **p<0.05, *p<0.1.

TABLE 6–1990 Neighborhood Characteristics

	(1)	(2)	(3)
		Panel A: Vacancy Rates	
$\mathbb{1}(dist < 0)$	0.379**	0.523***	0.415***
	(2.40)	(3.68)	(3.01)
N	78,158	122,953	158,858
R^2	0.042	0.045	0.047
		Panel B: Owner-Occupied Rates	
$\mathbb{1}(dist < 0)$	-1.651***	-1.935***	-1.931***
	(-2.91)	(-3.45)	(-3.06)
N	77,971	122,661	158,469
R^2	0.112	0.121	0.126
Bandwidth	250	500	1000
Order Polynomial	1	2	3
		Panel C: Housing Units per Structure	
$\mathbb{1}(dist < 0)$	0.017	-0.056	-0.056
	(0.12)	(-0.31)	(-0.27)
N	78,059	122,783	158,629
R^2	0.004	0.005	0.006
Bandwidth	250	500	1000
Order Polynomial	1	2	3

This table reports the estimates of the discrete change in 1990 neighborhood characteristics at the boundary between HOLC regions. Panel A examines the percent of households reported vacant (*Vacancy Rates*). Panel B examines the percent of households reported as being owner-occupied (*Owner-Occupied Rates*). Panel C examines the number of housing units per structure (*Housing Units per Structure*). For each panel we estimate

$$Y_i = \alpha + \beta \mathbb{1}(dist_i < 0) + \sum_{n=1}^{N} \theta_n dist_i^n + \mathbb{1}(dist_i < 0) \times \sum_{n=1}^{N} \gamma_n dist_i^n + \phi_j + \varepsilon_i$$

where Y_i is the outcome of interest, $dist_i$ is the distance of a census block to the HOLC boundary, and ϕ_j are region fixed effects. We control for continuous changes in the outcome variable with a N degree polynomial of *dist* on each side of the threshold that minimizes the Bayesian information criterion. Negative distances indicate a lower HOLC rating relative to adjacent areas. Reported t-statistics in parentheses are heteroscedasticity-robust and clustered by MSA. ***p<0.01, **p<0.05.

TABLE 7–1990 Resident Characteristics

	(1)	(2)	(3)
	Panel A: Percent Overcrowded		
$\mathbb{1}(dist < 0)$	-0.117	-0.055	-0.181*
	(-1.08)	(-0.72)	(-1.87)
N	77,971	122,661	158,469
R^2	0.029	0.032	0.036
	Panel B: Percent Minority		
$\mathbb{1}(dist < 0)$	0.018	-0.011	0.685
	(0.03)	(-0.02)	(0.97)
N	77,971	122,661	158,469
R^2	0.095	0.102	0.106

This table reports the estimates of the discrete change in 1990 resident characteristics at the boundary between HOLC regions. Panel A examines the percent of households with at least 1.51 persons per room (*Percent Overcrowded*). Panel B examines the percent of households with a non-white head (*Percent Minority*). For each panel we estimate

$$Y_i = \alpha + \beta \mathbb{1}(dist_i < 0) + \sum_{n=1}^{N} \theta_n dist_i^n + \mathbb{1}(dist_i < 0) \times \sum_{n=1}^{N} \gamma_n dist_i^n + \phi_j + \varepsilon_i$$

where Y_i is the outcome of interest, $dist_i$ is the distance of a census block to the HOLC boundary, and ϕ_j are region fixed effects. We control for continuous changes in the outcome variable with a N degree polynomial of *dist* on each side of the threshold that minimizes the Bayesian information criterion. Negative distances indicate a lower HOLC rating relative to adjacent areas. Reported t-statistics in parentheses are heteroscedasticity-robust and clustered by MSA.

