Persistence of mortgage lending bias in the United States: 80 years after the Home Owners’ Loan Corporation security maps

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ABSTRACT

Housing discrimination and racial segregation have a long history in the United States. The 1930s Home Owners’ Loan Corporation (HOLC) “residential security maps,” recently digitized, have become a popular visualization of Depression-era mortgage lending risk patterns across American cities. Numerous housing policies have since been instituted, including the Home Mortgage Disclosure Act (HMDA), but mortgage lending bias persists. The degree to which detailed spatial patterns of bias have persisted or changed along with urban change is not well understood. We compare historic HOLC grades and contemporary levels of mortgage lending bias using spatially detailed HMDA data. We further examine the relationship between HOLC risk grades and contemporary racial and ethnic settlement patterns. Results suggest that historical mortgage lending risk categorizations and settlement patterns are associated with contemporary mortgage lending bias and racial and ethnic settlement patterns. Concerted and deliberate efforts will be needed to change these patterns.

KEYWORDS

Mortgage lending bias; racial segregation; settlement patterns; redlining; housing discrimination

Introduction

Housing discrimination and residential racial segregation have a long history in the United States. Many scholars have studied the role of federal housing policies in creating persistent patterns of spatial inequality, including the iconic “residential security maps” created by the Home Owners’ Loan Corporation (HOLC) in the 1930s to indicate mortgage lending risk across American cities (Krysan & Crowder, 2017; Rothstein, 2017; Taylor, 2019). Recent work has also highlighted the key role of the Federal Housing Administration (FHA), which similarly undertook to review data on America’s neighborhoods and instituted its own practice of exclusionary lending just prior to the HOLC (Fishback et al., 2021). As a response to the challenge of housing discrimination, policies were instituted to support fair housing practices and bring more transparency to mortgage lending in the 1960s and 1970s. Despite these policy initiatives, mortgage lending bias still exists today. Recent work has indicated that HOLC appraised cities are more segregated than their ungraded counterparts (Faber, 2020) and that HOLC appraisals are associated with lower rates of homeownership and property value decline (Aaronson et al. 2020; Appel & Nickerson, 2016), reduced housing supply and population (Krimmel, 2018) and different housing finance
outcomes (Faber, 2020a). While evidence indicates that HOLC maps may not be causally related to ongoing patterns of mortgage lending bias and racial segregation, these maps represent a rich source of information about patterns of bias and segregation at the time, particularly as another potential source, the FHA, destroyed records of locations of loans (Fishback et al., 2021) and given that spatially disaggregated census data from the time is limited.

Although there are indications that historical patterns have persisted over time, spatial patterns of historical mortgage lending bias represented in these HOLC maps have not been compared with current mortgage lending bias measures across the country. In this paper, we revisit the history of mortgage lending bias, housing policies, and segregation patterns in the United States. We then present an empirical analysis of recently digitized HOLC data, contemporary mortgage lending bias metrics, and both historical and contemporary racial and ethnic settlement patterns to understand the degree to which patterns have persisted despite housing policies and urban change over time. We conclude with a discussion of the implications of our results and opportunities to address mortgage lending bias through practice or policy change.

Reconstruction and the Great Migration

Racial segregation, now a prominent feature of many American cities, did not exist prior to the Civil War. Segregation took hold after the end of the reconstruction era (1865–1877) as southern states instituted segregationist laws and policies during the Jim Crow period (1877–1950; Tolnay, 2003). Beginning around 1910, large numbers of Black/African American populations migrated from the southern to the northern states in search of new opportunities. Known as the Great Migration, this migration is generally described as taking place in two waves, from 1910–1940 and 1940–1970 (Tolnay, 2003). Reasons for the migration are numerous, including Jim Crow laws, race-based violence, and increasing mechanization of agriculture (Tolnay, 2003). In addition, the Great Migration was fueled by new employment opportunities in the north. For years, large numbers of European migrants had arrived in northern cities to work in factories and other low-wage jobs; however, with World War I came new restrictions on immigration, leading northern employers to consider southern Blacks as potential workers for the first time (Collins, 1997; Tolnay, 2003). Collins (1997) argues that a combination of mass European immigration and northern hiring practices that favored White immigrants over Blacks “may have delayed the Great Migration by decades.”

As a result of the Great Migration, Black populations in northern cities grew significantly. For example, in Milwaukee, Wisconsin, from 1910 to 1930, the Black population grew by 665% (Gurda, 2006). By 1950, 2.5 million southern-born Black individuals were living outside of the southern region (Tolnay, 2003). Further, as the migrants arrived, they tended to live in proximity to family and friends who had arrived earlier, and they were also constrained by limited housing choices, resulting in the concentration of Black populations within specific neighborhoods of northern cities (Tolnay, 2003; White et al., 2005). The migration began to slow during the 1960s and was mostly complete by the 1970s (Tolnay, 2003). While migrants traveled to many destinations, some destinations—such as large metropolitan areas in the Northeast (e.g., Philadelphia and New York City) and the Midwest (e.g., Chicago, Detroit)—were more popular due to transportation routes, the
presence of Black-serving community organizations, close proximity to friends or family, and other factors (Tolnay, 2003). Figure 1 illustrates changes in Black population between 1910 and 1950 and the major railroad routes taken by Black migrants from the south to northern cities.

The New Deal, the HOLC, and the FHA

In the 1930s, during this era of migration, the federal government first engaged in mortgage lending in the United States. An entity called the Home Owners’ Loan Corporation (HOLC) was created in 1933 as part of Franklin Delano Roosevelt’s New Deal in order to address the growing problem of home foreclosures during the Great Depression (Hillier, 2003). The HOLC purchased mortgages and reissued them with low down payments and interest rates to encourage home ownership (Hillier, 2003; Rothstein, 2017). Around 1935, HOLC’s parent organization, the Federal Home Loan Bank Board (FHLBB), created a new program to undertake a systematic appraisal of mortgage lending risk across 239 U.S. cities, leveraging HOLC staff, local realtors, and lenders (Hillier, 2003). This project included the creation of metropolitan area “residential security maps” (Greer, 2013) that visualized bounded HOLC areas within each metropolitan area. Auditors assigned each neighborhood a “grade” according to the risk it posed for investors. These grades were displayed on maps, with areas shaded green for “best,” blue for “still desirable,” yellow for “declining,” and red for “hazardous.” Auditors would also indicate in area reports a wide range of additional variables about the populations and housing in each area. Included in these variables were the percent “Negro” and the percent “foreign families,” making these maps a rare source of small area population estimates by race across numerous U.S. metropolitan areas from the early twentieth century.

