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Home Purchase Appraisals in Minority Neighborhoods

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Abstract

We study the impact of neighborhoods' race composition on appraisers' valuation decisions in home purchase appraisals. Controlling for many appraisal inputs, including the appraiser themselves, we find that low appraisals (below the contract price) are at least 23 percent more likely in majority African American neighborhoods relative to neighborhoods with no African American residents. Instrumental variable estimates, based on historical race shares, indicate an impact of at least 13 percent. However, this effect dissipates when appraisers work in neighborhoods in which they have appraised before or in which many appraisals were recently completed, facts consistent with information based models of discrimination.

Keywords: Appraisals · Discrimination · Mortgages

JEL Classification: R30 · J15 · G21

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1 Introduction

Racial discrimination in the housing market is a long-standing topic of interest among researchers and policymakers. The Fair Housing Act (FHAct) of 1968 and the Equal Credit Opportunity Act (ECOA) of 1974 prohibit discrimination in home sales or financing on the basis of race or color. However, differences in outcomes for racial minorities have been shown to persist. Most documented in this debate are disparities in the cost of homes and pricing of home loans (Bayer et al., 2017; Bayer, Ferreira, and Ross, 2018; Hanson et al., 2016; Bartlett et al., 2022; Bowen III et al., 2024). A key part of financing a home purchase, the appraisal, has until recently received less attention.

An appraisal is required by lenders and regulators to independently determine a property's collateral value. It directly enters the loan-to-value (LTV) calculation in the underwriting of a mortgage. As a result, the appraisal can dictate the viability and price of the loan. Unfavorable appraisals can prompt delays of sale, a re-negotiation of the contract price, or void transactions altogether (Fout and Yao, 2016). Given the weight of housing in private wealth, the extent to which race influences home appraisals may be one facet of enduring economic inequality stemming from geographic segregation along racial lines (Bayer, Charles, and Park, 2021).

This paper studies the impact of neighborhoods' race composition on appraisers' valuation decisions for home purchase appraisals. It then explores the underlying mechanisms driving the use of race. Unlike other aspects of mortgage underwriting, which are primarily based on borrowers' characteristics, the value of a home is intimately connected to the neighborhood in which it is located. Moreover, while most mortgage credit transactions related to a new home purchase require direct borrower-lender interaction, the appraiser, who is hired and paid by the lender, likely never interacts with or knows much about either buyer or seller, who may even be of different races altogether. Any use of race by the appraiser in the valuation would most likely stem from that which they observe most directly: the neighborhood or the property.

Our analysis uses data from the Federal Housing Finance Agency's Uniform Appraisal Dataset (UAD), a large repository of millions of appraisals nationwide. We combine the UAD with data on neighborhood characteristics, including race, from the US Census Bureau and the Centers for Disease Control and Prevention (CDC). These data are combined at the Census

tract level, our definition of neighborhood. The period of analysis spans January 2015 to December 2019, inclusive. This coincides with the Census Bureau's 2015-2019 American Community Survey (ACS) five-year averages, the most recent release not encompassing the pandemic period.

Empirically, we focus on how race influences the likelihood of low appraisals, or appraisals below the a-priori agreed upon buyer-seller (contract) price. Though an appraiser reports an exact dollar value, low appraisals are consequential because lenders are bound to underwrite a loan based on the lower of appraised value and contract price. An amount at or above the contract price has little material impact on the transaction. A low appraisal places economic burdens on both buyer and seller. It can trigger higher upfront payment, worse loan terms, or denial of credit altogether. Moreover, focusing on low appraisals allows us to benchmark the appraiser's decision to a previously agreed upon price, which is known to them at the time of the appraisal.

We begin by documenting the association between low appraisals and race, the low appraisal gap. Unconditionally, low appraisals are 0.11 percentage points (p.p.) more likely in a tract with a one p.p. greater proportion of African American residents. This corresponds to a 66 percent higher rate of low appraisals for a majority (50 percent) African American tract compared to one with no African American residents. Next, we incorporate the many mediating factors an appraiser considers in their valuation decision. These are categorized as follows: (1) characteristics of the subject property, (2) the comparable properties used and their reconciliation to the subject property, (3) the appraiser themselves, (4) the neighborhood and its history, and (5) local housing market trends.

Information on the subject property, comparable properties, and reconciliation come from the UAD. These are captured in extraordinary detail in the data. The UAD also includes information on the appraiser themselves. This allows us to construct a unique and anonymous appraiser identifier, a feature novel to this literature. We use this to account for time invariant appraiser fixed effects and to track their experience across neighborhoods and over time. Neighborhood information comes from the Census and the CDC. The latter captures neighborhood air quality, a crucial amenity determining property values (Chay and Greenstone, 2005). Local housing market trends come from the Zillow Home Value Index (ZHVI).

Our assessment of how these factors mediate the low appraisal gap proceeds in two steps. First, we measure their combined contribution and find it reduces the gap by 64 percent. Second, following a long standing tradition of discrimination studies dating back to Oaxaca (1973) and Blinder (1973), we evaluate each category's distinct contribution. To sidestep the "order" problem, we approach the accounting question using the method in Gelbach (2016). About 53 percent of the reduction is due to heterogeneity in observable neighborhood characteristics. Another 28 percent arises from differences in individual appraiser characteristics, almost exclusively from the inclusion of the appraiser fixed effect. This indicates that neighborhoods and the appraisers themselves matter most in accounting for the gap.

We then turn to the impact of race. Our broad set of controls absorbs many of the factors an appraiser uses to make their valuation. Most notably, we include rich information on the subject property, comparable properties, and the appraiser themselves. We also account for many neighborhood amenities and their trends over the medium term. Yet, there undoubtedly remain unobserved elements in appraiser's decision rule jointly determining race and appraisal value. Most notable among these are the evolving traits of the appraiser and changing facets of the neighborhood.

To identify the role of race, we use an instrumental variable design based on neighborhoods' historical race shares. Specifically, we use the 1970 Decennial Census. This Census is noteworthy for three reasons. First, it was recorded nearly half a century prior to the start of our analysis period. Second, it marked the end of the Great Migration of African Americans in the United States. Third, it took place at the start of a post FHAct and ECOA housing market. The 1970 Census thereby provides a snapshot of the geographic distribution of African Americans in the United States at the close of an historic migratory period and at the dawn of a new era of anti-discrimination laws in housing and housing finance.

The long horizon means that nearly all properties ($> 99\%$) in our data were not in existence or were substantially altered since that time. Also, no significant contingent of appraisers likely were working then, whereby an appraisal was not required for underwriting until the late 1980's. Further, recall that we analyze appraisers' valuation relative to a previously agreed upon contract price. This benchmark eliminates longer term secular differences in property values across neighborhoods. Discrepancies between an appraisal and the contract price would largely reflect shorter term differences in values or expectations about future

house prices brought on by the changing facets of the neighborhood.

Formally, our identification of the race effect relies on differential persistence in the unobserved processes driving a neighborhood's race shares and the omitted factors in the appraiser's decision rule. The maintained assumption is that historical race shares are long lasting for reasons that often go beyond economic factors (Bayer, Fang, and McMillan, 2014). Omitted factors in the valuation decision, while they can be persistent over time, ultimately contain information about shorter lived aspects of the property, the appraiser, and the neighborhood.

The instrumental variable estimates indicate that a one p.p. increase in the proportion of African American residents in a tract leads to a 0.022 p.p. increase in the likelihood of a low appraisal. In other words, the impact of race is about 43 percent smaller than that implied by the association. Nevertheless, it is still economically meaningful and precisely estimated. All else equal, increasing the proportion of African American residents in a tract by 50 percent generates a 1.10 p.p., or 13.3 percent, increase in the likelihood of receiving a low appraisal.

Neighborhood race also reduces the relative appraised value among low appraisals: a one p.p. increase in the proportion of African Americans in a tract reduces the difference between contract price and appraisal report by 0.034 p.p. A similar (50 p.p.) increase in the proportion of African Americans in a tract reduces low appraised home values by an additional 1.7 p.p. relative to the prior agreed upon contract price. On a typical property in our data, this translates to about $6,100 or 8.5 percent of the modal 20 percent down payment on the new purchase of a home.

Finally, we relate our findings to existing theories of discrimination by incorporating heterogeneity in the neighborhood race effect through a series of interactions. The economics literature has settled on two main forms of discrimination: that which is preference, or taste, based, and that which is information based, or statistical (Arrow, 1998). The former postulates an innate cost of doing business with individuals of a different background or race. The latter is premised on incomplete information between groups, whereby race is used as a surrogate for those unobserved characteristics with which it may be associated.

We find that the effect of a neighborhood's race share on valuation decisions is largely eliminated when appraisers work in a neighborhood where they are observed to have ap-

praised before. Moreover, we find that the effect also dissipates when appraisers work in a neighborhood in which many appraisals took place over the previous quarter. These are presumably "thicker" markets in which the appraiser likely has more up to date information on a property's expected resale value. In other words, race does not seem to factor into an appraiser's valuation decision when they are better informed about the neighborhood, a fact more consistent with information based, or statistical, models of discrimination.

In contrast, an appraiser's overall experience does not materially change how the neighborhood's race share enters their valuation choice. Rather, it is specific neighborhood experience that matters for the race effect. This also indicates that inexperienced appraisers do not seem to differ in their use of race from those who are more established. Though cursory evidence, it is somewhat inconsistent with a model of preference based discrimination in which inexperienced appraisers trying to establish a reputation may find it more costly not to be accurate.

Ostensibly, ours is not the only study of racial bias in appraisals. In recent years, this topic has garnered some interest in the popular press (Kamin, 2020; Mock, 2020; Edwards, 2021; Choe, 2022) and prompted scrutiny from policy circles (Perry, Rothwell, and Harshbarger, 2018; Pinto and Peter, 2022; Rothwell and Perry, 2022; Peter and Pinto, 2023; Howell, 2023*b*). Following this trend, a few academic studies have emerged as well (Howell, 2023*a*; Jackson, 2024).

Our work contributes to this literature in several ways. From a measurement perspective, we analyze appraisal level data for loans that were originated and for loans that were not. Previous work has relied on aggregated appraisal outcomes or on appraisals only from originated mortgages. Our approach overcomes the missing data problem, controls for appraisal specific attributes, and give broader coverage of both appraisals and appraisers - for whom we construct unique identifiers.

Conceptually, we focus on the neighborhood as the relevant source of race information used by the appraiser. As discussed above, this is more in line with the institutional reality of the home purchase appraisal process. It also sidesteps the need to decipher the mix of buyer and seller race and whether buyer and seller race are even observed by the appraiser in a purchase transaction. The focus on neighborhood race also forms a basis for our instrumental

variable design. With this, we provide estimates of the impact of neighborhood race shares on the appraiser's decision and tie these to long standing theories of racial discrimination. The latter allows us to comment on the likely reasons underlying observed racial bias in appraisal outcomes.

2 The Role of Appraisals in Home Purchases

A home purchase appraisal is meant to provide a lender with the fair market value of a property that is to be the collateral for a new mortgage. Appraisal standards were codified as part of the Financial Institutions Reform, Recovery and Enforcement Act of 1989 (FIRREA) in response to losses from the Savings and Loan crisis of the late 1980s (Getter, 2023).[1] The rule calls for an appraisal report to be ordered by the lending institution (or its agent) once the buyer and seller reach a purchase agreement and a purchase (contract) price is determined. In other words, lenders are the clients. They select, review, and pay for appraisal services.[2]

For most arm's length home purchases, appraisers rarely interact with either the buyer or the seller. The appraiser receives a contract from the lender that only includes financial information about the purchase, often only a contract price and the name of the buyer; no race is given. The vast majority of residential purchase mortgage appraisals require a site visit. Any information about the seller stems from this visit, at which point the appraiser may or may not meet the seller or learn about them if they enter the property.[3] The appraiser is nearly always informed by the neighborhood in forming their opinion of value.