Pockets of Poverty: The Long-Term Effects of Redlining

Ian Appel and Jordan Nickerson

Internet Appendix

Panel A: 500 Meter Bandwidth

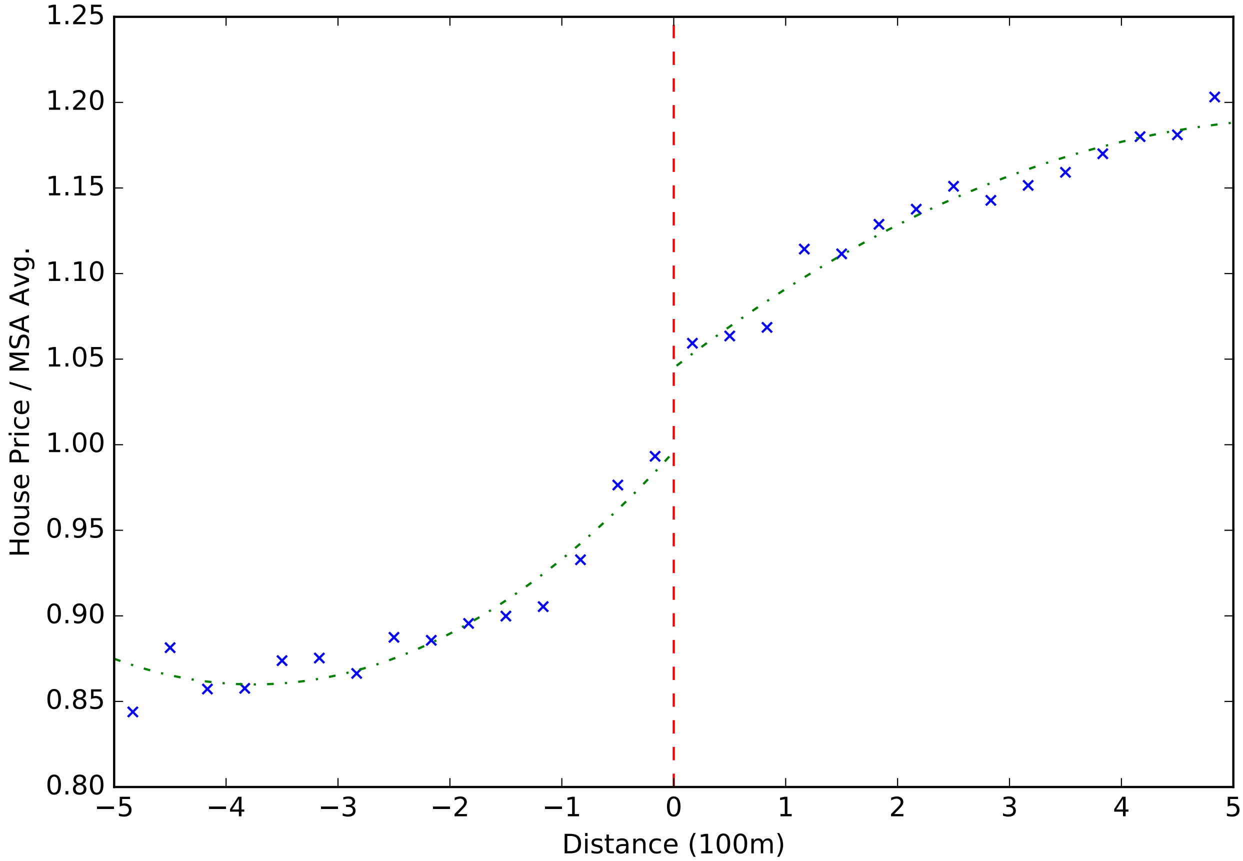
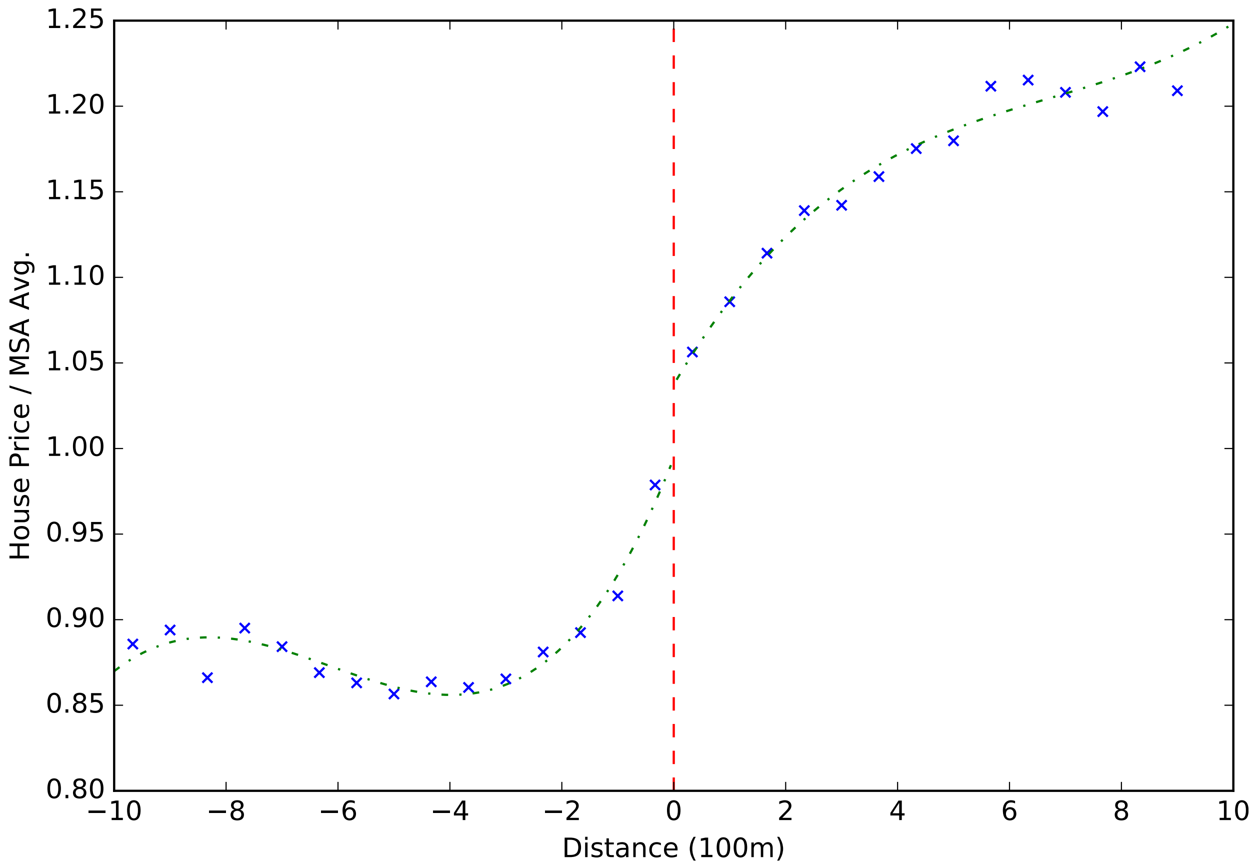