In 1934, just prior to the HOLC appraisal project, the Federal Housing Administration (FHA) was created to provide home financing among other pursuits. It also conducted data review activities and financed mortgages, with recent evidence suggesting biased lending patterns that predated the HOLC appraisals (Fishback et al., 2021). The HOLC maps, recently digitized and available for cities across the country in a similar format, have become a popular visualization of Depression-era mortgage lending risk patterns across American cities. These maps captured patterns of neighborhood investment and racial segregation that existed at the time and represent a valuable data source for understanding historical patterns.

There is some debate about the influence of these maps on lending practices. The HOLC maps were rediscovered by historian Kenneth Jackson, as he prepared his 1985 work Crabgrass Frontier; he argued that the FHA and private lenders had obtained copies of the documents and that these influenced their lending decisions (Jackson, 1985). However, this influence has been questioned, given (1) evidence that HOLC did not practice redlining in its own lending practices, (2) lenders were already avoiding areas considered to be “high risk” before the maps were published, and (3) the maps may not have been widely available in order to influence practice and there were other, sometimes better, data sources available that could have been used in this decision-making (Hillier, 2003). However, recent studies have indicated that HOLC appraised cities have become more segregated than their ungraded counterparts (Faber, 2020b) and that HOLC appraisals may have impacted homeownership, property values, housing supply, population, and housing finance
Figure 1. Great Migration primary routes and destinations.
Sources: National Historical GIS Data (2021); U.S. National Park Service (2020).
outcomes in the long term (Aaronson et al., 2020; Appel & Nickerson, 2016; Faber, 2020a; Krimmel, 2018). Regardless of the influence of the HOLC maps, housing discrimination has continued to be an issue for many years after the HOLC, and the HOLC maps provide a systematic appraisal of mortgage lending practices with neighborhood specific detail during this important period across the U.S., providing an important historical comparison for modern day mortgage lending practices.

**De jure discrimination and racial housing covenants**

As Rothstein notes, both before and after the HOLC project, discrimination was de jure, or legal, for many years (Rothstein, 2017). For example, racially restrictive covenants (private agreements to prohibit non-Whites from occupying and owning property, usually in the form of agreement articles between seller and buyer of properties and reinforced by homeowner associations) were pervasive. Covenants have been described as one of the early inventions of the emerging modern real estate industry in the 1900s to support adherence to its segregationist ideology that was embraced and fostered by The National Association of Real Estate Boards (NAREB; Gotham, 2000; Jones-Correa, 2000). Many researchers argue that the diffusion of racially restrictive covenants was a response to the Supreme Court’s decision to overrule racial zoning practices (Jones-Correa, 2000; Spear, 1967). Community builders and homeowner associations determined to create and preserve racially segregated neighborhoods started adopting exclusionary tools, and by the 1920s these restrictive covenants were spread across the country (Jones-Correa, 2000). This segregationist agenda to foster racial homogeneity was even added into the codes of ethics of the NAREB in 1924 as a responsibility of a realtor, and homeowner associations pushed to revoke the licenses of realtors who did not enforce racial restrictions (Gotham, 2000). Segregation manifested more visibly in large cities with higher percentage of Black population, such as New York and Chicago; however, as Hirsch (1986) points out, local real estate boards were the “gatekeepers” responsible for enforcing exclusionary practices and therefore even in a city like Milwaukee with a small Black population, they created a network of restrictive covenants and 90% of the plats filed after 1910 contained restrictions to ban the sale of property to Black people (Hirsch, 1986). In 1948, the Supreme Court’s decision on *Shelley v. Kraemer* overruled the legal enforcement of restrictive covenants, but this did not stop the practice by real estate agents. Many scholars have pointed out the significance of the racial discourse borne out of a segregation ideology in the emerging real estate industry that propagated a negative relationship between minorities, behavior, neighborhood stability and property value, paving the way for the institutionalized discrimination that persists to this day (Gotham, 2000; Sister Claire Marie, 1953).

Although covenants were written years prior to the HOLC maps, a recent study suggests that agents weighed them heavily when determining between blue and yellow areas (Santucci, 2019). Decades later, recent studies show that covenanted properties have higher present day value and that census blocks with covenanted properties are associated with lower Black homeownership (Sood et al., 2019). Although racially restrictive covenants are not enforceable in today’s courts, attempts to remove the language from the deeds have been largely unsuccessful and racially homogenous neighborhoods remain segregated due to continued mortgage discrimination and lack of enforcement of the Fair Housing Act (Shepherd, 2020).
**Fair housing and the HMDA**

Fair housing laws passed in the 1960s and 1970s sought to address housing discrimination. The passage of the Fair Housing Act in 1968, in the era of Rev. Dr. Martin Luther King Jr.’s assassination, banned racial discrimination in the housing market (Massey, 2015). This legislation, a major milestone for the civil rights movement, was anticipated to lead to desegregation. However, the envisioned enforcement power designated to the federal department of Housing and Urban Development (HUD) was not enacted, making its goals very hard to achieve in practice; moreover, this legislation did not target mortgage lending discrimination (Massey, 2015; Smith & Cloud, 2010). The passage of the Equal Credit Opportunity Act in 1974 and the Community Reinvestment Act in 1977 prohibited mortgage lending discrimination against individuals and minority neighborhoods (Lief & Goering, 1987).