An appraisal is included in mortgage underwriting through the loan-to-value (LTV) calculation. For this, the lender is required to follow the minimum value rule, whereby the property's value is the minimum of the contract price and the appraised value. The LTV measures the amount of equity held by the borrower. High LTV has been shown to predict poor mortgage performance (Elul et al., 2010; Mayer, Pence, and Sherlund, 2009). As a result, GSE rules for

[1]The rule covers conventional mortgages originated by regulated entities such as banks, credit unions, and mortgages eligible to be purchased by Government Sponsored Enterprises (GSE). It also covers mortgages underwritten by the Federal Housing Administration (FHA), Veterans Administration (VA), and the United States Department of Agriculture (USDA) Development backing. Certain loan program types (e.g., FHAct's streamline refinance) and transactions with loan sizes under a threshold are exempted from the requirement.

[2]Though, this cost is usually passed on to the borrower.

[3]Other than the lender, an appraiser might interact with the listing agent of the property to arrange a site visit. Frequently, listing agents advise sellers to not be present when the appraiser arrives. The appraiser may learn about their race from entering their home, if it is still occupied. They likely never learn anything about the sellers if the property has been vacated.

purchase eligibility include LTV standards. Moreover, LTV ratios are watched by investors of privately securitized mortgage pools. Higher LTV mortgages require mortgage insurance and higher interest rates. When the reported appraisal is below the contract price, the LTV at origination rises relative to that determined by the contract price. Usually this occurs in the middle of the mortgage application process, after the buyer and seller have agreed on a price. As a result, it adversely affects the buyer's financial position, the viability of the mortgage, and purchase transaction.[4]

The appraisal regulatory system is substantial. It is comprised of the Appraisal Foundation, the Appraisal Subcommittee (ASC) of the Financial Institutions Examinations Council (FFIEC), and state-level appraiser regulatory agencies. The Appraisal Foundation sets the standards for the real estate valuation profession and publishes the Uniform Standards of Professional Appraisal Practice (USPAP).[5] The ASC oversees state-level licensing and certification standards, as well as appraisal management companies (AMCs). Licensing standards can vary across states. Since the adoption of the Home Valuation Code of Conduct (HVCC) in 2009, lenders often interact with appraisers through intermediary appraisal management companies (AMC).[6]

The USPAP identifies three principal approaches to valuation: the sales comparison approach, the cost approach, and the income approach. The sales comparison approach is required for mortgages eligible to be purchased by Fannie Mae and Freddie Mac.[7] It unfolds in five parts. First, the appraiser may conduct an on-site inspection to collect information about the

[4]Upon review of the appraisal, if the buyer believes the appraisal failed to include relevant information about the property or improperly compared it to recent property sales, they have the option to initiate the Reconsideration of Value (ROV) process with the lender by submitting a written request with included evidence. The lender then may or may not order a second appraisal.

[5]The USPAP is the generally recognized ethical and performance standards for the appraisal profession.

[6]The literature has documented how prior to 2009 direct interaction between lenders and appraisers may have led to inflated housing values, potentially contributing to the 2007 financial crisis (Shi and Zhang, 2015). In 2009, FHFA adopted the Home Valuation Code of Conduct (HVCC). The HVCC was "based on an agreement between the Enterprises, the New York State Attorney General Andrew Cuomo, and FHFA to improve the reliability of home appraisals" (see FHFA's announcement: `https://www.fhfa.gov/news/news-release/fhfa-announces-home-valuation-code-of-conduct`). Attorney General Cuomo's invovlement likely stemmed from a complaint, *People Cuomo v. First American Corporation*, filed in 2007.

[7]The sales comparison approach is the most common practice, in part due to guidance from Fannie Mae, Freddie Mac, and government insuring or guaranteeing agencies such as the U.S. Department of Housing and Urban Development (HUD), VA, and USDA. The cost approach is mostly applicable to proposed or new construction, while the income approach is relevant only for properties that are intended to be used for income-generating purposes (i.e., rental properties). If the appraiser develops more than one approach to value, the approaches are reconciled.

subject property. This includes the legal, sale (contract), site, neighborhood, and detailed physical characteristics of the property. It does not necessarily require an onsite inspection of the property. Second, the appraiser identifies comparable properties that are most similar to the subject property.[8]

Third, the appraiser analyzes each comparable property and assigns an adjustment amount to each attribute that is different from the subject property. Fourth, the appraiser calculates the attribute-adjusted sale price for each comparable property. Fifth, the appraiser reconciles the attribute-adjusted sale price of the comparable properties to arrive at an appraised market value for the subject property. There is no explicit formula for reconciliation. It is done by assigning implicit weights to each comparable property.

As a result, under the USPAP, the sales comparison approach still affords appraisers substantial discretion in how they value homes. Notably, the literature has shown that following the adoption of the HVCC, which reduced lenders' direct contact with appraisers, indicators of inflated property prices waned. However, the effect largely attenuated in the years since (Ben-David, 2011; Calem et al., 2021). This suggests both parties retain sufficient flexibility in selection and reporting to allow for accommodation to a new regulatory regime. It also provides scope for bias on other dimensions. Specifically, there has been a recent surge of interest in analyzing appraisal bias on the basis of race. This has primarily taken the form of various policy studies, press articles, regulatory discussion and action, as well as civil litigation.

A number of descriptive policy studies have highlighted a low appraisal gap in high minority neighborhoods (Perry, Rothwell, and Harshbarger, 2018; Howell and Korver-Glenn, 2018, 2021; Narragon et al., 2021; Williamson and Palim, 2022; Narragon et al., 2022). These have shown an increase in the gap since the adoption of the HVCC. As reasons for the disparity, the studies cite unconscious biases, legacies of segregation, as well as current valuation practices of the appraisal industry, namely the sales comparison approach. Policymakers have taken

[8]They most commonly do so by researching county/municipal records, Multiple Listing Service (MLS) records, and other data services. Similarity is defined in terms of location, age, physical characteristics, and timing of the sale transaction. Appraisals for mortgages eligible to be purchased by Fannie Mae and Freddie Mac must contain at least three settled (closed) comparable sales, although listing or pending sales can also be included as comparables in the reports. Recent analysis conducted by FHFA indicates that majority of the appraisal reports include five or more comparable properties (Cannon and Fischler, 2024).

note of these studies, leading to numerous hearings in Congress on this issue.[9] Around the same time, several court cases alleging racial discrimination received much press attention, giving rise to the term "whitewashing" in the appraisal industry.[10]

In June 2021, against this backdrop, the Biden-Harris Administration announced the creation of the Interagency Task Force on Property Appraisal and Valuation Equity (PAVE), comprising 13 federal agencies and offices. The Interagency Task Force was instructed to: (1) identify the causes, forms, and consequences of bias that can appear in home appraisal practices; and (2) establish the steps that government agencies and industry stakeholders can take to eliminate appraisal bias (PAVE, 2022). Public hearings were held by the ASC from January 2023 to February 2024, and an Action Plan report was issued by the Interagency Task Force in March 2022.[11] Among the recommendations, it calls for federal agencies to conduct further research and develop data-sharing arrangements to make appraisal data available to researchers, practitioners, policymakers, and examiners. This paper is in large part motivated by this mandate and the dearth of work on the impact of race in appraisals.

[9]For example, part of Perry, Rothwell, and Harshbarger (2018) was submitted as a witness testimony for a Congressional hearing titled "What's Your Home Worth? A Review of the Appraisal Industry" conducted by the U.S. House of Representatives Committee on Financial Services Subcommittee on Housing, Community Development and Insurance on June 20, 2019.Howell (2023*b*) participated in the Appraisal Subcommitee's (ASC) first public hearing on Appraisal Bias in the Residential Real Estate Market, conducted on January 24, 2023.

[10]In these cases African American or Latino homeowners refinancing their homes were offered a substantially higher appraised value in a second appraisal from another appraiser after they installed a white stand-in and removed all artifacts in the house that hint at their race. Two of these prominent court cases took place in Marin City, CA and Baltimore, MD (Edwards, 2021; Choe, 2022). While both were settled recently out of court, they received national attention. The Baltimore case was featured in a hour-long documentary titled "Our America: Lowballed", released by the ABC television network in 2021. See: `https://ouramericaabc.com/lowballed`. The homeowners in Marin City, CA, served as part of a panel of witnesses in the public hearing on Appraisal Bias in the Residential Real Estate Market, conducted by the Appraisal Subcommittee (ACS) in January 24, 2023. Similar accounts of appraisal bias were reported in major cities across the nation, including Chicago, IL, Pittsburgh, PA, Jacksonville, FL, Hartford, CT., and Denver, CO. (Kamin, 2020; Haythorn, 2021). In relation to our study, it is important to note that all cases involved refinance transactions in which the appraiser is likely to meet the borrower, the only party to the transaction, on a site visit. Our study is on purchases. Unlike purchases, refinance transactions do not include a contract price. This presents a different problem for the appraiser than is considered in our analysis. It is treated in Ambrose et al. (2021).

[11]The hearings covered witness testimonies on widespread topics ranging from the forms of bias in appraisal practices; industry standards, qualifications and oversight; reconsideration of value (ROV) process; development of rural appraisals, including tribal lands; to opportunities and challenges for the appraisal profession, including barriers to entry into the profession. For witness testimonies and transcripts, see: `https://www.asc.gov/node/846256`.

3 Data

Our analysis combines several sources of data. Principal among these is the Federal Housing Finance Agency's Uniform Appraisal Dataset (UAD). The UAD comprises the universe of home appraisals submitted to the Uniform Collateral Data Portal (UCDP). It is part of the Uniform Mortgage Data Program (UMDP), an effort undertaken jointly by Fannie Mae and Freddie Mac at the direction of the Federal Housing Finance Agency to enhance mortgage data quality and standardization. The UAD represents the standard for data entry for home appraisals. It has been required by Fannie Mae and Freddie Mac since 2011 for all mortgages intended to be delivered to them for acquisition.[12]

Each UAD record contains a wealth of information about the subject property, the comparable properties used, and their reconciliation. In addition to the appraisal outcome, this includes extraordinarily detailed information on the location, contract price and characteristics of the subject property, sale price and characteristics of each comparable property, and concession, or adjustment, amount.[13] The appraiser is also required to provide standardized ratings on the property condition and construction quality, and an indication on whether there was any recent upgrade. We use information on comparable properties to calculate the distance between the subject and comparable properties, differences in attributes, and adjustments made by the appraiser. Using information on the appraiser, we construct a unique anonymous identifier to track them across space and over time.

A critical feature of the UAD is that it comprises appraisals that led to a mortgage origination as well as appraisals that did not. Once an appraisal is ordered by the lender as part of the mortgage application process and the report has been completed and submitted to the UCDP system by the appraiser, a UAD record is generated and kept in the system. This is an important feature of the data because a low appraisal substantially raises the likelihood a sale is not completed and the mortgage is not originated. It follows that analyses of appraisal

[12]We analyze all UAD purchase appraisal records for 1-unit single-family properties, including 1-unit properties with an accessory unit or a unit in a planned unit development (PUD). These are digitized from the Uniform Residential Appraisal Report (URAR) for purchase mortgage applications requiring a traditional home appraisal. It excludes hybrid or desktop appraisals, exterior-only appraisals, and appraisals for a manufactured home or a unit in a condominium or cooperative project. The data is collected using Fannie Mae Form 1004/Freddie Mac Form 60. For details, see: `singlefamily.fanniemae.com/delivering/uniform-mortgage-data-program/uniform-appraisal-dataset`, and `sf.freddiemac.com/tools-learning/uniform-mortgage-data-program/uad`.

[13]See Appendix A for more information.

outcomes based on appraisals from originated mortgages suffer a severe selection problem. The full UAD is not prone to this limitation.

Our definition of the neighborhood is a Census tract, and we obtain demographics at the tract level from the American Community Survey's (ACS) five-year averages.[14] These include race, population density, education, income, take up of public assistance, home ownership rates, and age of homes in the neighborhood. We include information on these for the analysis period, 2015-2019, and also for the previous 5 year period, 2010-2014. Including this historic information allows us to control for the medium term growth or decline of the neighborhood.[15]

As aforementioned, air quality is an important neighborhood amenity and, more importantly, a determinant of property values (Chay and Greenstone, 2005). It is not explicitly captured in the appraiser's report, though it more than likely forms part of their valuation decision. We obtain air quality data from the Centers for Disease Control and Prevention's (CDC) modeled predictions from the EPA's *Downscaler* model. Specifically, we use the $PM_{2.5}$ daily forecast at the Census tract level.[16] We include both mean and standard deviation of this measure over our five year analysis period. The latter accounts for the significant chance of bad quality days even when the average air quality is fair.