Figure IA.1. Excluding Rivers, Rails, and Landmarks

This figure shows the relation between the distance to HOLC boundaries and 1990 house prices (scaled by MSA average). Observations for which there is a river, railroad, or landmark between it and the nearest boundary are excluded. Panel A restricts the sample to observations within 500 meters of HOLC boundaries and fits second-order polynomials for each side of the threshold. Panel B expands the sample to observations within 1000 meters of HOLC boundaries and fits third-order polynomials.

Panel B: 1000 Meter Bandwidth



Panel A: 1940 House Prices

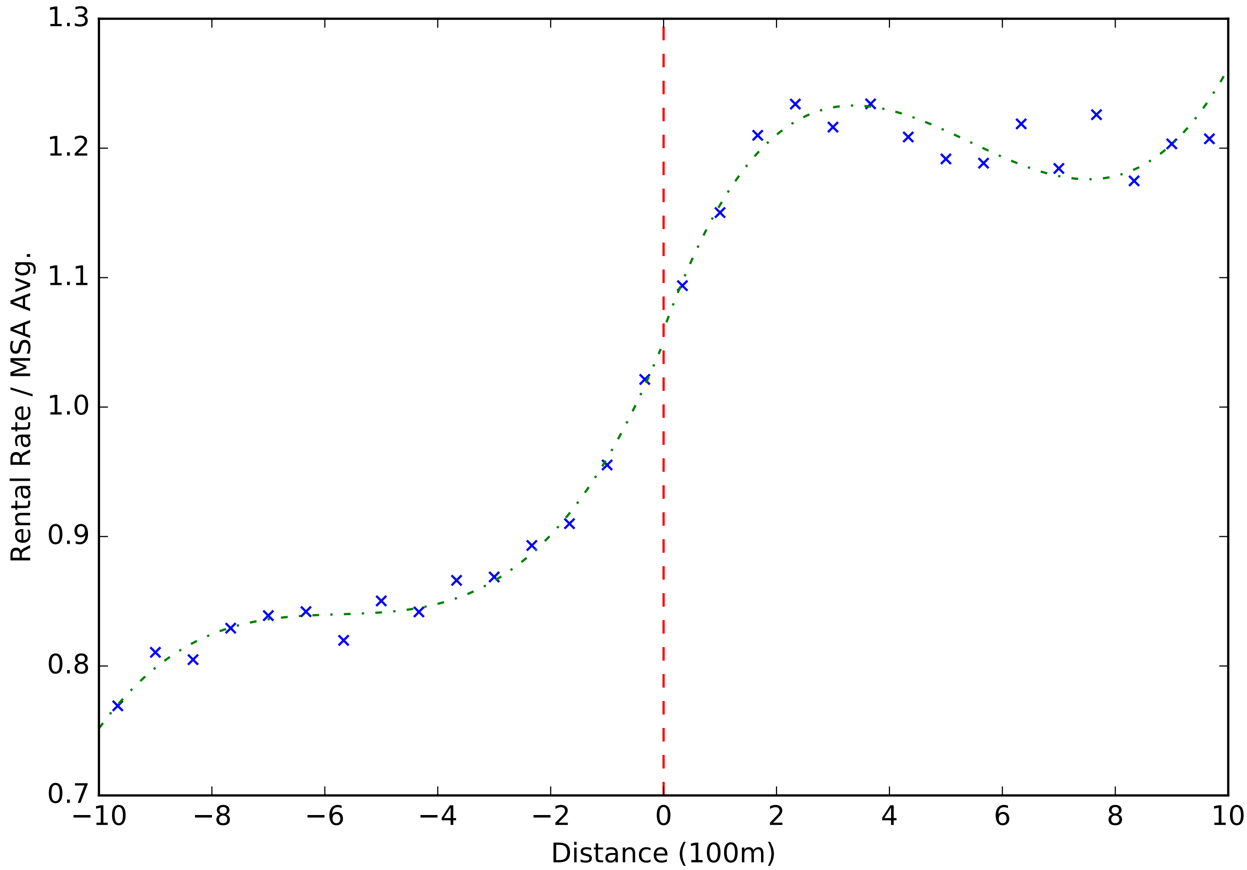
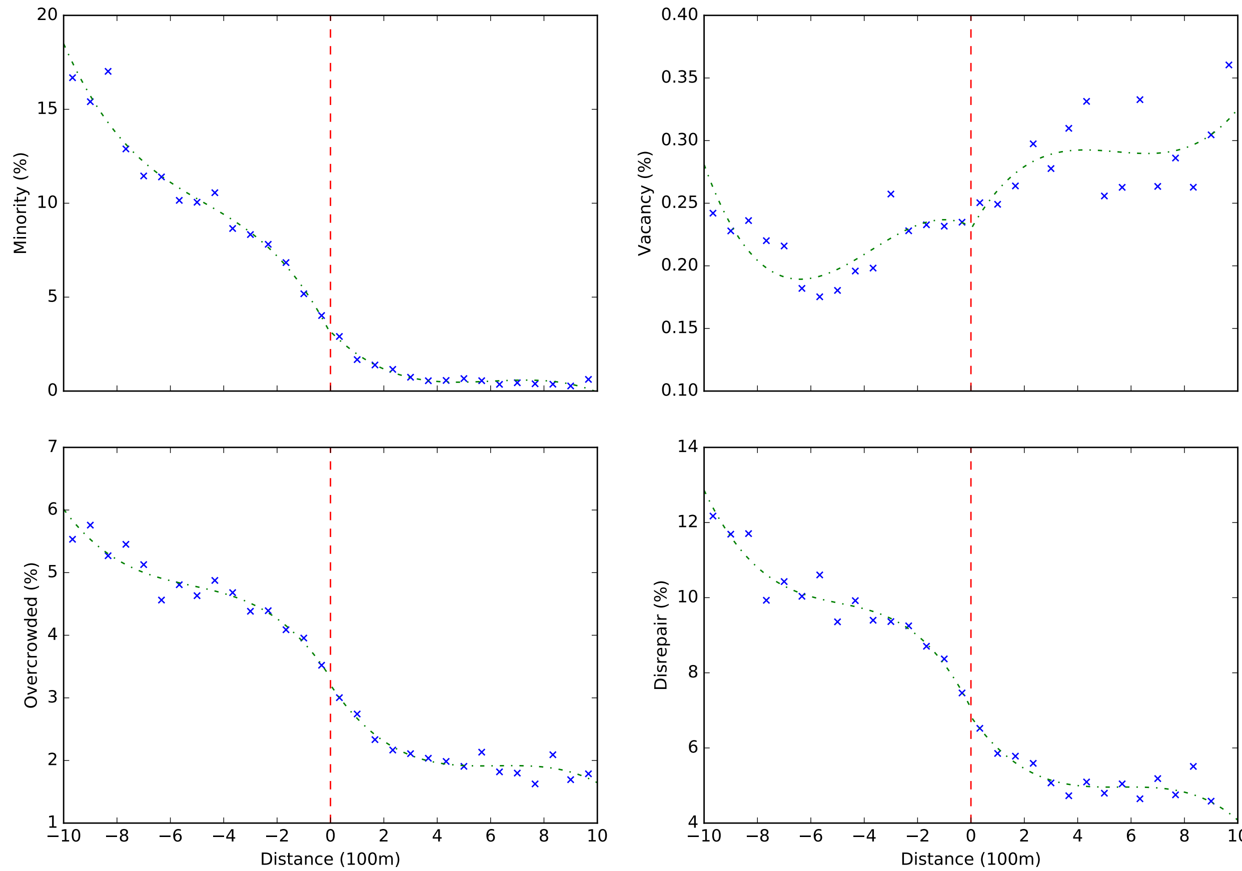