In 1975, the Home Mortgage Disclosure Act was passed. This law required mortgage lending institutions to submit lending data to the Federal Financial Institutions Examination Council (FFIEC) and generally sought to bring transparency to mortgage lending in the U.S. Originally, HMDA required aggregated statistics of the lending activity of institutions by census tracts and applicants’ information was not collected (McCoy, 2007). The HMDA has been modified several times since 1980, with the most sweeping legislative amendments occurring in 1989, requiring the disclosure of application and loan-level information for home loans (Avery et al., 2007). Starting in 1990, new variables such as income of applicant, sex and race of applicant and co-applicant, and type of action taken (approved, denied, or other actions), were mandatorily collected and released as a part of the HMDA dataset. The Regulation C revisions made by the Federal Reserve Board in 2002 expanded the types and the amount of information made available about home lending. The most important change was to require lenders to disclose pricing information for loans with prices (interest rates and fees) above designated thresholds (referred as “high-priced loans”) beginning with the 2014 data (Avery et al., 2007). Other new information being reported include lien status (first, junior, or unsecured), whether a loan is subject to the protections of the Home Ownership and Equity Protection Act (HOEPA) of 1994, and whether preapproval for home purchase loans was requested or not. Ethnicity (Hispanic or Latino, or not) of applicant and co-applicant was a new variable, separated from the race variable in HMDA data prior to 2004, which contained information about either race or national origin and regarded Hispanic as one of its categories (Avery et al., 2007). HMDA variables have again recently been expanded beginning with data for 2018, including variables directly considered by underwriters such as the automated underwriting system (AUS) recommendation, the debt to income ratio, and the credit score (Bhatta et al., 2021).

**HMDA data and housing discrimination research**

Most studies investigating the significance of race and ethnicity in the U.S. mortgage lending market have used HMDA data in their analyses. Prior to 1990, researchers used HMDA data (restricted to the number of loans and dollar flows at the census tract level) to find evidence of discrimination by examining whether census tract race composition affects mortgage flows, controlling for area economic variables (Ahlbrandt, 1977; Hutchinson et al., 1977). The logic is that if mortgage lending decisions rely solely on area economic factors, then area race effects would be insignificant. However, if there are lower loan flows in minority areas when minority areas and non-minority areas have equivalent economic
conditions, racial redlining may be inferred. This approach was criticized on multiple dimensions including the scale of analysis, lack of demand side data, and potential confounding by other factors (e.g., greater residential turnover) contributing to high lending risk (Benston, 1979; Holmes & Horvitz, 1994). When HMDA started requiring lending institutions to collect and release applicant-level data in 1990, it allowed researchers to examine differential access to housing market credits at the individual level. The findings have generally revealed that compared to Whites, minority applicants were less likely to have their mortgage loans approved (Canner & Smith, 1991; Cherian, 2014; Hubbard et al., 2011; Holloway, 1998; Mendez et al., 2011; Squires & Vélez, 1996; Wheeler & Olson, 2015), and more likely to be granted high-cost or subprime loans (Bocian et al., 2008; Faber, 2013; Faber, 2018; Hubbard et al., 2011).

Although these studies have shed light on the racial and ethnic differentials in access to housing market credit, scholars have questioned the usefulness of HMDA data for identifying discrimination. This is due to the fact that many important variables during the underwriting process, including applicant’s wealth and creditworthiness (Delis & Papadopoulos, 2019; Ross & Yinger, 2002), as well as the loan’s cost structure (e.g., loan-to-value ratio, down payment size, note rate; Avery et al., 2007; Turner & Skidmore, 1999), have not been reported in HMDA data. In order to mitigate the omitted variables bias, some studies have augmented HMDA data with additional information about applicants and properties from local markets. Results from these studies showed that race still played a significant role in the mortgage lending decision, although racial and ethnic disparities around access to mortgage credits were weaker than those estimated using HMDA data alone (Munnell et al., 1996; Tootell, 1996). However, it has been argued that even with augmented data, endogeneity of omitted variables related to race or ethnicity still persists and that findings from local markets may not be generalizable to the entire U.S. (Delis & Papadopoulos, 2019). In part due to these data issues, decades after the first release of HMDA data, research on racial and ethnic discrimination in the U.S. credit and housing markets is still contentious and inconclusive (Dymski, 2006). Preliminary work has used the 2018–2019 HMDA data to examine the influence of long sought after variables (credit score, debt to income ratio, AUS recommendation) on explaining the racial gap in mortgage lending, finding that these factors explain a substantial amount of the racial gap in mortgage approvals but leave some variation unexplained (Bhutta et al., 2021).

Despite limitations, HMDA data remain the most comprehensive publicly available database for studying racial, ethnic and geographical biases in mortgage lending in the U.S. nationally. Discrimination, in its pure legal sense, in contemporary housing credit markets may be difficult to determine but understanding the racial and ethnic geographies of mortgage lending and how historical policies correspond to modern day patterns of mortgage lending bias and racial and ethnic settlement patterns is still of great relevance as solutions are sought.

**Contribution of this paper**

The recent digitization of the HOLC maps by Mapping Inequality (Nelson et al., 2016), in tandem with the availability of HMDA data at the census tract level for all U.S. cities, offers an opportunity to examine the association between early twentieth century mortgage risk estimates and racial settlement patterns and contemporary patterns of mortgage bias and racial segregation. In this paper, we examine the persistence of housing discrimination after the HOLC security maps through a direct comparison of HOLC grades and contemporary
levels of mortgage lending bias as estimated from HMDA data. We further investigate the role of both historical and contemporary racial and ethnic settlement patterns. Of note, we do not indent to address causality in this analysis, but rather to quantify and illustrate associations between historical and contemporary practices.

We pose two research questions:

**Question 1:** Do HOLC lending risk grades predict contemporary levels of mortgage lending bias by race, ethnicity, or property location?

**Hypothesis A:** HOLC areas with more favorable grades ("best," "still desirable") will have higher levels of present-day racial and ethnic bias in mortgage lending when compared to less favorable HOLC grades ("declining," "hazardous"). Rationale: highly rated HOLC areas are likely to have attracted greater economic investment prior to and after the HOLC maps were drawn, as well as the settlement of wealthier, white populations; the resistance of these communities to racial and ethnic minority populations settling in these areas is likely to be greater.

**Hypothesis B:** HOLC areas with more favorable grades ("best," "still desirable") will have lower levels of present-day property location-based bias when compared to less favorable HOLC grades ("declining," "hazardous"). Rationale: Highly rated HOLC areas are likely to have attracted economic investment and the settlement of wealthier, white populations in the years since the HOLC maps were drawn; investment is likely to have led to better maintained housing stock that mortgage lenders are more likely to finance; from a racial discrimination perspective, limited settlement of populations of color in these areas would make contemporary redlining of these areas less likely.