The instrumental variable design is based on race shares from the 1970 Decennial Census. In 1970, many areas of the United States were not assigned a Census tract. Moreover, tracts change after each decennial census. To account for these changes and standardize to 2010 geographic boundaries, we obtain data from the Longitudinal Tract Data Base (LTDB) described in Logan, Xu, and Stults (2014). The LTDB uses area and population weighted information to standardize tract boundaries over time. Finally, we use the monthly Zillow Home Value Index (ZHVI) at the County level for tracking local market fluctuations.[17] These

[14]We use the ACS five-year data available through the University of Michigan's Integrated Public Use Micro-data Series (IPUMS). The data can be obtained at `usa.ipums.org`.

[15]In our main analysis, we use the tract as our definition of a neighborhood in large part because it is a reasonably sized geographic unit and the most granular level of geography available in the historical context (see below our discussion of the IV). However, in Table B2 of Appendix B we provide robustness analysis showing our OLS results are almost completely unchanged when conducting the analysis re-defining the neighborhood to be a Census block-group.

[16]More information on the *Downscaler* model and these data can be found in `data.cdc.gov/Environmental-Health-Toxicology/Daily-Census-Tract-Level-Ozone-Concentrations-2016/hf2a-3ebq/about_data`

[17]Specifically, we use the smoothed ZHVI time series for all homes. The data can be obtained at `https://www.zillow.com/research/data/`.

are merged at the tract and county-month level, respectively.

Our period of analysis spans January 2015 to December 2019, inclusive. We choose this period because it coincides with the 2015-2019 American Community Survey (ACS) 5-year average. This is the most recent ACS release prior to the beginning of the COVID-19 pandemic. It thereby avoids complications to our analysis brought on by market disruptions stemming from the pandemic shock.[18] Summary statistics of the data are reported in Table 1. The analysis data includes a little over 7.5 million appraisal records completed in 45,608 tracts.[19]

As shown in the table, about 8.3 percent of appraisals are below the contract price, or are low appraisals. The typical low appraisal is nearly 5 p.p. lower than the contract price. Given the average contract price is about $357,000, this amounts to $\$357,000 \times 4.95\% \approx \$17,680$ lower, or 25 percent of the modal down payment. For more than 75 percent of low appraisals in our sample, the appraised value is more than 1.8 p.p. lower than the contract price.[20]

Of the remaining 91.7 percent of appraisals in our sample, 28.6 are exactly equal to the contract price and 63.1 are above. The large mass of appraisals exactly equal to the contract price has long been a source of interest in the literature. As aforementioned, it has been used as evidence to show bias in appraisal outcomes on numerous fronts. Our sample largely confirms this statistic. Previous work has claimed as additional evidence of potential bias the fact that appraisers observe the contract price prior to submitting their appraisal report (Eriksen et al., 2020). This information is included in their report, and is confirmed in Table 1. It is a USPAP requirement for an appraiser to have knowledge of the contract price. This is confirmed in the data, whereby in nearly all ($> 99\%$) appraisals, the appraiser reports having previous knowledge of the contract price.

[18]During this time, many appraisals were not conducted on site and numerous exceptions to the regular process were given. Many of these, though not all, have dissipated since.

[19]There are about 70 thousands Census tracts in the United States. This means our analysis sample does not include about 25 thousand tracts, which account for about 3.5 million appraisals in the UAD. In 1970, the area belonging to these 25 thousand tracts were areas where census tracts were not created by the Census in 1970 and are likely to have smaller populations. As a result, the LTDB is not able to provide standardized demographic (race) values for them. While we cannot carry out a full analysis on these remaining tracts, in the Appendix sections A and B we provide information on how the full sample, including all tracts comprising the UAD, compares to our analysis sample. We show both updated summary statistics and OLS regression results from our main specifications. Overall, we find that including these tracts does not materially alter our estimates. See the Appendix A and B for more details.

[20]Not shown in the table, about 90 percent of low appraisals are at least 1 p.p. below the contract price.

Table 1: Selected Summary Statistics

	Mean	SD	P25	P50	P75
Appraisal Outcomes					
% Low Appraisals	8.26				
Difference | Low (%)	-4.76	4.95	-6.06	-3.36	-1.82
% Equal Appraisals	28.6				
% High Appraisals	63.1				
Subject Property					
Contract Price ($)	357,143	296,098	190,000	285,000	425,000
Over Conforming Limit (%)	9.52				
Financial Assistance (%)	41.62				
Quality Score (1-5)	3.57	0.57	3	4	4
Condition Score (1-5)	2.85	0.89	3	3	3
Was for Sale Last 3 Years (%)	25.30				
Effective Age (Years)	13.46	10.59	5	12	20
Actual Age (Years)	35.74	29.92	12	30	56
Comparables					
Comparable Prop. for Sale ≤ 2 (%)	22.24				
# of Comparable Prop. Used	5.18	1.32	4	5	6
Calc Avg Proximity of Comps (Miles)	0.83	1.28	0.28	0.48	0.85
Avg Gross Adjustment (%)	9.71	6.00	5.58	8.48	12.43
Market					
%ΔZHVI	56.98	46.33	30.00	54.98	81.04
%ΔZHVI_{t-1}	57.39	46.81	30.21	55.22	81.57
Appraiser					
Appraiser Saw Contract Price (%)	99.99				
Gained Experience (#)	325.49	356.99	89	215	436
Gained Exp. in Neighborhood (#)	4.44	12.01	0	1	4
Tract/Neighborhood					
% African American	15.17	22.46	1.57	5.55	17.32
% African American in 1970	7.70	18.83	0.00	0.45	3.96
Pop. Density (1k/mi^2)	5.73	8.19	1.44	3.49	6.60
% Bachelors or Higher	41.94	19.55	26.60	39.81	55.82
Median Annual Household Income ($)	72,649	35,716	47,500	65,219	89,963
% Owner Occupied	62.67	22.44	46.55	65.74	81.29
% Public Assistance	2.56	2.98	0.67	1.67	3.38
% Constructed Pre 1970	44.98	30.51	15.80	44.69	72.78
Mean Predicted Daily $PM_{2.5}$ Level	8.88	1.46	7.94	8.87	9.66
SD Predicted Daily $PM_{2.5}$ Level	4.45	1.22	3.76	4.29	4.81
Number of Observations	7,508,826				
Number of Tracts	45,608				

The average contract price in our sample is $357,143, with an inter-quartile range of $140,000. In just over nine in ten properties of our sample, 80 percent of the contract price falls above the conforming limit in that county-year. This indicates that our sample is made up largely of properties in the middle range of the home value distribution, in line with the construction of the UAD described above. While some properties may be high value, they are few.

Condition and quality scores are important variables in our analysis because they provide a standardized scale of assessment for the property and do not vary across neighborhoods or over time. Property Condition and Quality of Construction scores are determined by the appraiser and are based on a holistic view of the property and any improvements. The measurements range from C1-C6 and Q1-Q6 for condition and quality ratings, respectively. The median condition score in our sample is C3 while the median quality score is Q4. These metrics are recorded for both subject properties and comparable sales.[21]

As reflected in the actual age variable, the typical subject property in our sample was built 36 years prior to its appraisal, and 75 percent were built fewer than 56 years prior. However, many improvements are made to homes after their construction. These changes are reflected in the effective age variable, which captures the appraiser's assessment of what age the property best compares to in its current condition. As shown in Table 1, the effective age for a typical property in our sample is just 13 years, whereas about 75 percent of homes are "effectively" less than 20 years old.[22]

On average, five comparable properties are used in an appraisal and at least 4 are used in 75 percent of appraisals. This is in line with estimates from Cannon and Fischler (2024) showing that the modal appraisal is based on 5 comparable properties. Moreover, for most appraisals, more than 2 comparable properties used have been recently or are currently for sale. On average, a comparable property is less than a mile away from the subject, though this also varies by neighborhood. The average gross adjustment of comparable property

[21] A lower number indicates a higher quality/construction. For example, a "custom" home has quality rating Q2, whereas a standard tract home has a quality rating of Q4. A condition score of C1 refers to a home that is entirely new and has not yet been occupied. A home with condition rating C4 features minor deferred maintenance and physical deterioration due to normal wear and tear. For exact definitions, see: `singlefamily.fanniemae.com/media/21731/display`, and `sf.freddiemac.com/docs/pdf/requirements/uad_appendix_d_field_specific_standardization_requirements.pdf`.

[22] As discussed further below in Section 4, about 99 percent of homes in our sample are "effectively" less than 45 years old. In other words, nearly all properties in our sample were either built more recently or substantially renovated after 1970.

values made by an appraiser is nearly 10 percent of the contract price. This is a substantial amount underscored by the fact that its coefficient of variation is nearly two thirds of the mean. Such significant variation in the appraisers' gross adjustment highlights their flexibility in determining property values.[23]

The proportion of African Americans in a tract is 15 percent, on average. However, this is highly skewed. At the 25^{th} percentiles, only 1.6 percent of tract residents are African American. Only 5 percent of tracts are majority African American (not shown). Also shown in the table, as compared to today, the distribution of African Americans was more concentrated in 1970. In an average tract, about 42 percent have a college degree and annual income is just over $72 thousand. About 62 percent of homes are owner occupied and just over 55 percent were constructed prior to 1970.[24]

High levels of particulate matter in the air are hazardous to health and are correlated with housing prices. They also disproportionately negatively affect communities with higher shares of African American residents (Tessum et al., 2021). In our analysis sample, the average daily level of $PM_{2.5}$ is 8.88 µg/m^3. To put this in context, the Environmental Protection Agency (EPA) sets a daily $PM_{2.5}$ standard of 35 µg/m^3 and recently lowered the standard for annual $PM_{2.5}$ emissions from 12 µg/m^3 to 9 µg/m^3.

We use a 5-year average of daily particulate matter in order to be consistent with ACS 5-year estimates and the 5-year averages of UAD data included in the sample. While not an exact comparison to the annual standard, we note that each individual annual mean $PM_{2.5}$ estimate ranges only between 8.8 and 8.9 µg/m^3, similar to the overall average of 8.87 µg/m^3. Moreover, a (mean) standard deviation of 4.45 µg/m^3 suggests the average census tract often rises above the annual standard, but does not often go over the daily standard.

[23]For example, recent evidence suggests time adjustments to comparable sales is not frequent nor large enough for majority minority African American and Hispanic neighborhoods (Doerner and Susin, 2024)

[24]Note this statistic is distinct to actual age reported in UAD. This reflects all housing units in a tract, regardless of whether or not they have been put up for sale. As might be expected, homes put up for sale are on average younger (about 25 percent of properties appraised were for sale in the previous 3 years). This is reflected in the difference between these two variables shown in Table 1.

4 Race and Appraisal Outcomes

4.1 Race and the Frequency of Low Appraisals

We begin the analysis by documenting the basic relationship between low appraisals and the proportion of African American residents in a Census tract, commonly referred to as the low appraisal gap. This is reported in Column 1 of Table 2. The association is quantitatively

Table 2: Appraisals and Minority Presence

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	OLS		1^{st} *Stage*	*Instrumental Variable*			
	Low Appraisal	Low Appraisal	% African American	Low Appraisal	Equal Appraisal	High Appraisal	%Difference
% African American (A_g)	0.107**	0.038**		0.022**	0.008	-0.030	-0.034**
	(0.002)	(0.002)		(0.006)	(0.007)	(0.0096)	(0.002)
% African American in 1970 (A_g^{1970})			0.523**				
			(0.006)				
County-QtrYr FE	✓	✓		✓	✓	✓	✓
Controls							
Property (R)		✓		✓	✓	✓	✓
Comparables (S)		✓		✓	✓	✓	✓
Appraiser (E)		✓		✓	✓	✓	✓
Tract (G)		✓	✓	✓	✓	✓	✓
Market (M)		✓		✓	✓	✓	✓
Mean Dep. Var	8.257	8.257	15.170	8.257	28.618	63.125	-4.756
N	7,508,826	7,508,826	45,608	7,508,826	7,508,826	7,508,826	615,307

Notes: *Data are from the UAD and include appraisals completed between 2015 and 2019, inclusive. See Section 3 for full description on data construction. See Appendix B for complete regression results including the full set of estimates for controls. Standard errors in parentheses are clustered at the Census tract level.* + $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

large and precisely estimated. A one p.p. higher proportion of African American residents in a tract is associated with a 0.107 p.p. higher likelihood of a low appraisal. As compared to a tract with few or no African American residents, the likelihood of a low appraisal is at least $0.107 \times 50 \approx 5.35$ p.p., or $5.35/8.26 \approx 65$ percent, higher in a tract that is majority ($\geq 50\%$) African American.