Figure IA.2. Wide Bandwidth for 1940 Characteristics
This figure shows the relation between the distance to HOLC boundaries and 1940 housing characteristics. The sample includes include all observations within 1000 meters of HOLC boundaries. Panel A reports the rental rate (scaled by MSA average). Panel B reports the percent of households with a non-white head (*Minority*), households reported vacant (*Vacancy*), households with at least 1.51 persons per room (*Overcrowded*), and households reported as requiring repair (*Disrepair*). Third-order polynomials estimated separately for each side of the threshold are reported by the dashed lines.

Panel B: 1940 Housing Characteristics



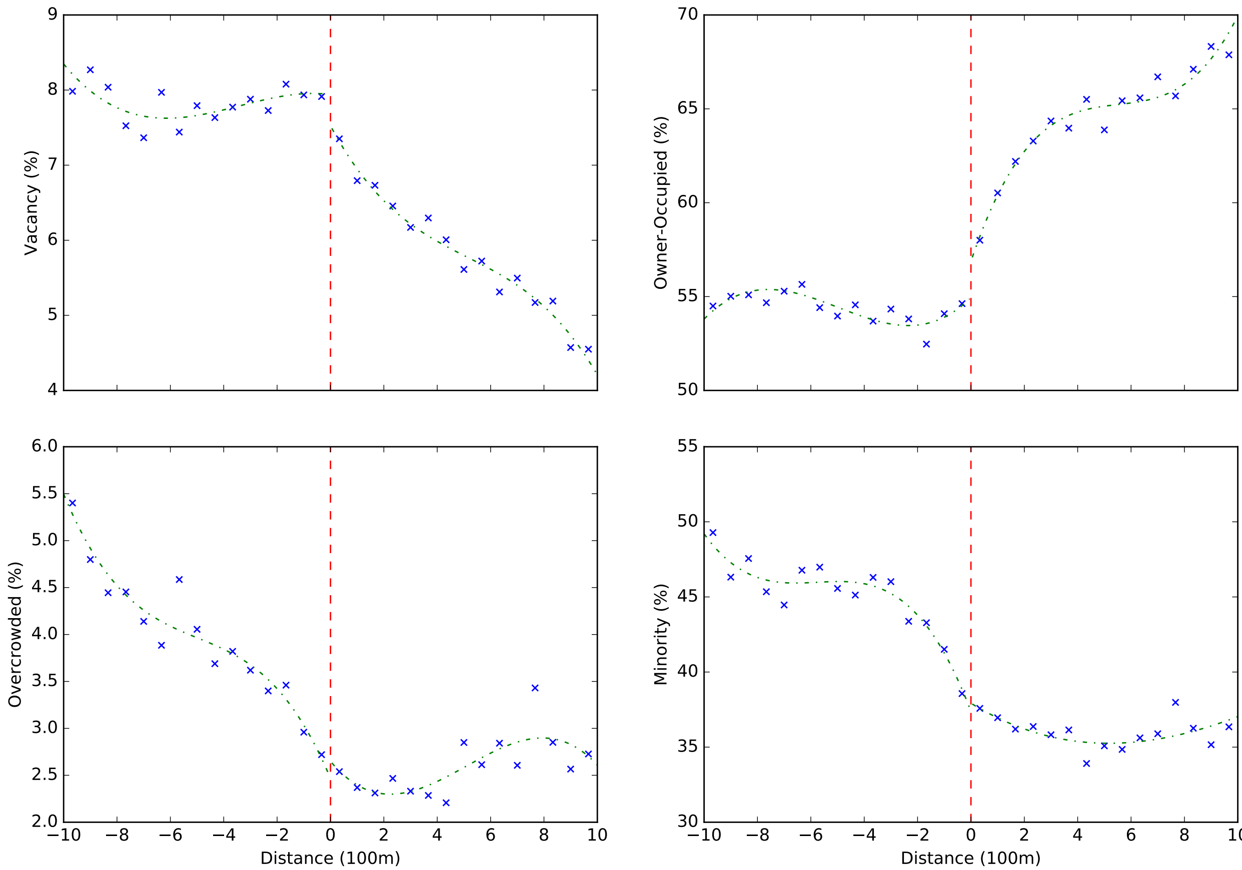


Figure IA.3. Wide Bandwidth for 1990 Characteristics

This figure shows the relation between the distance to HOLC boundaries and 1990 housing characteristics. The sample includes all observations within 1000 meters of HOLC boundaries. The outcomes are the percent of households reported vacant (*Vacancy*), households that are owner-occupied (*Owner-Occupied*), households with at least 1.51 persons per room (*Overcrowded*), and households with a non-white head (*Minority*). Third-order polynomials estimated separately for each side of the threshold are reported by the dashed lines.

Table IA.1–House Price Growth Subsamples

State	H.P. Growth: 1940-1960	Above Median	H.P. Growth: 1960-1990	Above Median
Alabama	2.524	1	1.618	0
California	2.027	1	3.358	1
Connecticut	1.715	0	2.761	1
Delaware	1.411	0	2.093	1
Illinois	2.123	1	1.428	0
Indiana	2.012	1	1.370	0
Iowa	2.085	1	1.201	0
Kansas	2.544	1	1.456	0
Kentucky	2.009	1	1.486	0
Louisiana	3.585	1	1.417	0
Maryland	1.860	0	2.539	1
Massachusetts	1.704	0	3.059	1
Michigan	1.983	0	1.310	0
Minnesota	2.003	1	1.498	0
Missouri	2.157	1	1.423	0
New Jersey	1.633	0	2.697	1
New York	1.650	0	2.229	1
Ohio	1.859	0	1.229	0
Oregon	2.119	1	1.658	1
Pennsylvania	1.506	0	1.771	1
Texas	2.466	1	1.753	1
Virginia	1.942	0	2.186	1
Washington	2.355	1	2.068	1
West Virginia	1.527	0	1.636	1
Wisconsin	1.848	0	1.287	0

This table reports the classification of states into above- and below-median house price growth from 1940-1960, and 1960-1990. Data are from U.S. Census of Housing.