**Question 2:** Do HOLC lending risk grades predict contemporary racial and ethnic settlement patterns, regardless of historical settlement patterns and contemporary levels of mortgage lending bias?

**Hypothesis C:** HOLC areas with more favorable grades ("best," "still desirable") will have higher percentages of contemporary non-Hispanic White populations and lower percentages of Black and Hispanic populations when compared to less favorable HOLC grades ("declining," "hazardous"), including after adjustment for historical settlement patterns and contemporary levels of mortgage lending bias. Rationale: highly rated HOLC areas are likely to have attracted economic investment and the settlement of wealthier, white populations in the years since the HOLC maps were drawn; populations of color are less likely to have been able to obtain mortgages in these areas; long term settlement of people of color in these areas is unlikely.

**Methods**

**Study area**

The study area is defined as cities with HOLC boundaries that fall within the boundaries of today’s 100 most populated U.S. Metropolitan Statistical Areas (MSAs). The 100 most populated U.S. MSAs in 2013 were identified. Then, digitized and georectified HOLC
maps and “area descriptions” were sought for each of these cities from Mapping Inequality (Nelson et al., 2016). Of these 100, only 53 MSAs contained available HOLC boundaries, including a total of 105 cities. Eighty-six of the cities with boundaries also included area descriptions. We used boundaries and area descriptions in 1937 for 85 cities. For St. Louis, the 1940 boundary and area descriptions were employed because the 1937 area descriptions were narrative and did not contain the information about historical settlement patterns needed for addressing research questions. Thus, 86 HOLC cities in 48 current day MSAs are included in our study, containing a total of 5,370 individual HOLC areas (the small neighborhood-like areas comprising each HOLC city map are henceforth referred to as HOLC “neighborhoods” for clarity). HOLC boundary files for these cities were used to operationalize the study area, and all measures reported here are estimated at the HOLC neighborhood level. Among the 5,370 areas in the analytical dataset, 53 areas were missing the racial population composition variables %negro and %foreign and thus these areas were excluded from the models containing these variables but were included in the other analyses. For the models involving derived census race variables in 2010, 123 areas were excluded due to having missing or zero value (37 missing and 86 zeros). For the models involving derived census ethnicity variable in 2010, 84 areas were excluded due to having missing or zero value (37 missing and 47 zeros).

Measures

**Historical mortgage lending risk**

Historical mortgage lending risk was measured using HOLC neighborhood “risk” grades: (A) “best” (green), (B) “still desirable” (blue), (C) “declining” (yellow), and (D) “hazardous” (red).

**Contemporary mortgage lending bias**

Current day racial, ethnic, and property location-based bias in mortgage lending patterns were estimated for each HOLC neighborhood using Home Mortgage Disclosure Act (HMDA) data in 2007–2013. Each HMDA record includes applicant race/ethnicity, sex, income, loan amount, outcome of the loan application (e.g., denial), and location (census tract) of the property. Racial and ethnic bias measures are estimated as the odds ratio of denial of a mortgage application from a Black (or Hispanic) applicant compared to a White applicant using a logistic regression model-based, spatial filtering approach as has been described in the literature (Beyer et al., 2016). Models control for the applicant’s sex, and the ratio of the loan amount to the applicant’s gross annual income. Location bias is estimated as the odds ratio of denial of a mortgage application for local properties (within the spatial filter), as compared to the MSA as a whole, adjusting for the applicant’s sex and the loan to income ratio. To apply a spatial filtering approach, a grid of estimation points is placed across each MSA, and a circular filter expands, based on a specified threshold, to obtain data from multiple census tract centroids until a stable statistic is estimated for each grid point using logistic regression models specified for each HMDA measure. The statistic is mapped as a continuous surface using an inverse distance weighting method. Because the measures are continuously defined, they are easily summarized by different types of boundaries. This is important, as the HOLC boundaries created in the 1930s do not correspond to any
current day administrative boundaries. Thus, HMDA bias measures (raster pixel values) were averaged within each HOLC defined neighborhood boundary using the geographic information systems (GIS) software to create a HOLC neighborhood level measure.

**Historical racial and ethnic settlement patterns**

Historical racial and ethnic settlement patterns were derived from HOLC area descriptions. Area descriptions for each HOLC neighborhood are generally comprised of auditor observations regarding the population and housing characteristics of each neighborhood, often including narrative notes. We extracted two demographic variables, percent “Negro” and percent foreign-born families, for each neighborhood. We downloaded georectified images of residential security maps and shapefiles of HOLC neighborhood boundaries for each city from the Mapping Inequality website (Nelson et al., 2016). By cross-validating HOLC area description scans, residential security maps and boundary shapefiles, we corrected geometry or attribute-related errors in shapefiles observed in several situations (17 out of 86 cities): (1) where the polygons delineating neighborhood boundaries did not match the corresponding neighborhoods in the security map (shapefiles were modified); (2) where the values of the grades in the area descriptions did not correspond with the labels seen in the security map (we used the map indicated category); (3) where HOLC neighborhoods were placed in a city adjacent to another city the neighborhoods truly belonged to (we changed the city name). In addition, we created a crosswalk (see supplemental materials) for converting non-numeric, textual demographic information (e.g., Few, Very few, Nominal) recorded in area descriptions to numeric values so that the corresponding neighborhoods could be included in the analyses instead of simply dropping them. The compiled database was quality-checked by multiple persons in our research group to ensure the neighborhood boundaries, grades and historical racial and ethnic population data were as accurate and complete as possible. Finally, only the unique HOLC neighborhoods without missing demographic and HOLC-grade attributes that fell within an MSA were kept in the analytical dataset.

**Contemporary racial and ethnic settlement patterns**

U.S. Census Bureau data were used to measure contemporary population distributions by race and ethnicity in HOLC boundaries. We obtained block level population data from the 2010 decennial census and aggregated total population and numbers of people by race or ethnicity to HOLC neighborhoods to calculate demographic percentages, including percent Black and percent Hispanic. Because census block boundaries do not align with HOLC areas’ boundaries, the centroid of each block was used to assign blocks to HOLC neighborhoods.