However, recall that an appraiser follows the USPAP in reaching their value estimate. This means they consider the subject property's attributes, find comparable sales that best match the subject property, adjust for differences, and reconcile these based on physical property,

neighborhood, and market characteristics. This process requires the appraiser to incorporate a great many factors that mediate race into their decision rule. We map these factors into five categories: (1) characteristics (R) of the subject property (r), (2) characteristics (S) of the comparables used and their reconciliation, (3) the appraiser (E) themselves, (4) characteristics (G) of the neighborhood (g), and (5) local housing market conditions (M).

Characteristics of properties brought to market (R) can differ across neighborhoods in ways that are associated with neighborhood race. The UAD captures these in extraordinary detail. We include controls for total number of rooms, bedrooms, bathrooms, half bathrooms, total lot size, gross living area, basement, below-grade finished and unfinished area, central air conditioning system, swimming pool, fireplace, parking garage, number of stories, quality and condition ratings, and whether the unit has a water view or is situated in a water-view location. We also control for the appraiser's determination of the property's effective age.[25]

When finding comparable properties (S), appraisers may have fewer available and/or more differentiated options when appraising properties in a majority minority neighborhood. We control for the number of comparables properties used by the appraiser, their average distance from the subject property, and gross price adjustment (as a share of the sale price) made by the appraiser. We also control for other properties currently offered for sale in the neighborhood and the volume of appraisals in the neighborhood over the past three months. The latter accounts for overall thickness of sales in the neighborhood.

Appraisers themselves (E) often vary in the decisions they make given similar circumstances. These differences can be informed by their time invariant type or their evolving experience. Moreover, appraisers may be differently assigned to properties in neighborhoods with more or fewer African American residents. Transactions in minority neighborhoods may be assigned to appraisers with more or less experience, or to those who are intrinsically more conservative in their approach, regardless of the neighborhood.

We account for this heterogeneity using a unique, anonymous, appraiser identifier. We apply this identifier in two ways. First, we include a fixed effect to account for time invariant differences across appraisers. Second, we track appraisers' experience overall and in each neighborhood to account for their evolving traits throughout the period of analysis. Note

[25]See Section 3 and Appendix A details.

that an appraiser's baseline experience is also absorbed by the fixed effect. As a result, we can only measure how the experience they acquire throughout the study period changes their decisions. We further control for whether the appraiser saw the contract price prior to conducting the appraisal.

Qualities of a neighborhood (G) other than race, but which may be associated with it, likely also play an important role in the appraiser's decision rule. For example, similar properties in low-income neighborhoods with low home-ownership rates are less likely to attract future home buyers, and thereby may be appraised at a lower value. Further, medium term changes to the tract's character, such as increases in median income or education, can also signal its desirability and expected property values.

Specifically, we control for tract-level population density, education level of residents, median household income, home ownership rates, shares of residents receiving public assistance, and neighborhood air quality. We also include controls for the proportion of homeowners residing in a tract since 1970 and the share of homes built prior to 1970. These measures serve as a proxy for the long-term stability and longevity of home ownership in the neighborhood. To account for medium term neighborhood change, we control for each of these characteristics recorded in the previous 5-year period.[26]

Finally, an appraiser is compelled to incorporate local real-estate market conditions (M) into their valuation of the subject property. Principal among these is house price growth trends, which we construct using the Zillow Home Value Index (ZHVI). Specifically, we incorporate the monthly ZHVI growth rate and the lagged growth rate in the regressions. For secular time trends, we include County by Quarter fixed effects. We also include the previous 3-month moving average of contract prices (in log scale) of the appraisals in the neighborhood.

Column 2 of Table 2 reports OLS results of a linear regression controlling for the above discussed factors. As might be expected, the association between race and low appraisals is attenuated by 64 percent. Nevertheless, it remains both quantitatively meaningful and precisely estimated. All else equal, an appraisal in a tract that is majority ($\geq 50\%$) African American is at least $0.038 \times 50 \approx 1.90$ p.p. ($1.90\%/8.26\% \approx 23\%$) more likely to experience

[26]Since our period of analysis spans Jan 2015 - Dec 2019, the previous 5-year period includes Jan 2010 - Dec 2014, inclusive. See Section 3 and Appendix B for details.

a low appraisal relative to a sale in an otherwise similar tract with no African American residents.

Following a long standing tradition of discrimination studies dating to Oaxaca (1973) and Blinder (1973), we evaluate the distinct mediating role for each category of observable factors. This provides insight into the importance of race by highlighting how much the addition of each factor category accounts for the observed low appraisal gap. Specifically, we apply the conditional decomposition proposed in Gelbach (2016). This method derives a linear component structure characterizing the distinct role each observable factor plays in moderating a coefficient of interest. Importantly, it resolves the "order" problem.[27]

Equation 1 reports the results of this decomposition into the five aforementioned categories. The baseline (β_1^{base}) and full specification (β_1^{full}) estimates are those reported in Columns 1 and 2 of Table 2, respectively. Then, δ^k denotes the component of omitted variable bias estimated due to each factor k.

$$\begin{aligned} \beta_1^{base} - \quad \beta_1^{full} &= \quad \delta^{Property} + \delta^{Comps.} + \delta^{Market} + \delta^{Tract} + \delta^{Appraiser} \\ 0.107 - 0.038 &= \quad 0.004 \quad + 0.007 \quad + 0.002 \quad + 0.036 \quad + 0.020 \end{aligned} \tag{1}$$

Two categories emerge as especially prominent moderators: the neighborhood (tract) characteristics and the appraiser characteristics. All else equal, $0.036/0.068 \approx 53$ percent of this association can be attributed to heterogeneity in neighborhood characteristics captured in the regression. Similarly, were all appraisals completed by "the same" appraiser the association would attenuate by $0.020/0.069 \approx 29$ percent. Heterogeneity in the remaining factors accounts for $0.013/0.069 \approx 19$, with a larger weight on the comparable properties used and their reconciliation than on variation in the subject property characteristics. Count level differences of trends in property values account for about 3 percent of the observed gap.

[27] When added covariates are correlated to each other, the order in which they are introduced plays an exceptionally important role in how they moderate a coefficient of interest. The method exploits the well known omitted variable formula in a linear regression. Let $y = \beta_1 X_1 + \beta_2 X_2 + \epsilon$, and define β_1^{base} as $y = \beta_1^{base} X_1 + \epsilon$. Then,

$$\beta_1^{base} = \beta_1 + \Gamma\beta_2 = \beta_1 + \delta, \quad X_2 = X_1\Gamma + \nu.$$

It follows that the omitted variable can be written as the sum of individual factors, $\delta = \sum_{k=1}^{k_2} \Gamma\beta_{2k}$, whereby these are invariant to the order in which elements of X_2 are introduced. See paper for more details.

Broadly, the above findings indicate a quantitatively meaningful and precisely estimated association between a neighborhood's racial composition and the likelihood of a low appraisal. Though attenuated, this relationship remains economically substantial after controlling for observable factors comprising inputs into the appraisers' decision. Two sets of these inputs emerge as important moderators: (1) neighborhood (tract) characteristics, and (2) appraisers' "type" and experience.

4.2 The Impact of Race

Our broad set of controls absorbs much of the information the appraiser uses to make their valuation. However, there likely remain unobserved elements used by the appraiser to make their valuation that are associated with neighborhood race shares. To fix ideas, consider the following linear approximation of an appraiser's decision rule:

$$V_{rget} = F(A_g, R_{rgt}, S_{rgt}, E_{gt}, G_{gt}, M_{gt}, \nu_{rgt}, \epsilon_{rgt}$$

$$\approx \beta A_g + \gamma^r R_{rgt} + \gamma^s S_{rgt} + \gamma^e E_{gt} + \gamma^g G_{gt} + +\gamma^m M_{gt} + \nu_{rgt} + \epsilon_{rgt}. \quad (2)$$

V_{rgt} is the appraisal outcome for property r in neighborhood g at time t, and A_g is the race composition of neighborhood g. Characteristics $[R, S, E, G, M]$ are defined above. ϵ_{rgt} is an independently distributed idiosyncratic state observed only by the appraiser. Let ν_{rgt} denote the omitted component observed only by the appraiser and associated with A_g.

A great deal of information about the property, comparable set, neighborhood, and appraiser are already included in the regression reported in Column 2 of Table 2. Nevertheless, the omitted term ν can include remaining unreported information about these elements of their decision. Principally, it most likely contains information about the changing facets of the neighborhood affecting a property's prospective value. Our market controls are at the county-month level, leaving more granular market trends to be captured in ν. Notably, we analyze appraisers' valuation relative to a previously agreed upon contract price, eliminating variation in levels across neighborhoods.

Discrepancies between an appraisal and the contract price then largely reflect shorter differences in current or expected house prices brought about by changing facets of the neighborhood. For example, the appraiser might expect the neighborhood to experience house price decline or lower growth than surrounding areas in the County. They may also have knowledge of

(changes in) its unreported amenities not (or differently) incorporated in the contract price.[28] These factors, which are plausibly associated with the demographic composition of a tract and not captured well in our regression, would influence the appraiser's decision, spuriously pointing to them incorporating race in the appraisal.

To isolate the impact of race we apply an instrumental variable design. Our instrument is the historical race shares in a tract. Specifically, we use the 1970 census. We use shares in 1970 for several reasons. First, the 1970 Census takes place nearly half a century prior to the start of our analysis period. Neighborhoods changed a great deal throughout this time.[29] About 66 percent of the homes in our sample were not in existence before 1970, and over 99 percent are deemed "effectively" less than 45 years old.[30] In other words, of the minority of properties built before 1970, nearly all were substantially modified and updated. This assuages concerns that unobserved characteristics of the subject or comparable properties are associated with contemporaneous race in the tract. Further, the 1970 Census precedes the FIRREA by nearly two decades. It is unlikely any significant contingent of appraisers working as of 2015 were appraising homes in 1970.

Second, this decennial census marked the end of the Great Migration of African Americans from the South to northern cities during the 20^{th} Century. Over this period, which lasted from about 1910 to 1970, the number of African Americans living in non-southern areas grew from two and a half to nine million. As has been discussed in the literature on the Great Migration, this movement of people was driven by a mix of economic opportunity and social motivations (Tolnay, 2003). After 1970, the geographic movement of African Americans largely settled. Our instrument captures demographic patterns at the close of this migratory period.

[28] Recall that our specification already controls for 5 year changes in neighborhood characteristics.

[29] In Appendix C we provide a detailed analysis of neighborhood change between 1970 and our sample period via a neighborhood change index. Our analysis reveals that tract characteristics changed substantially over this half century. Some tracts experienced relative gains based on popular economic measures of well being, and some experienced relative decline. Notably, the index is less persistent than tract race shares. Moreover, the distribution of relative change does not shift, but rather becomes more disperse, when conditioning on race.

[30] Effective age is determined and reported by the appraiser. It captures what the appraiser deems the effective age of the property after accounting for renovations and improvements. As a point of comparison from Table 1, in over 75 percent of tracts the actual age of typical property being appraised is less than 56 years. Moreover, in a typical tract, over 55 percent of housing units, whether up for sale or not, were constructed after 1970.

Third, the 1970 Census took place at the start of a post FHAct and ECOA housing market. With few exceptions, the FHAct newly prohibited any discrimination in the sale, rental, or financing of housing on the basis of race or color. The ECOA, passed just six years later, further restricted creditors from discriminating on these bases. Prior to FHAct and ECOA, racial restrictive covenants abounded (Jones-Correa, 2000; Brooks, 2011). Further, even in the absence of sales covenants, lenders were not prohibited from, and often practiced, "redlining" credit to African Americans seeking financing for new home purchases (Aaronson, Hartley, and Mazumder, 2021).

As has been shown, these practices fostered racial segregation and interrupted the free development of cities and neighborhoods. The FHAct and ECOA did not eliminate discrimination and resultant segregation (Yinger, 1991). However, they provided a template for its undoing. Improved enforcement of these rules in the 1980's augured a more dynamic and equitable housing market (Yinger, 1999). The 1970 census represents a snapshot of housing and the demographic shares at the start of this new era of housing policy.

More formally, our identification of the race effect relies on differential persistence in the unobserved processes driving a neighborhood's racial makeup and the omitted variable. The instrument's association with a neighborhood's demographic character today represents its long-term, or enduring, demographic path dependence. In contrast, the omitted factors contain information about persistent yet ultimately shifting aspects of the neighborhood.[31] We should note that, while popular, there has been criticism of the application of "lagged" variables as instruments, i.e. Reed (2015). However, nearly all studies cited use recent past

[31]Consider the following formal argument for identification. As a simple example, let the processes generating A_g and ν be given by:

$$\textbf{(i)}\ \ A_{g,t} = \rho A_{g,t-1} + \psi_{i,t} = \rho^k A_{g,t-k} + \sum_{j=0}^{k} \psi_{i,t-j}, \quad \textbf{(ii)}\ \nu_{rg,t} = \sum_{s=0}^{S} \alpha_s \nu_{rg,t-s}.$$

The evolution of a tract's racial composition follows a stationary AR(1) process with $\rho \in (0,1)$ shown in Equation **(i)**. This highlights the path dependence of tracts' demographic evolution. In contrast, systematic factors known only to the appraiser (ν) follow an MA(S) process with $\alpha \in (0,1)$. This is a persistent but ultimately finite process driving unobserved factors of neighborhood change. The maintained assumption is that $cov(A_{g,t}, \nu_{rge,t}) \neq 0$, or that $A_{g,t}$ is endogenous. Let k be the number of lags corresponding to the instrument. In this application, measured in five year intervals based on ACS releases, $k = 9$. Differential persistence in A and ν can be more precisely expressed as $S < k$. It follows that,

$$\textbf{FS}\text{: } Cov(A_{g,t}, A_{g,t-k}) = \mathbb{E}\big[(\sum_{j=0}^{k} \rho^j \psi_{g,t-j}) \cdot \psi_{g,t-j}\big] = \sum_{j=0}^{k} \rho^j \mathbb{E}\big[\psi_{g,t-j} \cdot \psi_{g,t-k}\big] = \rho^k \sigma_\psi^2 \neq 0,$$

values as instruments. In contrast, we look nearly a half century into the past. In addition to the long perspective, our choice is informed by the historical context. That is, we pick a point in history pivotal to the evolution of neighborhood shares and home-ownership of African Americans in the United States.

Column 3 of Table 2 reports the first stage regression. As shown in the table, a tract's racial composition displays considerable path dependence, with a correlation coefficient of just over 0.52. It is also precisely estimated, with a first stage F-statistic $> 10^3$. This is in line with our claim that neighborhood race shares are long lived. Column 4 reports the impact of race on the likelihood of a low appraisal. A one p.p. increase in the proportion African Americans in a tract raises the likelihood of a low appraisal by 0.022 p.p. In other words, increasing the share of African American residents in a tract by 50 percent generates a $0.022 \times 50 \approx 1.10$ p.p., or $1.10\%/8.26\% \approx 13.3$ percent increase in the rate of low appraisals.

The amount by which a low appraisal lies below the contract price also materially impacts the outcome of, and related surplus from, a transaction (Fout and Yao, 2016). Column 7 of Table 2 reports the impact of race on this difference. For low appraisals, a one p.p. increase in the proportion of African Americans in the tract reduces the relative appraisal value by 0.034 p.p. Increasing the proportion of a tract's African American residents by 50 p.p. leads a low appraised property to be valued $50 \times 0.034 \approx 1.7$ p.p. lower. Given the contract price for a typical property receiving a low appraisal is $391,000$, this amounts to $\approx \$6,650$, or 8.5 percent of the modal 20 percent down payment.

Though the appraiser reports an exact dollar value, much of the policy and academic discussions highlight three important reporting regions (Ben-David, 2011; Calem et al., 2021). The first is the low appraisal, or values below the contract price. Second is the "equal" appraisal, or the case of a home being appraised at exactly the contract price. A well known and highly cited fact in this market is that about 30 percent of properties are appraised at *exactly* the contract price.[32] The third is an appraisal above the contract price, or a "high"

---

and

$$\textbf{EXCL}\text{: } Cov(A_{g,t-k}, \nu_{rg,t}) = \mathbb{E}\big[\psi_{i,t-k} \sum_{s=0}^{S} \alpha_s \nu_{rg,t-s}\big] = \sum_{s=0}^{S} \alpha_s \mathbb{E}\big[\psi_{g,t-k} \cdot \nu_{rg,t-s}\big] = 0.$$

As shown, both requirements for the validity of the instrument, a non-zero first stage **(FS)** covariance and the exclusion **(EXCL)** assumption, are satisfied.

[32]As aforementioned, this excessive bunching at the contract price has motivated an intense debate about both the accuracy and independence of appraisals.

appraisal. High appraisals have little material impact on the transaction. They do provide some comfort to the buyer, though they may also trigger an overvaluation flag from the GSEs.

Columns 5 and 6 of Table 2 report the impact of race on "equal" and (the remaining) "high" appraisals, respectively. As shown in the table, race does not have a significant impact on equal appraisals. Rather, race reduces the likelihood of high appraisals. This indicates a secular shift down of the distribution as a whole, rather than just a lower incidence of equal appraisals. This is likely the results of appraisers' overall reticence to generate high valuation risk scores, or over-valuation flags, that can lead to overturned appraisals in post acquisition audits, even exposing the lender to risk from default.

4.3 Relation to Existing Theories

We now turn to understanding the potential mechanisms underlying the effects of neighborhood race on appraisals. Theories of discrimination have for the most part converged on two forms of racial bias (Arrow, 1998). The first is taste-based discrimination (Becker, 1957; Krueger, 1963). Under this market based view, discrimination is expressed as a preference that distorts "trade" between groups. A preference for discrimination generates a kind of tax on trade leaving a wedge between factors of production. The second type is commonly referred to as statistical discrimination (Phelps, 1972; Spence, 2002; Stiglitz, 1973). Statistical discrimination is premised on incomplete information between parties, whereby decisions rely on prior beliefs or expectations. Race is used as a surrogate for those unobserved characteristics with which it is associated.

In our setting, the appraiser may incorporate race into their decision rule because, all else equal, they intrinsically value homes in minority neighborhoods less. Alternatively, uncertainty about actual home values can lead them to substitute race for specific knowledge about a neighborhood or property. In this latter case, they may use race to establish beliefs about the expected resale price of a property. Were they to have more experience in a neighborhood, or were more information about expected property values available to them, we would expect race to have a smaller influence on their beliefs, and thereby to matter less for the outcome.

We test these predictions by estimating heterogeneous effects through a series of interactions of race share with appraisers' experience and the information available on recently appraised

homes in the neighborhood.[33] Our results are shown in Table 3. Column 1 reports heteroge-

Table 3: Heterogeneous Effects

(Depvar = Low Appraisal)	(1)	(2)	(3)
Interaction Var (I^k_{rget}) =	Previous Qtr. Num. Appraisals in Tract (> Median)	Appraiser's Previous Experience in Tract (> Median)	Appraiser's Previous Experience Overall (> Median)
(i) % African American (A_g)	0.025**	0.025**	0.024**
	(0.005)	(0.005)	(0.006)
(ii) $A_g \times I^k_{rget}$	-0.017**	-0.015**	-0.003
	(0.006)	(0.004)	(0.004)
(i) + (ii)	0.008	0.010	0.021**
	(0.009)	(0.007)	(0.006)
County-Qtr-Yr. FE	✓	✓	✓
Controls (R, S, E, G, M)	✓	✓	✓
Mean Dep. Var	8.257	8.257	8.257
Mean I^k_{rget}	24.518	4.442	325.487
Median I^k_{rget}	14	1	215
N	7,508,826	7,508,826	7,508,826

Notes: *Data are from the UAD and contain appraisals completed between 2015 and 2019, inclusive. See Section 3 for full description on data construction. Standard errors in parentheses are clustered at the Census tract level.* $+\ p < 0.10,\ *\ p < 0.05,\ **\ p < 0.01$

neous race effects across tracts in which many purchase appraisals occurred over the past quarter compared to those with few. When appraisers work in tracts with many appraisals there is more up to date information about expected resale prices. Under an information model, we would expect the effect to be attenuated in tracts with more previous appraisals. As shown in Column 2 of the table, the impact of race is not statistically different from zero when a typical appraiser works in these tracts. In other words, the average appraiser does not incorporate race into their decision when appraising in neighborhoods with more up to date information about previous appraisals, and potentially re-sale, is known.

In Column 2 of Table 3, we interact race with an appraiser's past experience in the tract and their experience generally. As shown in the table, when appraisers work in a neighborhood they have worked in previously, the magnitude of the race effect is substantially reduced to the point where it is no longer statistically different from zero. This is also consistent with models information based discrimination: more knowledge of the neighborhood reduces an

[33]These interactions require a second instrument. We use the product of a tract's historical race share and the interaction variable. See Wooldridge (2010) for a further discussion of this approach.

appraiser's reliance on race to form beliefs. In contrast, overall appraisal experience does not seem to significantly alter the effect. This is shown in Column 3 of Table 3.[34]

This last finding on overall experience suggests two things. First, it is specific experience in a neighborhood that matters for assessing resale values. Second, all else equal, inexperienced appraisers do not seem to differ in their use of race from those who are more established. Though cursory evidence, it is inconsistent with a model of preference based discrimination: inexperienced appraisers trying to establish a reputation may find it more costly to be inaccurate or report a low appraisal (Ben-David, 2011; Calem et al., 2021; Conklin et al., 2020). Taken together, our estimates are more consistent with an information based, or statistical, model of discrimination in which race serves as a surrogate for unobserved factors determining resale value.

5 Conclusion

In this paper, we show that appraisers incorporate the neighborhood's race mix into their valuation decisions. A rise in the proportion of African Americans in a tract, or neighborhood, significantly increases the incidence of low appraisals. All else equal, increasing the proportion of African American residents in a tract from none to 50 percent (just a majority) generates a 13.3 percent rise in the likelihood of receiving a low appraisal.

We further show that the role of race in appraisers' decision rule largely dissipates when the (typical) appraiser is working in a neighborhood they have worked in before or in a neighborhood where many recent appraisals took place. This new set of results is more consistent with models of statistical, or information based, discrimination. In this class of models, race is used as a surrogate to help form expectations for property values when more specific information is unavailable. When such information is available, like when appraisers have experience in a neighborhood or when they work in "thicker" markets, race no longer seems to play a role.

The findings in this paper arise from our analysis of a large database of appraisals, the UAD.

[34]Note that, since our specifications include appraiser fixed effects, our estimates are based on within appraiser (over time) variation. That means all of an appraiser's experience prior to the start of the analysis period is time invariant and incorporated in their fixed effect. The results in Columns 2 and 3 are therefore based on experience acquired during the analysis period. In other words, once we observe an (average) appraiser gaining additional experience in a tract, the share of African American residents in that tract no longer factors into their appraisal decision.

The UAD is especially well suited to this study for a number of reasons. Principal among these is that it includes both appraisals that led to a mortgage origination and those that did not. This feature assuages concerns over missing data that have been a limiting factor in previous work on this topic. Further, the UAD records extraordinarily detailed information about the appraiser's decision process. This allows us to include a rich set of controls for factors that may confound the race effect, limiting pathways for unobserved confounding elements and informing our instrumental variable design.

Lastly, it is important to note the results in this study are incremental to our knowledge on the topic of discrimination in home purchase appraisals. Much is left to future work. In particular, two questions naturally arise from our analysis. First, what are the welfare and distributional impacts of racial discrimination in home purchase appraisals? Second, to the extent information drives the impact of race on appraisals, what does this imply for optimal policy designs meant to address the issue?