**Analysis**

Descriptive statistics were used to describe HMDA measures, historical settlement patterns, and contemporary settlement patterns by HOLC grade. Graphical plots were used to visualize relationships between HOLC grade and HMDA measures, including across U.S. census regions (Northeast, Midwest, South, West; see Figure 1). Since the assumptions of normality and homogeneity were violated, we adopted a non-parametric Anova using Kruskal-Wallis to test the null hypothesis, for each of the HMDA measures (racial, ethnic, and location bias), that there was no association between HOLC grade and contemporary
mortgage lending bias (Kruskal & Allen Wallis, 1952). We used the Mann–Whitney U-test, also known as the Wilcoxon Rank-Sum statistic, to determine which pairwise relationships (between different HOLC grades) were significant. Beta regression models (Cribari-Neto & Zeileis, 2010; Ferrari & Cribari-Neto, 2004) were used to examine the association between HOLC grade and contemporary neighborhood demographic composition (percent Black, percent Hispanic), including while controlling for historic settlement patterns and contemporary mortgage lending bias. The MSA was included as a random intercept in all models to account for the clustering structure of HOLC neighborhoods within cities and MSAs.

Results

Results are presented according to hypotheses tested. In our first question, we hypothesized that HOLC neighborhoods with more favorable grades would have higher levels of present-day racial and ethnic bias in mortgage lending and lower levels of present-day location bias when compared to less favorable HOLC grades. As illustrated in Figure 2, there is a clear gradient relationship in line with this hypothesis for all three measures.

The results of the Kruskal–Wallis test for the different HMDA measures indicate that for all the measures, there were significant differences across HOLC grades. As illustrated in Table 1, Mann–Whitney U-tests revealed that for racial and location bias, all the differences were statistically significant. For ethnic bias, except for the difference between grade B and A and the difference between grades C and D, all other pairwise comparisons were

![Figure 2](image_url)  
**Figure 2.** Box plots illustrating the relationship between HOLC grade and HMDA mortgage lending measures: racial bias (Panel A), ethnic bias (Panel B) and location bias (Panel C). Box plots show the median odds of denial of a mortgage application, the 25th and 75th percentiles, as well as the ± 1.5 times interquartile range of the distribution.
|                | Location bias | Race Bias     | Ethnic Bias |
|----------------|---------------|---------------|-------------|
|                | Difference in Median | [95% CI] | Difference in Median | [95% CI] | Difference in Median | [95% CI] |
| B-A            | −0.170***     | [−0.216, −0.124] | 0.285**     | [0.071, 0.498] | 0.027     | [−0.093, 0.148] |
| C-A            | −0.579***     | [−0.661, −0.501] | 0.672***     | [0.485, 0.867] | 0.210***     | [0.099, 0.324] |
| D-A            | −1.033***     | [−1.148, −0.923] | 0.939***     | [0.745, 1.143] | 0.242***     | [0.124, 0.362] |
| C-B            | −0.360***     | [−0.419, −0.305] | 0.389***     | [0.261, 0.517] | 0.182***     | [0.104, 0.259] |
| D-B            | −0.772***     | [−0.861, −0.688] | 0.647***     | [0.506, 0.791] | 0.212***     | [0.125, 0.300] |
| D-C            | −0.364***     | [−0.443, −0.288] | 0.252***     | [0.137, 0.368] | 0.030     | [−0.045, 0.107] |

*p < 0.05, **p < 0.01, ***p < 0.001.

Table 1. Mann–Whitney U-test results between three HMDA discrimination measures and HOLC grades.
statistically significant. Median differences comparing grade D to grade A neighborhoods were \(-1.033 \ [−1.148, −.923]\) for location bias, 0.939 [0.745, 1.143] for racial bias, and 0.242 [0.124, 0.362] for ethnic bias, all significant with \(p < .001\).

The results also show that the relationship between HOLC grades and HMDA mortgage lending bias measures vary in magnitude, but not direction, across U.S. regions. As shown in Figure 3, the gradient observed nationally is also present when examined by U.S. Census region. However, some variation is noted. For racial bias, the gradient is clearly observable for the Midwest, South and Northeast, but less distinct in the West. For ethnic bias in the Midwest and Northeast, higher bias is observed in the two favorable HOLC categories and lower bias in the two less favorable categories, whereas this pattern is almost reversed in the South. In the West, there is more distinction between the two higher categories. For location bias, the magnitude of bias is different across regions, with highest bias in the Midwest, followed by the Northeast, South and West. In all regions, a gradient of higher location bias in historically redlined areas is clear.

In our second question, we hypothesized that HOLC areas with more favorable grades would have higher percentages of non-Hispanic White populations and lower percentages of Black and Hispanic populations today, when compared to less favorable HOLC grades. We further hypothesized that this would be true even after controlling for historical population distributions and current day mortgage lending bias. We used beta regression models to examine these relationships. Table 2 illustrates the results of these models examining the relationship between HOLC grade and contemporary racial/ethnic composition measures (one set of models for Black, and one for Hispanic populations), including unadjusted models and models adjusted for covariates. We include an unadjusted model for comparison, models adjusting for historical racial (or ethnic) composition and contemporary racial (or ethnic) bias, and then a final pair of models adjusting also for location-bias. All models are adjusted for MSA level clustering. The odds can be interpreted as the ratio of the “proportion with” divided by the “proportion without,” \(p/(1-p)\) where in this case \(p\) is the percentage of Black population or Hispanic population.

Unadjusted models reveal clear gradients, as expected, such that decreasing HOLC “risk” grades correspond to increasing proportions of Black and Hispanic residents today. Models adjusting for historic racial (or ethnic) composition and contemporary racial (or ethnic) mortgage lending bias indicate that this relationship persists at each HOLC grade level but is attenuated for both Hispanic and Black composition. For example, for grade D the ratio of the proportion of Black population to the proportion of non-Black population is estimated to be 1.89 times that of grade A. In other words, the odds of proportion Black for grade D are 89% higher than grade A. Also, regarding the historical settlement patterns, grades with higher percentage of “negro” families in the 1930s have higher percent Black population today, after accounting for modern day racial bias in mortgage lending. The same pattern is observed for HOLC grade level and proportion of Hispanic populations.