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Appendix

A Summary Statistics

Table A1 reports complete summary statistics for the analysis sample and the full UAD. The estimation sample encompasses 7,508,826 appraisals in 45,608 tracts while the full data includes 11,010,358 appraisals in 69,382 tracts. Summary statistics of the estimation sample compare closely to the full data with reasonable variation. The main outcome, percent of appraisals that are low, shows a minimal difference between the full and estimation samples, though it is slightly higher in the estimation sample. The vast majority of the other demographic, market, and property specific dimensions had similar means between the full and estimation samples, with less than a 10 % difference as a percentage of the full sample mean for most variables. [35]

A few variables did have noticeably larger percent differences. These include whether the property is located near water (57%), whether there is a water view (38%), the site area in acres (32%), the average proximity of comps (31%), population density (23%), and appraiser experience in African American-majority tracts (20%). This is not unexpected given the additional tracts in the full sample are those not well populated in 1970. Moreover, most of these have a low baseline and therefore show low nominal differences. For example, for average proximity the estimation sample had a mean of 0.81 miles while the full sample was greater by less than half a mile at 1.21 miles on average.

B Full Regression Results

Table B1 reports the complete set of estimates of regressions shown in Table 2. We find that the signs of parameter estimates typically align with intuition. For example, the positive direction on the estimate of the number of comparable properties used might indicate that appraisers may incorporate more comparable properties, or information, to justify a low appraisal. Additionally, the positive sign on the gross adjustments made to comparable

[35] Property condition and quality of construction scores are determined by the appraiser and recorded as part of a home appraisal, representing a holistic view of the property and any improvements. The property condition scale ranges from C1 to C6, with C1 representing very recently constructed properties with no physical depreciation and C6 representing properties with substantial damage, deferred maintenance, or deficiencies. Similarly, Quality of Construction is scored on a scale ranging from Q1 to Q6, with Q1 representing exceptionally high-quality refinements, workmanship and materials. Conversely, Q6 properties represent lower cost, basic properties with unprofessional build quality that may lack electrical, plumbing, or mechanical systems.

Table A1: Complete Summary Statistics for Full and Estimated Sample

	Estimation Sample					Full Data				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Mean	SD	P25	P50	P75	Mean	SD	P25	P50	P75
Appraisal Outcomes										
Low Appraisals	8.26					7.78				
Difference | Low	-4.76	4.95	-6.06	-3.36	-1.82	-4.94	5.24	-6.25	-3.45	-1.84
Equal Appraisals	28.62					26.83				
High Appraisals	63.13					65.39				
Subject Property										
Contract Price	357,143	296,099	190,000	285,000	425,000	338,900	291,307	178,398	269,900	404,980
View Type: Water	2.29					3.70				
Location: Water	0.57					1.35				
Total Rooms	6.96	1.68	6	7	8	6.86	1.66	6	7	8
Bathrooms	2.45	0.96	2	2	3	2.41	0.95	2	2	3
Bedrooms	3.31	0.81	3	3	4	3.26	0.82	3	3	4
Site Area (Acres)	0.50	1.82	0.14	0.20	0.33	0.74	2.89	0.15	0.22	0.40
Gross Living Area (1k Sqft)	2.01	0.86	1.38	1.81	2.44	1.98	0.84	1.37	1.79	2.40
Quality Score (1-5)	3.57	0.57	3	4	4	3.57	0.58	3	4	4
Condition Score (1-5)	2.85	0.89	3	3	3	2.84	0.91	3	3	3
Effective Age	13.46	10.59	5	12	20	13.04	10.49	5	10	20
Actual Age	35.74	29.92	12	30	56	34.76	30.65	11	28	54
Below Grade Total Sqft	459.47	634.09	0	0	920	447.70	632.08	0	0	912.00
Below Grade Finished Sqft	215.60	425.59	0	0	277	206.58	422.86	0	0	72
Central A/C	87.44					85.60				
Pool	9.50					8.95				
Fireplace	61.31					58.16				
Basement	42.14					40.95				
Garage	85.63					84.05				
Has a Half Bathroom	44.11					41.20				
2 or More Stories	52.60					49.92				
Transaction										
Financial Assistance	41.62					42.36				
Over Conforming Limit	9.52					8.63				
Comparables										
Comparable Prop. for Sale ≤ 2	22.24					22.90				
Number of Comparable Properties Used	5.18	1.32	4	5	6	5.16	1.34	4	5	6
Calc Avg Proximity of Comps (Miles)	0.83	1.28	0.28	0.48	0.85	1.21	2.21	0.31	0.54	1.09
Avg Gross Adjustment Percent	9.71	6.00	5.58	8.48	12.43	10.64	6.96	5.88	9.10	13.64
Was for Sale Last 3 Years	25.30					25.26				
Market										
$\%\Delta$ZHI	0.57	0.46	0.30	0.55	0.81	0.56	0.46	0.29	0.54	0.81
$\%\Delta\text{ZHI}_{t-1}$	0.57	0.47	0.30	0.55	0.82	0.56	0.47	0.29	0.54	0.81
Appraiser										
Appraiser Experience	325.49	356.99	89	215	436	304.41	344.35	77	197	409
Experience in AA Neighborhoods	4.44	12.01	0	1	4	5.53	14.12	0	1	5
Appraiser Saw Contract Price	99.99					99.99				
Tract/Neighborhood										
% African American	15.17	22.46	1.57	5.55	17.32	13.60	21.48	0.99	4.26	15.24
% African American in 1970	7.70	18.83	0.00	0.45	3.96					
Pop. Density (1k/mi^2)	5.73	8.19	1.44	3.49	6.60	4.67	8.79	0.33	2.23	5.26
Pct Bachelors or Higher	41.94	19.55	26.60	39.81	55.82	39.04	18.71	24.61	35.61	51.33
Pct Bachelor or Higher 2014	38.72	19.24	23.54	36.23	52.04	35.91	18.36	21.73	32.25	47.55
Median Annual Household Income ($)	72,649	35,716	47,500	65,219	89,963	67,380	33,241	44,783	49,875	81,866
Median Annual Household Income 2014 ($)	61,893	30,540	40,362	55,704	76,752	57,579	28,284	38,388	51,285	70,035
Log Income	11.08	0.48	10.77	11.09	11.41	11.01	0.47	10.71	11	11.31
Log Income 2014	10.92	0.48	10.61	10.93	11.25	10.85	0.46	10.56	10.85	11.16
Pct Owner Occupied	62.67	22.44	46.55	65.74	81.29	64.63	21.72	50.44	69.25	81.93
Pct Owner Occupied 2014	63.08	22.23	47.43	66.26	81.54	64.92	21.49	51.11	69.60	81.95
Pct Public Assistance	2.56	2.98	0.67	1.67	3.38	2.51	2.85	0.71	1.68	3.31
Pct Public Assistance 2014	3.10	3.47	0.85	2.04	4.10	3.00	3.29	0.90	2.05	3.95
Mean Predicted Daily $PM_{2.5}$ Level	8.88	1.46	7.94	8.87	9.66	8.54	1.49	7.59	8.64	9.37
SD Predicted Daily $PM_{2.5}$ Level	4.45	1.22	3.76	4.29	4.81	4.26	1.22	3.52	4.11	4.69
Mean Predicted Daily $PM_{2.5}$ Level 2014	9.77	1.56	8.74	9.89	10.75	9.43	1.62	8.42	9.59	10.45
SD Predicted Daily $PM_{2.5}$ Level 2014	4.70	1.23	3.99	4.69	5.40	4.46	1.17	3.77	4.31	5.20
Pct Constructed Pre 1970	44.98	30.51	15.80	44.69	72.78	42.91	28.41	18.05	40.66	66.80
Number of Observations	7,508,826					11,010,358				
Number of Tracts	45,608					69,382				

properties indicates that, on average, more adjustments are made to the sale price on low appraisals.

The results suggest that, when looking at general experience, more seasoned appraisers may have more confidence delivering a low appraisal. Additionally, when an appraiser has specific experience in a neighborhood or greater information about the market, they are less likely to deliver a low appraisal. Some results, like the estimates on the quality and condition scores, are less predictable. Though these scores are likely positively correlated, they measure different attributes of the property and the parameter estimates on the scores have opposite signs. Overall, regression results are robust and a majority of the parameter estimates are precisely estimated.

Table B1: Complete Regression Results (Analysis Sample)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	OLS		1^{st} *Stage*	*Instrumental Variable*			
	Low Appraisal	Low Appraisal	% African American	Low Appraisal	Equal Appraisal	High Appraisal	%Difference
Pct. African American (%AA)	0.1073**	0.0379**		0.0221**	0.0078	-0.0300**	-0.0341**
	(0.0022)	(0.0017)		(0.0055)	(0.0070)	(0.0096)	(0.0024)
%AA in 1970			0.5225**				
			(0.0062)				
View Type: Water		0.0100		0.0021	0.2213^{+}	-0.2234	-0.0016
		(0.0978)		(0.0980)	(0.1263)	(0.1520)	(0.0444)
Location: Water		-0.9154**		-0.9220**	-0.9402**	1.8622**	-0.1764
		(0.1666)		(0.1667)	(0.2300)	(0.2654)	(0.1089)
Total Rooms		-0.1311**		-0.1303**	-0.0879**	0.2183**	0.1007**
		(0.0151)		(0.0151)	(0.0238)	(0.0268)	(0.0095)
Bathrooms		0.0352		0.0329	-0.7465**	0.7135**	-0.0054
		(0.0271)		(0.0271)	(0.0430)	(0.0492)	(0.0176)
Bedrooms		-0.0297		-0.0246	0.3028**	-0.2782**	0.1508**
		(0.0239)		(0.0239)	(0.0370)	(0.0431)	(0.0143)
Site Area (Acres)		-0.0914**		-0.0917**	-0.0571**	0.1488**	0.0086
		(0.0061)		(0.0061)	(0.0099)	(0.0112)	(0.0082)
Gross Living Area (1k Sqft)		-2.5716**		-2.5640**	-2.9591**	5.5231**	0.0015
		(0.0389)		(0.0389)	(0.0605)	(0.0725)	(0.0256)
Quality Score (1-5)		-0.3301**		-0.3269**	-1.5337**	1.8606**	-0.0883**
		(0.0283)		(0.0283)	(0.0453)	(0.0512)	(0.0197)
Condition Score (1-5)		0.4792**		0.4771**	6.0788**	-6.5559**	-0.2973**
		(0.0272)		(0.0272)	(0.0636)	(0.0785)	(0.0124)
Effective Age		-0.0800**		-0.0811**	-0.1369**	0.2181**	-0.0358**
		(0.0021)		(0.0021)	(0.0033)	(0.0039)	(0.0013)
Below Grade Total Sqft		0.0006**		0.0006**	-0.0011**	0.0005**	-0.0002**

Notes: Footnotes. $+ p < 0.10$, $* p < 0.05$, $** p < 0.01$ Continued on next page

Table B1: Complete Regression Results (Analysis Sample)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	OLS		1^{st} *Stage*	*Instrumental Variable*			
	Low Appraisal	Low Appraisal	% African American	Low Appraisal	Equal Appraisal	High Appraisal	%Difference
		(0.0000)		(0.0000)	(0.0001)	(0.0001)	(0.0000)
Below Grade Finished Sqft		0.0005**		0.0005**	0.0007**	-0.0013**	0.0001**
		(0.0000)		(0.0000)	(0.0001)	(0.0001)	(0.0000)
Central A/C		0.7257**		0.7196**	1.3415**	-2.0610**	0.3868**
		(0.0429)		(0.0429)	(0.0694)	(0.0775)	(0.0325)
Pool		0.3782**		0.3703**	0.9196**	-1.2900**	0.1211**
		(0.0518)		(0.0519)	(0.0694)	(0.0859)	(0.0207)
Fireplace		0.6307**		0.6358**	0.8157**	-1.4515**	0.1419**
		(0.0310)		(0.0311)	(0.0509)	(0.0606)	(0.0169)
Basement		-1.7768**		-1.7728**	-0.5720**	2.3448**	0.4380**
		(0.0578)		(0.0578)	(0.0901)	(0.1036)	(0.0414)
Garage		0.2014**		0.1886**	-0.7724**	0.5839**	0.5283**
		(0.0431)		(0.0433)	(0.0587)	(0.0699)	(0.0251)
Has a Half Bathroom		0.3613**		0.3698**	0.7838**	-1.1536**	0.0696**
		(0.0304)		(0.0306)	(0.0474)	(0.0545)	(0.0190)
2 or More Stories		0.2899**		0.2899**	0.1768**	-0.4667**	-0.1195**
		(0.0367)		(0.0367)	(0.0527)	(0.0647)	(0.0196)
Appraiser Saw Contract Price		-2.2480^{+}		-2.2478^{+}	5.1146**	-2.8668	0.5112
		(1.2277)		(1.2278)	(1.6435)	(1.7632)	(0.5016)
Financial Assistance		-0.8562**		-0.8487**	-1.2352**	2.0839**	0.2725**
		(0.0249)		(0.0250)	(0.0433)	(0.0496)	(0.0148)
Over Conforming Limit		3.7926**		3.8054**	3.4764**	-7.2818**	-2.0904**
		(0.0676)		(0.0676)	(0.1008)	(0.1280)	(0.0455)
Comparable Prop. for Sale ≤ 2		2.0640**		2.0568**	0.8602**	-2.9170**	-0.0884**
		(0.0333)		(0.0333)	(0.0489)	(0.0540)	(0.0171)
Number of Comparable Properties Used		2.1371**		2.1370**	0.2683**	-2.4054**	-0.0919**
		(0.0151)		(0.0151)	(0.0192)	(0.0214)	(0.0065)
Calc Avg Proximity of Comps (Miles)		-0.0659**		-0.0697**	0.2616**	-0.1919**	-0.0799**
		(0.0106)		(0.0107)	(0.0167)	(0.0192)	(0.0108)
Avg Gross Adjustment Percent		0.1759**		0.1767**	-0.1681**	-0.0086^{+}	-0.1625**
		(0.0029)		(0.0029)	(0.0039)	(0.0046)	(0.0019)
Was for Sale Last 3 Years		1.4455**		1.4614**	1.0155**	-2.4769**	-0.1003**
		(0.0290)		(0.0294)	(0.0501)	(0.0583)	(0.0140)
Pop. Density (1k/mi^2)		0.0410**	-0.0007	0.0407**	0.0881**	-0.1288**	0.0073*
		(0.0069)	(0.0144)	(0.0069)	(0.0098)	(0.0129)	(0.0031)
Pct Bachelors or Higher		-3.8443**	-12.0427**	-3.8607**	-2.6619**	6.5227**	0.1721
		(0.3281)	(1.3256)	(0.3280)	(0.4490)	(0.5916)	(0.1399)
Pct Bachelors or Higher 2014		0.3350	5.1745**	0.4832	0.7753^{+}	-1.2584*	0.1073
		(0.3137)	(1.3010)	(0.3170)	(0.4589)	(0.5975)	(0.1379)
Log Income		0.0523	-7.9806**	-0.0629	0.3116	-0.2488	0.2324**
		(0.1520)	(0.5606)	(0.1580)	(0.2065)	(0.2804)	(0.0687)
Log Income 2014		-0.0390	2.6452**	-0.0804	0.7452**	-0.6647*	0.3190**

Notes: Footnotes. $+ p < 0.10$, * $p < 0.05$, ** $p < 0.01$

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Table B1: Complete Regression Results (Analysis Sample)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	OLS		1^{st} *Stage*	*Instrumental Variable*			
	Low Appraisal	Low Appraisal	% African American	Low Appraisal	Equal Appraisal	High Appraisal	%Difference
		(0.1516)	(0.5631)	(0.1532)	(0.2068)	(0.2797)	(0.0632)
Pct Owner Occupied		-0.7952**	-18.7208**	-0.9271**	-0.5646	1.4918**	-0.0207
		(0.3057)	(1.3080)	(0.3077)	(0.4189)	(0.5604)	(0.1256)
Pct Owner Occupied 2014		0.9485**	8.4471**	1.0213**	0.9113*	-1.9326**	-0.2782*
		(0.3130)	(1.3121)	(0.3144)	(0.4395)	(0.5917)	(0.1225)
Pct Public Assistance		1.6106	18.5957**	2.3688*	-0.9681	-1.4007	-1.3710**
		(1.0766)	(4.0135)	(1.1032)	(1.4729)	(1.9238)	(0.5268)
Pct Public Assistance 2014		-0.8853	38.7836**	-0.0927	-0.1647	0.2573	-2.4139**
		(0.9429)	(3.6728)	(0.9682)	(1.3712)	(1.8147)	(0.4077)
Mean Predicted Daily $PM_{2.5}$ Level		0.1664	3.9685**	0.1944	-0.1032	-0.0912	-0.1378*
		(0.1359)	(0.2590)	(0.1367)	(0.2125)	(0.2717)	(0.0594)
SD Predicted Daily $PM_{2.5}$ Level		0.1023	-5.0677**	0.0496	0.4148*	-0.4644*	0.0644
		(0.1119)	(0.2389)	(0.1145)	(0.1818)	(0.2328)	(0.0937)
Mean Predicted Daily $PM_{2.5}$ Level 2014		0.9053**	-1.8261**	0.9594**	0.7314**	-1.6908**	0.2290**
		(0.1254)	(0.2162)	(0.1263)	(0.1893)	(0.2422)	(0.0508)
SD Predicted Daily $PM_{2.5}$ Level 2014		-0.4566**	2.6424**	-0.4819**	-0.5422**	1.0241**	-0.0378
		(0.1017)	(0.1829)	(0.1022)	(0.1731)	(0.2154)	(0.0743)
Pct Constructed Pre 1970		-3.4513**	3.9007**	-3.4964**	-1.6598**	5.1561**	-0.3988**
		(0.0845)	(0.2984)	(0.0864)	(0.1179)	(0.1531)	(0.0413)
Appraiser Experience		0.0001^{+}		0.0001^{+}	0.0001	-0.0003^{+}	-0.0000
		(0.0001)		(0.0001)	(0.0001)	(0.0001)	(0.0000)
Experience in AA Neighborhoods		-0.0023		-0.0024	-0.0462**	0.0486**	-0.0042**
		(0.0016)		(0.0016)	(0.0037)	(0.0045)	(0.0008)
%ΔZHI		0.4449**		0.4535**	-0.0082	-0.4453**	-0.1216**
		(0.0654)		(0.0654)	(0.0973)	(0.1029)	(0.0336)
$\%\Delta ZHI_{t-1}$		0.5108**		0.5196**	0.1722^{+}	-0.6918**	0.0132
		(0.0627)		(0.0628)	(0.0960)	(0.1019)	(0.0338)
3 Month Average Purchase Appraisals		-0.0113**		-0.0109**	-0.0190**	0.0300**	-0.0006^{+}
		(0.0012)		(0.0011)	(0.0025)	(0.0034)	(0.0003)
Log 3 Month Average Contract Price		-2.0242**		-2.1589**	-1.4638**	3.6227**	0.1601**
		(0.0650)		(0.0792)	(0.1076)	(0.1393)	(0.0537)
N	7,508,826	7,508,826	45,608	7,508,826	7,508,826	7,508,826	615,307
Mean Dep. Var	8.2565	8.2565	15.1697	8.2565	28.6184	63.1251	-4.7562

Table B2 reports OLS regressions. This table compares results using the estimation sample to the full UAD. We find that coefficient estimates are stable between specifications run using the sample and full data. This is true for both the independent variable of interest and the

vast majority of regressors in the specification with controls. Some parameter estimates have minor differences in magnitude or statistical significance. For example, the estimate on the Mean Predicted Daily $PM_{2.5}$ Level is statistically significant when using the full UAD, as compared to not statistically significant using the estimation sample. Other variables, like the presence of a pool or garage, have minor differences in magnitude when using the full UAD. As an additional check, the final two columns report OLS results from the estimation sample run at the block group level. Block group level estimates are very similar in terms of parameter estimates and minor differences in statistical significance are reported. In general, results are largely consistent between the estimation sample, full data, and block group level specifications.

Table B2: OLS Regression Results: Analysis Sample vs. Full UAD

	Estimation Sample (ES)		Full UAD		*Block Group (ES)*	
	(1)	(2)	(3)	(4)	(5)	(6)
	No Controls	Controls	No Controls	Controls	Controls	No Controls
Pct. African American (%AA)	0.1073**	0.0379**	0.1044**	0.0408**	0.1022**	0.0405**
	(0.0022)	(0.0017)	(0.0019)	(0.0015)	(0.0018)	(0.0014)
View Type: Water		0.0100		0.0408		0.0326
		(0.0978)		(0.0657)		(0.0970)
Location: Water		-0.9154**		-1.0520**		-0.8500**
		(0.1666)		(0.0951)		(0.1664)
Total Rooms		-0.1311**		-0.1173**		-0.1316**
		(0.0151)		(0.0125)		(0.0152)
Bathrooms		0.0352		0.0112		0.0154
		(0.0271)		(0.0223)		(0.0272)
Bedrooms		-0.0297		-0.0180		-0.0096
		(0.0239)		(0.0197)		(0.0240)
Site Area (Acres)		-0.0914**		-0.0583**		-0.0959**
		(0.0061)		(0.0033)		(0.0065)
Gross Living Area (1k Sqft)		-2.5716**		-2.5327**		-2.5488**
		(0.0389)		(0.0320)		(0.0381)
Quality Score (1-5)		-0.3301**		-0.4202**		-0.3206**
		(0.0283)		(0.0239)		(0.0286)
Condition Score (1-5)		0.4792**		0.3934**		0.4947**
		(0.0272)		(0.0224)		(0.0272)
Effective Age		-0.0800**		-0.0739**		-0.0829**
		(0.0021)		(0.0018)		(0.0021)
Below Grade Total Sqft		0.0006**		0.0004**		0.0006**
		(0.0000)		(0.0000)		(0.0000)
Below Grade Finished Sqft		0.0005**		0.0005**		0.0005**
		(0.0000)		(0.0000)		(0.0000)
Central A/C		0.7257**		0.6524**		0.7727**
		(0.0429)		(0.0346)		(0.0431)

Notes: Footnotes. + $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

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Table B2: OLS Regression Results: Analysis Sample vs. Full UAD

	Estimation Sample (ES)		Full UAD		*Block Group (ES)*	
	(1)	(2)	(3)	(4)	(5)	(6)
	No Controls	Controls	No Controls	Controls	Controls	No Controls
Pool		0.3782**		0.4846**		0.4025**
		(0.0518)		(0.0444)		(0.0501)
Fireplace		0.6307**		0.5901**		0.6113**
		(0.0310)		(0.0251)		(0.0317)
Basement		-1.7768**		-1.5128**		-1.8357
		(0.0578)		(0.0462)		(0.0569)
Garage		0.2014**		0.1234**		0.2578**
		(0.0431)		(0.0336)		(0.0434)
Has a Half Bathroom		0.3613**		0.3392**		0.3621**
		(0.0304)		(0.0252)		(0.0309)
2 or More Stories		0.2899**		0.3694**		0.2565**
		(0.0367)		(0.0298)		(0.0358)
Appraiser Saw Contract Price		-2.2480+		-3.4294**		-2.3943
		(1.2277)		(0.9834)		(1.2415)
Financial Assistance		-0.8562**		-0.6846**		-0.8516**
		(0.0249)		(0.0208)		(0.0245)
Over Conforming Limit		3.7926**		3.7072**		3.6510**
		(0.0676)		(0.0581)		(0.0639)
Comparable Prop. for Sale ≤ 2		2.0640**		1.9144**		2.0475**
		(0.0333)		(0.0276)		(0.0335)
Number of Comparable Properties Used		2.1371**		2.0323**		2.1458**
		(0.0151)		(0.0124)		(0.0150)
Calc Avg Proximity of Comps (Miles)		-0.0659**		-0.0391**		-0.0678**
		(0.0106)		(0.0055)		(0.0110)
Avg Gross Adjustment Percent		0.1759**		0.1446**		0.1847**
		(0.0029)		(0.0022)		(0.0029)
Was for Sale Last 3 Years		1.4455**		1.2653**		1.4428
		(0.0290)		(0.0244)		(0.0289)
Pop. Density (1k/mi^2)		0.0410**		0.0496**		0.1304**
		(0.0069)		(0.0066)		(0.0143)
Pct Bachelors or Higher		-3.8443**		-3.2965**		-2.4909**
		(0.3281)		(0.2721)		(0.1769)
Pct Bachelors or Higher 2014		0.3350		-0.3691		-0.4652**
		(0.3137)		(0.2608)		(0.1734)
Log Income		0.0523		0.1149		-0.2299**
		(0.1520)		(0.1232)		(0.0843)
Log Income 2014		-0.0390		0.1647		0.0212
		(0.1516)		(0.1232)		(0.0848)
Pct Owner Occupied		-0.7952**		-1.0416**		0.1203
		(0.3057)		(0.2530)		(0.1680)
Pct Owner Occupied 2014		0.9485**		0.6471*		0.4887**
		(0.3130)		(0.2599)		(0.1712)
Pct Public Assistance		1.6106		1.4598		1.0067
		(1.0766)		(0.8914)		(0.5999)