In our last models, we included location bias. Inclusion of location bias had a strong impact on the model predicting Black composition, but little impact on the model predicting Hispanic composition. For Hispanic composition, for grade D, the ratio of the proportion of Hispanic population to the proportion of non-Hispanic population is estimated to be 1.88 times that of grade A, such that the odds of proportion Hispanic for grade D are 88% higher than grade A. Regarding historical settlement patterns, as the results show, grades with higher percentage of foreign families in the 1930s have higher percent Hispanic
Figure 3. Variation in the gradient by U.S. Census Region. Box plots show the median odds of denial of a mortgage application, the 25th and 75th percentiles, as well as the ± 1.5 times interquartile range of the distribution.
Table 2. Models predicting contemporary racial/ethnic composition.

| Variables                      | Unadjusted Models | Adjusted Models without Location Bias | Fully Adjusted Models |
|--------------------------------|-------------------|---------------------------------------|-----------------------|
|                                | Percent Black     | Percent Hispanic                      | Percent Black         | Percent Hispanic |
|                                | n = 5244          | n = 5285                               | n = 5244              | n = 5285         |
| HOLC Grades                    | OR                | 95% CI                                | OR                    | 95% CI          |
| Grade A                        | REF               | [0.15, 0.38]                          | 1.30***               | [0.15, 0.38]    |
|                                |                   | [0.25, 0.44]                          | 1.42***               | [0.25, 0.44]    |
|                                |                   | [0.13, 0.35]                          | 1.28***               | [0.13, 0.35]    |
|                                |                   | [0.25, 0.44]                          | 1.41***               | [0.25, 0.44]    |
|                                |                   | [−0.02, 0.17]                         | 1.08                  | [−0.02, 0.17]   |
|                                |                   | [0.24, 0.43]                          | 1.40***               | [0.24, 0.43]    |
| Grade B                        | REF               | [0.51, 0.73]                          | 1.86***               | [0.51, 0.73]    |
|                                |                   | [0.62, 0.80]                          | 2.03***               | [0.62, 0.80]    |
|                                |                   | [0.45, 0.66]                          | 1.74***               | [0.45, 0.66]    |
|                                |                   | [0.52, 0.71]                          | 1.86***               | [0.52, 0.71]    |
|                                |                   | [0.04, 0.24]                          | 1.15**                | [0.04, 0.24]    |
|                                |                   | [0.51, 0.70]                          | 1.84***               | [0.51, 0.70]    |
| Grade C                        | REF               | [0.86, 1.10]                          | 2.68***               | [0.86, 1.10]    |
|                                |                   | [0.77, 0.97]                          | 2.39***               | [0.77, 0.97]    |
|                                |                   | [0.51, 0.76]                          | 1.89***               | [0.51, 0.76]    |
|                                |                   | [0.54, 0.74]                          | 1.90***               | [0.54, 0.74]    |
|                                |                   | [0.08, 0.14]                          | 1.03                  | [0.08, 0.14]    |
|                                |                   | [0.52, 0.73]                          | 1.88***               | [0.52, 0.73]    |
| Racial Bias                    | 0.90***           | [−0.11, −0.08]                        | 0.95***               | [−0.05, −0.03]  |
| Ethnic Bias                    | 0.98***           | [−0.02, −0.00]                        | 0.98*                 | [−0.02, −0.00]  |
| Location Bias                  | 1.90***           | [0.61, 0.67]                          | 1.01                  | [−0.00, 0.02]   |
| HOLC percent “negro”           | 3.80***           | [1.13, 1.54]                          | 4.44***               | [1.30, 1.67]    |
| HOLC percent foreign families  | 2.42***           | [0.76, 1.00]                          | 2.41***               | [0.75, 1.00]    |
| MSA random effect              | Variance: 0.2193  | Variance: 0.5163                       | Variance: 0.2208      | Variance: 0.5044 |
|                                | Std.Dev: 0.4683   | Std.Dev: 0.7185                        | Std.Dev: 0.4699       | Std.Dev: 0.7102  |
|                                |                  |                                        | Std.Dev: 0.4957       | Std.Dev: 0.7118  |
| Pseudo-R²                      | Conditional R²: 0.412 | Conditional R²: 0.540                 | Conditional R²: 0.542  | Conditional R²: 0.560 |
|                                | Marginal R²: 0.126 | Marginal R²: 0.069                     | Marginal R²: 0.303    | Marginal R²: 0.105 |
|                                |                  |                                        | Marginal R²: 0.069    | Marginal R²: 0.699 |
|                                |                  |                                        | Marginal R²: 0.105    |Marginal R²: 0.105 |
population today, even after accounting for modern day location and ethnic bias in mortgage lending. Location bias was not significant. For Black composition, adjustment for location bias attenuates much of the influence of HOLC grade, such that the relationship is only statistically significant for category C (as compared to A, OR = 1.15, [0.04, 0.24]). For HOLC areas that were predominantly Black in the 1930s, today the ratio of the proportion of Black population to the proportion of non-Black populations is 4.44. The results further show that contemporary location bias is also a strong predictor of current day Black settlement (OR = 1.90, [0.61, 0.67]).

Discussion

We sought to examine the degree to which spatial patterns of mortgage lending bias and racial segregation have persisted over time. The HOLC maps represent a compelling historical snapshot of patterns of lending bias, economic investment, and racial settlement patterns in the 1930s. Eighty years later, these patterns established so long ago, predating the HOLC maps, persist. This persistence and the strength of these associations indicate considerable inertia in these spatial patterns, despite the laws, policies and practice changes that have occurred in the intervening years to ensure equitable access to quality housing and mortgage investments.

It is tempting, given the length of time that passed between the predictor (HOLC, 1930s) and the outcome (HMDA, 2007–2013) and the strength of association, to dwell on causality. However, the degree to which HOLC maps themselves influenced policy remains unclear, and it is known that patterns of exclusionary lending predated the maps. Some earlier work (Jackson, 1985) as well as more recent writings, have suggested that HOLC maps caused patterns of disinvestment that followed, while others have argued that little evidence points to widespread use of the HOLC maps in lender decision-making (Bhutta et al., 2021; Hillier, 2003). The question of causality is interesting from a historical and statistical perspective, but it is not the focus of this paper. Instead, we focus on association—the persistence of patterns of lending bias over time. Presumably, if housing policy and practice changes were effective in the years since the HOLC maps were drawn, we would see a decoupling between historical and contemporary spatial patterns. Instead, we see a clear gradient pointing to a powerful inertia that maintains inequality in access to mortgage investments by race, ethnicity and property location and demands a focused policy response.

We first asked whether HOLC lending risk grades would predict contemporary levels of mortgage lending bias. We found a clear gradient association between historical HOLC grade and three types of current day mortgage lending bias—racial, ethnic and location bias. Although the share of minority population has increased in grade A-C neighborhoods over the last few decades, racial and ethnic minorities still face unfavorable biases in credit access in those neighborhoods compared to Whites (Aaronson, 2017). This may be related to decades-long disproportionate disinvestments, underappreciation of housing values and challenges in the accumulation and intergenerational transmission of wealth among minorities in lower-grade neighborhoods. Due to these disadvantages, minorities families in those neighborhoods may experience lower social mobility, reflected by the greater bias in access to housing credit in those neighborhoods with better HOLC grades. Further, we identified a similar gradient across the country with the exception of a less clear gradient for racial bias in mortgage lending in the West.
Next, we asked whether HOLC grades would predict contemporary racial and ethnic settlement patterns, regardless of historical settlement patterns and contemporary levels of mortgage lending bias. Again, we found clear evidence of persistence over time, such that policy and practice instituted over 80 years ago has a clear association with current racial and ethnic settlement patterns today, even after controlling for historical settlement patterns and current practices in mortgage lending by race, ethnicity and location. Notably, controlling for location bias significantly attenuated the relationship between HOLC grade and current Black settlement, but did not affect Hispanic settlement, indicating a strong relationship between contemporary location bias and Black composition. Again, this study cannot assess the causal direction of that relationship.

The present paper adds to the literature on mortgage lending bias and socioeconomic equity in three ways. First, to our knowledge, this is the first study to empirically analyze the spatial relationships between modern and historical forms of mortgage lending bias across the nation with detailed spatial resolution. Our results indicate that after 80 years and despite numerous fair housing policy changes, these grades are still strong predictors of current day mortgage bias. Among the four U.S. census regions, the location bias index is the highest in the Midwest followed by the Northeast and the South; the denial odds are the highest in historically graded D areas in the Midwest (Figure 3). The HOLC gradient is most clearly observed for the location bias measure, which is conceptually akin to “redlining.” For racial bias, the only deviation from the HOLC hierarchy is observed in the West where the pattern is unclear. Ethnic bias is generally lower in magnitude and the expected pattern is not clearly observed across all regions.

Second, to isolate the different contributors to current day mortgage lending bias and segregation, we account for neighborhoods’ population profiles at the time when the HOLC maps were being compiled. Accounting for the relationship between historical population profiles and current-day racial profiles of HOLC areas can inform efforts to combat hyper-segregation and policies to prioritize intervention strategies by providing a contextual description of population changes and/or persistent segregation. Results of regression models show that percent “Negro” estimates as recorded in the area description of HOLC maps are good predictors of percent Black population today. The results also indicate that the location bias index is a good predictor for percent current day Black population but not the Hispanic population. As for percent Hispanic, the best predictor is the estimated percent of foreign families recorded in the HOLC era, despite the fact that foreign families at the time of the HOLC maps were not primarily Hispanic. These results suggest that historical settlement patterns reinforced by HOLC era policies are likely to have formed the foundation for racial and ethnic population patterns still observed across the U.S. today.

Third, by providing a comprehensive comparison between the contemporary and historical redlining and mortgage lending bias, this study provides a resource for future research focused on the evolution/outcome of political discourse around race and housing discrimination. As previously discussed, the dominant discourse that equated minority populations with higher risk and deteriorating neighborhoods was the main justification for early discriminatory policies. As we have observed since the 1990s, more subtle policies still enforce these discriminatory agendas mainly through predatory lending and mortgage denial. These findings are important to communicate to policymakers and the public to understand that the persistent and systematic mortgage discrimination, which still exist today, cannot be successfully mitigated without acknowledging past policies and implementing targeted interventions.
It is interesting to consider what the inertia of these spatial patterns may have meant for the affected communities. Racial bias that restricted the settlement of people of color in wealthier neighborhoods throughout the twentieth century essentially restricted people of color, including wealthier people, to live in poorer central city neighborhoods, resulting in Black residents living in mixed income neighborhoods longer than they might have had restrictions not been in place. It remains true that middle class Blacks live primarily in poor neighborhoods, and the wealth gap between Blacks and Whites is substantial, attributed in large part to differentials in wealth accumulation through home ownership. Further, our work indicates that Black home ownership is still challenged both for Black applicants and those seeking to buy homes in primarily Black neighborhoods. However, half a century later, as Frey declares, “a full-scale suburbanization of blacks is finally underway” (Frey, 2015). There have been losses of Black populations in the central cities of the 100 largest metropolitan areas amounting to 300,000 between 2000 and 2010, and 96 of these 100 cities showing gains in suburban Black populations; gains are mostly noted in metropolitan areas in growing parts of the country (e.g., Atlanta, Houston, Washington, D.C., and Dallas) and mostly comprise younger, more highly educated, and married couples with children (Frey, 2015).

What has this 50-year delay meant for Black populations in the U.S.? Looking back, the inability of higher income Black residents to move to greater “opportunity” neighborhoods that their White counterparts were able to access, is likely to have ensured that Black people, regardless of income, have been more exposed to the detrimental aspects of low resource neighborhoods, including lack of access to health and social services, high-quality education, and social and built environment amenities known to positively influence health and wellbeing. However, living within a neighborhood comprised of individuals of the same historical, racial and/or cultural background could offer advantages. These benefits, for Black Americans, might include stronger cultural or religious communities, enhanced social support, and buffering from interpersonal racial discrimination that might have been encountered in primarily White suburban communities. It is also possible, as some have suggested, that the lengthy delay in Black access to suburbanization, despite its negative impacts, may also have strengthened Black community resilience and institutions, such as churches, businesses or schools, that have then been critical in supporting Black residents impacted by the adverse impacts of segregation and economic disinvestment (The First Measured Century, 2014). It remains to be seen how the patterns of contemporary mortgage lending bias identified in this work may shift in the face of Black suburbanization, and whether the historical patterns represented by the HOLC maps can be disconnected from contemporary patterns of mortgage lending or racial settlement.