Notes: Footnotes. + $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

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Table B2: OLS Regression Results: Analysis Sample vs. Full UAD

	Estimation Sample (ES)		Full UAD		*Block Group (ES)*	
	(1)	(2)	(3)	(4)	(5)	(6)
	No Controls	Controls	No Controls	Controls	Controls	No Controls
Pct Public Assistance 2014		-0.8853		-0.6844		-1.3563*
		(0.9429)		(0.8009)		(0.5460)
Mean Predicted Daily $PM_{2.5}$ Level		0.1664		0.4201**		0.2587*
		(0.1359)		(0.1058)		(0.1299)
SD Predicted Daily $PM_{2.5}$ Level		0.1023		-0.0922		0.1065
		(0.1119)		(0.0863)		(0.1082)
Mean Predicted Daily $PM_{2.5}$ Level 2014		0.9053**		0.6333**		0.7947**
		(0.1254)		(0.1013)		(0.1167)
SD Predicted Daily $PM_{2.5}$ Level 2014		-0.4566**		-0.2559**		-0.4410**
		(0.1017)		(0.0830)		(0.1001)
Pct Constructed Pre 1970		-3.4513**		-3.2487**		-2.8968**
		(0.0845)		(0.0748)		(0.0647)
Appraiser Experience		0.0001+		0.0001*		0.0001
		(0.0001)		(0.0001)		(0.0001)
Experience in AA Neighborhoods		-0.0023		-0.0012		-0.0062**
		(0.0016)		(0.0011)		(0.0023)
$\%\Delta$ZHI		0.4449**		0.4462**		0.4906**
		(0.0654)		(0.0492)		(0.0674)
$\%\Delta\text{ZHI}_{t-1}$		0.5108**		0.4501**		0.5109**
		(0.0627)		(0.0473)		(0.0650)
3 Month Average Purchase Appraisals		-0.0113**		-0.0105**		-0.0141**
		(0.0012)		(0.0010)		(0.0023)
Log 3 Month Average Contract Price		-2.0242**		-1.5870**		-1.6700**
		(0.0650)		(0.0500)		(0.0489)
N	7,508,826	7,508,826	11,010,358	10,339,253	7,080,329	7,080,329
Adj. R^2	0.0189	0.0898	0.0162	0.0858	0.0186	0.0895
Mean Dep. Var	8.2565	8.2565	7.7813	7.8163	8.234	8.234

C Neighborhood Change Index

Since 1970, neighborhoods have changed considerably along a number of demographic and economic measures. However, it is often the case that the demographic composition of these neighborhoods is more persistent than their relative socioeconomic standing. As shown in Bayer, Charles, and Park (2021), this can be the result of sorting by race or other demographics not altogether related to economic factors. This stems from individuals' preference for neighborhoods where they feel that their race or other demographic characteristic is represented. Communities across the United States can exhibit persistent demographic

character for reasons that are complex, long-lasting, and not entirely tied to economic factors underlying property values.

To better understand this difference, we construct a neighborhood change index based on economic factors to assess neighborhood change along economic dimensions between 1970 and 2019. We then relate it to changes the neighborhood's race shares. In the construction of our index, we follow existing work on neighborhood change. We start with historical Census data (see Section 3) for 43,544 normalized tracts.[36] The base (1970) data is from the Decennial Census. The contemporaneous data is from the 2015-2019 ACS five-year averages.

As noted above, there is a considerable amount of work assessing neighborhood change and gentrification using economic indices (UIC-Voorhees, 2014; Cohen and Pettit, 2019; Swanstrom, Webber, and Metzger, 2015) Our index closely follows those prevalent in this literature. More precisely,

$$index_t = z_{i,t} + z_{h,t} - z_{p,t} + z_{e,t} - z_{u,t} + z_{o,t} - z_{v,t}$$

Three features of the tract level index are highlighted here. First, it is additive in economic factors. Second, absent any prior weighting scheme, all factors are weighted equally in the sum. Third, factors are standardized to z-scores prior to summing. An interpretation of this index is the relative standing of a tract based on the equal weighted sum of individual economic factors.[37] Since it eliminates level differences, this method is especially useful when comparing neighborhood change over long time horizons, as we are doing here.

Our index is constructed from seven economic factors listed in Table C1. These include tract averages in income, education, unemployment, and housing. Notably, some variables represent an improvement over time, while some represent a decline. Specifically, increases in poverty, unemployment, and vacant housing are associated with a negative outcome. As is standard practice, these factors receive a weight of minus one in the index.

First, we compare persistence in race shares and the index. A raw correlation supports our assertion that race shares are more persistent than neighborhood quality along a large set of

[36]Not all economic variables were available for all tracts used in the main analysis. These 43,544 tracts comprise the majority ($> 95\%$) of tracts in our analysis sample.

[37]Formally, absent any correlation among the factors, the index should be (close to) normally distributed with zero mean and variance equal to the number of factors in the index.

Table C1: Neighborhood Index Factors

Variables	Improve (+) / Decline (-)
Log Adj. Average Family Income	(+)
Log Adj. Average Housing Value	(+)
% Families in Poverty	(-)
Percent Bachelors or Over	(+)
Percent Unemployed	(-)
% Dwellings Owner Occupied	(+)
% Dwellings Vacant	(-)

economic factors. The raw correlation between the share of African Americans in 1970 and in 2015-2019 is 61 percent. In contrast, the correlation between our quality index over the same period is 53 percent. Among tracts in which more than five percent of residents were African American in 1970, the top quartile in shares, this difference is still greater. Correlation in the index is about 43 percent versus 60 percent correlation in the rank order of race share. In all, though still persistent, neighborhood change is substantially less persistent than race. Recall that all elements are standardized. As a result, this is measuring the change in relative neighborhood gains over this period. All secular growth or improvement in neighborhoods is normalized out.

Next, we explore the association between neighborhood change and relative race shares in 1970. If unobserved components of housing values are associated with race shares in 1970, we might expect that the conditional distribution of neighborhood change shifts to the left, or right, with the share of African Americans in 1970.[38] This would support the notion that majority African American neighborhoods saw less or more relative gains, on average, over this time.

The top panel of Figure C1 plots the distribution of the change in the index for all tracts (left), minority African American tracts (middle), and majority African American tracts (right). By visual inspection, the (relative) neighborhood change is substantial and, by design, centered at about zero (0.57). The distribution of the change among majority African American neighborhoods in 1970 is change distribution for neighborhoods that were majority African American in 1970 (0.56) is not materially different than for minority neighborhoods (0.57). This suggests the modal neighborhood with high shares of African Americans in 1970 did not

[38]Note that z-scores are normalized unconditionally.

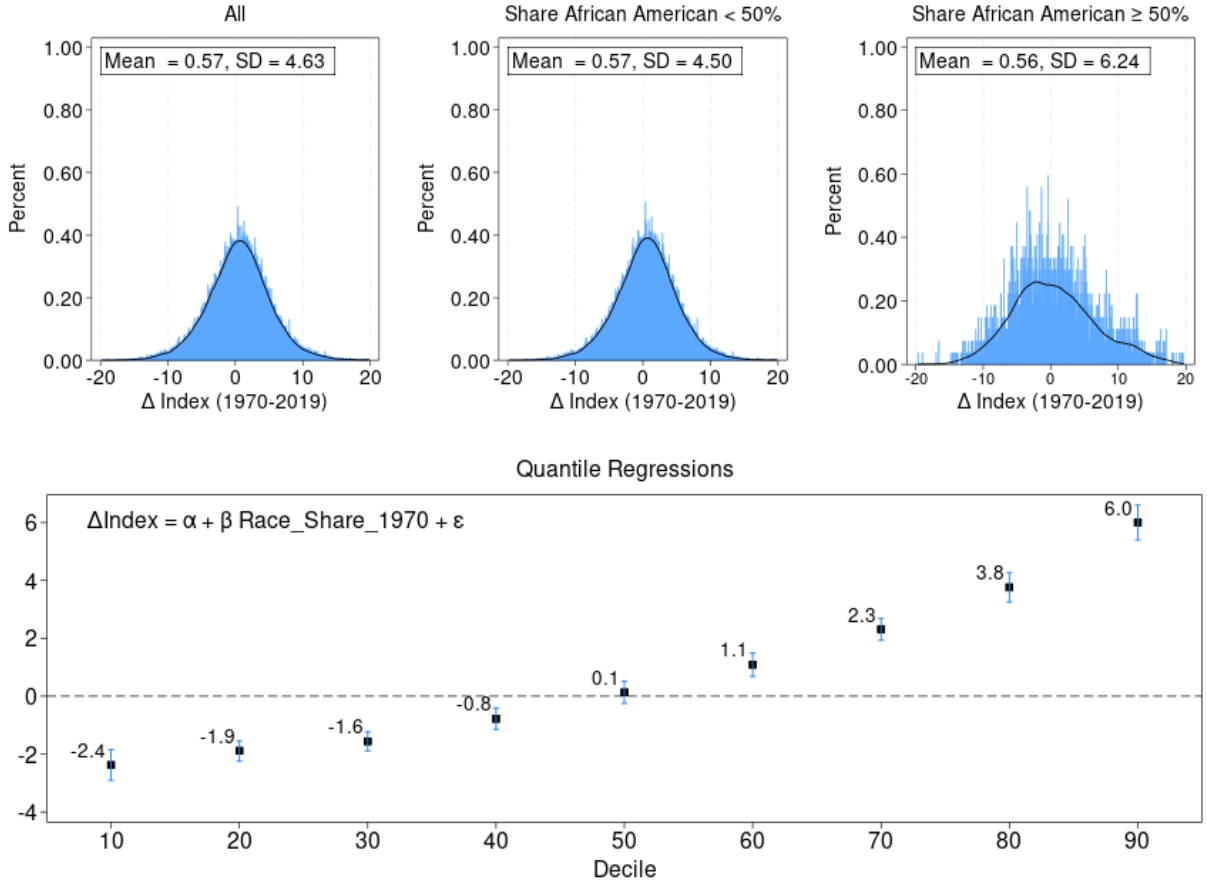

Figure C1: Differences in Index Score and Race Shares

Notes: *The figure plots distribution of neighborhood change by base (1970) race shares. The top panels show, from left to right, these distributions for all, minority African American, and majority African American tracts in 1970. The bottom panel plots coefficients and robust confidence intervals from a quantile regression of the index change between 1970 and 2019 on the tract race share in 1970. See Section 3 for details on data construction, and 1970 race shares specifically.*

fair relatively better or worse than overall. However, the distribution of the change is much more dispersed among these neighborhoods.

The bottom panel of Figure C1 takes a more formal approach to the relationship between race shares in 1970 and the distribution of the index change. The figure plots the coefficients and their confidence intervals from a series of quantile regressions relating the index change to the race shares in 1970. This confirms more generally the earlier conclusion that the distribution of the change in the index did not experience a level shift by historical race shares. Rather, it shows an increase in dispersion. This suggests a thicker tale of improvement among these neighborhoods. In other words, more instability in relative change among originally minority neighborhoods than a systematic level shift in their relative development.

Note that conditioning on base year race shares does not influence the neighborhood change distribution symmetrically. There is more a fattening of the right tail relative to the left. This is consistent the facts above in which the correlations become more distinct for tracts with some share of African American residents. Moreover, given that property values in majority African American neighborhoods are lower both in 1970 and today, this fact is consistent with the assumptions underlying our instrument.