**Limitations**

This study has several limitations. First, the study sample is limited by availability of digitized HOLC maps and area descriptions provided by the Mapping Inequality project. During the 1930s, HOLC maps were created for 239 U.S. cities. In this study, we include 86 cities. Although the sample accounts for only 36.4% of the total number of HOLC cities, it includes the majority of cities with large populations in both time periods. Second, for calculating the percentage “Negro” and percentage foreign families for each HOLC grade we relied on the field notes of the HOLC agents, which in many cases were subjective perceptions, yet were the only available source to estimate population profiles at a detailed
spatial scale. Although we did intensive quality checks to ensure the correctness and completeness of the HOLC data (including boundaries and variables extracted from area descriptions) in some cases the area descriptions only included text, and not numbers; for the key variables of interest (percent “Negro” and percent foreign families), we converted the text to numbers in order to maintain the records in the database. Third, while we were able to adjust for percent “Negro” in examining current day Black settlement patterns, we were not able to control for a corollary to current day Hispanic populations, relying instead on the designation of “foreign families” from the HOLC documents. While imperfect, as Hispanics did not constitute a large number of immigrants at the time, we believe that this proxy measure is preferable as anti-immigrant sentiments often target all “outsiders” instead of specific ethnic groups. The strong relationship between percent foreign families and percent Hispanic speaks to the enduring bias against immigrants, regardless of race or ethnicity. Fourth, we report the results as differences between odds ratios which is a relative measure rather than absolute measures per racial group. Future research with separate calculations for Black approval rates and White approval rates could shed more light on the mechanisms and context of mortgage approval rates.

Finally, the HDMA data available for this analysis did not contain some important information, such as credit score, and thus a complete accounting of housing discrimination is not possible (though this was not the goal of the paper).

It should be noted that previous studies have shown that historical HOLC grades may have long-term associations with some factors affecting contemporary racial and ethnic settlement patterns. For example, using a regression discontinuity approach, (Appel & Nickerson, 2016), showed that compared to adjacent areas, “redlined” neighborhoods have lower home prices (Appel & Nickerson, 2016). Considering the persistent racial/ethnic disparities in wealth and access to mortgage credit, minorities may be restrained to those redlined neighborhoods because housing is relatively more affordable in those areas. Other factors associated with HOLC grades that could affect contemporary racial/ethnic settlement patterns may include employment opportunities (Fischer & Massey, 2000; Jencks & Mayer, 1990), land use patterns (Galster & Cutsinger, 2007) and other factors. However, these factors are intricately intertwined and separating them would result in an underestimation of the association with HOLC grades.

**Conclusions**

Mortgage lending is a key source of economic investment for neighborhoods and a primary source of wealth accumulation for individuals. Racial and spatial bias in mortgage lending thus represents unequal economic investment in particular places or people, regardless of whether this bias can be confirmed as discrimination. It is important to acknowledge that bias in mortgage lending as identified in this work is likely to be the result of both measurable applicant financial factors (i.e. disparities in credit scores by race) as well as bias or discrimination in lending based on the race or ethnicity of the applicant or characteristics of the property location. So, policy responses must follow suit to address both domains. Further, the actual approval or denial of a mortgage application is one aspect of a lengthy process that could be affected by other forms of racial bias, including whether potential buyers are encouraged to submit applications or not, whether lenders “overlay” expectations on top of automated underwriting recommendations, and whether aspects of
the process such as the property appraisal or the ability to confirm documentation and complete the application process are impacted (Bhutta et al., 2021). Further, while not reflected in the HMDA or HOLC databases, additional aspects of the home buying process may also be impacted, such as differential treatment by race in the pre-application process, including responsiveness, receipt of information or assistance (Hanson et al., 2016; Ross et al., 2008).

From a policy perspective, addressing bias in patterns of mortgage lending and improving access to housing among low-income people and people of color is a complex issue requiring policy and practice changes at multiple levels and multiple domains. Of course, better identifying racial discrimination and redlining is important so that policy targets are clear; the recent availability of new variables in HMDA data (2018 onward) is a start, but more work is needed then to explain the gap in approvals that remains once all known factors are controlled. Additionally, we must consider the existence of bias in factors that can ultimately lead to mortgage denials, such as disparities in employment, income, property values/appraisals, bank accounts, wealth, previous home ownership and credit scores. We can also consider the products available for low-income buyers, such as increasing the availability of “micro mortgages” or small dollar amount mortgage loans (McCargo et al., 2019). Policy potential exists in addressing gaps in credit scores, including education to enhance financial literacy. Mortgage lending processes can also be examined to determine whether specific aspects of automated underwriting algorithms or lender overlays are causing undue burden on specific types of applicants without substantial benefit.

Pre-application, there are opportunities to reduce racial bias in the way applicants of color are treated—i.e. the responsiveness of loan officers, how much information is provided by loan officers to prospective applicants, and whether potential applicants of color are encouraged to apply (Hanson et al., 2016; Ross et al., 2008). Finally, fair housing is a cornerstone for addressing the existing racial and social inequities in the housing sector and Affirmatively Furthering Fair Housing (AFFH) and creating incentives for zoning reforms (e.g., Inclusionary Zoning Implementation) are policy priorities to increase housing opportunities, dismantling the patterns of discrimination (American Planning Association, 2021) and ultimately reduce wealth inequality among U.S. populations.

Overall, our findings suggest that the inertia in geographic patterns of housing investment and racial segregation is strong and will require concerted efforts to be reversed. Those efforts must include data transparency, empirical evidence, complex and multiple policy solutions, and a recognition of the presence of bias in factors adjacent to mortgage lending, ultimately resulting in persistent disparities in home ownership and economic investment. As described by Korver-Glenn (2018), there are multiple possible “exits” from the housing exchange process and each may be affected by bias, discrimination or stereotyping (Korver-Glenn, 2018). To undo nearly a century of inertia in housing inequity based on race, ethnicity and place, it will be important to take a multilevel, comprehensive approach and reconsider the route to home ownership and neighborhood vitality across racial, socio-economic and geographical groups.

Note
1. For beta regression analysis, NAs and 0s were removed but were included in the other analyses.
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