

# Financial Constraints and the Racial Housing Gap\*

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## Abstract

Financial constraints can lead to persistent disparities in wealth across demographic groups and geographies. We document large differences in housing leverage by race, mirroring well established differences in pre-existing wealth and family assistance via bequests. Financial constraints—particularly leverage constraints—lead minority borrowers to specific mortgage channels, especially Federal Housing Administration (FHA) loans. Use of these channels in turn limits access to high opportunity areas. We use a structural model to highlight the persistent impact of these initial conditions for asset purchases on spatial misallocation and long-term wealth accumulation for minority borrowers. Our model highlights tensions in policies to address racial gaps in wealth, leverage and homeownership. Highly effective policies for addressing the racial wealth gap—e.g. direct transfers—have relatively little impact on the homeownership gap. Most households adjust their leverage or location choice but not the decision to buy. Many policies that explicitly target housing shrink the wealth gap at the top of the distribution with little effect at or below the median. Our results highlight important inequalities in use of the housing ladder as a means of wealth accumulation, and difficult tradeoffs and tensions in policies intended to address these disparities.

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# 1 Introduction

Disparities in homeownership mirror long-standing wealth differences across demographic groups. As a result, homeownership gaps between Black and white households (e.g. [Charles & Hurst, 2002](#)) and across the lifecycle (e.g. [Goodman & Mayer, 2018](#)) have been well-studied in prior literature. The role of financial constraints in perpetuating racial housing gaps, however, remains a source of considerable debate. While historic differences in access to housing and finance have profoundly impacted the relative Black-white wealth gap, the degree to which existing financial constraints—such as leverage requirements—lead to persistent differences in wealth accumulation over time remains unknown. In fact, considerable empirical and theoretical work has emphasized the extent to which individuals can self-save to overcome financial constraints ([Moll, 2014](#); [Blattman \*et al.\*, 2020](#)), suggesting the possibility of long run convergence for Black borrowers.

In this paper, we argue that financial and geographic constraints determine and perpetuate disparities—in location, leverage, homeownership, and wealth—through the lens of the Black-white housing gap. To do so, we construct a micro-founded structural model of housing choice with incomplete markets and heterogeneous households. Households belong to different demographic groups and endogenously sort into housing stocks with different leverage constraints and labor market returns. We use detailed micro-data that combines household migration patterns with homeownership decisions and mortgage contract details to motivate and calibrate the model. The model allows us to first evaluate the role of financial constraints in persistently affecting wealth over time, next to examine the responses of different groups to broad trends in house prices (which have been a particularly salient shock over the last few decades), and last to evaluate the efficacy of policy proposals that target wealth and housing gaps.

Our model contains three key features which generate a persistent impact of financial constraints over time. First, financially constrained borrowers—who require high leverage—are only able to purchase homes in a relatively low cost housing stock. This restriction is directly motivated by the Federal Housing Administration (FHA) program, which disproportionately caters to high-leverage borrowers and has a relatively low maximum loan size. Second, housing is a necessary condition to access local incomes; and high housing costs generally accompany high opportunity areas. As a consequence, entry to high income regions is rationed by house prices. And finally, homeowners cannot borrow against future labor income in high income areas. Financial constraints, as a consequence of these realistic features, result in spatial misallocation of borrowers in ways which disproportionately negatively impact Black borrowers and limit their ability to build wealth over time.

This approach provides several key insights which result from the joint modeling of leverage, home-

ownership, and geographic sorting. In our model, increases in home prices have unambiguously positive implications for the average wealth of white households, but have non-monotonic consequences for Black households: average wealth rises for small changes as households adjust leverage on the intensive margin, but begins to fall for large changes as leverage constraints bind and they drop out of homeownership. Alternatively, we find that highly effective policies for addressing the racial wealth gap—for example via direct transfers—have relatively little impact on the homeownership gap, as most households adjust their leverage or location choice but not the decision to buy. We highlight an important tension between racial gaps in leverage and homeownership. While racial gaps in homeownership have received greater attention by policymakers and in prior literature; we argue that the racial gap in leverage points to important financial constraints faced by Black borrowers which affect the experience of Black homeownership and wealth accumulation, and place important limitations on policies intended to correct these gaps.

We begin by highlighting stylized facts on the broader dimensions of the Black-white housing gap in the United States. Beyond the persistent gap in homeownership, there is a stark leverage gap between Black and white homeowners. In 2020, more than 50 percent of white homeowners put at least 10 percent down for new purchase mortgage originations, compared to less than 20 percent of black households. Indeed, the median combined loan to value at origination (CLTV) for new purchase mortgages was 96.5 percent for Black households. These differences in leverage correspond to different channels of loan origination, with Black borrowers disproportionately relying on government-backed mortgages. More than half of new purchase mortgages for Black households in 2020 were through the Veterans Administration (VA) or FHA programs. By contrast, less than 25 percent of white households obtained a mortgage through these government channels.

The housing stock, in other words, can be modeled as comprising two key subsegments based on choice of loan channel. First, the upper end of the housing stock, which combines conventional mortgages, borrowers with loans through the government GSEs (Fannie Mac and Freddie Mae), and jumbo mortgages for borrowers with loan sizes above the conforming limit. Borrowers using these programs are disproportionately white; live in relatively high-opportunity areas with higher income; and access housing with down payments closer to the traditional 20 percent down payment. Second, the FHA-eligible part of the housing stock consists of housing units under the FHA loan cutoff (a nation-wide limit of \$356,362 for 2021, with varying eligibility by county).<sup>1</sup> Such borrowers typically access lower-cost housing through minimal down payments. While most FHA borrowers are white; Black borrowers are disproportionately represented among FHA mortgages.

We develop a structural model incorporating these stylized facts in order to understand whether differ-

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<sup>1</sup>See [https://www.hud.gov/program\\_offices/housing/sfh/lender/origination/mortgage\\_limits](https://www.hud.gov/program_offices/housing/sfh/lender/origination/mortgage_limits).

ences in financial constraints and mortgage product access lead to persistent differences in wealth accumulation. We construct an overlapping-generations endowment economy in which households face idiosyncratic income and mortality risks and choose their location, homeownership status, and leverage. Markets are incomplete, and we conduct our baseline calibration and policy experiments with exogenous prices, rents, and interest rates. At the center of our model is a  $2 \times 2$  framework: households exogenously belong to one of two demographic groups and endogenously choose to live in one of two locations (or, equivalently, housing stocks). The two locations differ in five dimensions: home prices, rents, average income, maximum leverage (LTV cap), and moving costs. The two demographic groups differ in four dimensions: initial wealth, average income, the net taste for homeownership (which captures all unmodeled costs and benefits of homeownership, including any discriminatory barriers), and the probability of being born in each location.

To calibrate the model, we base demographic groups on observed levels of and Black-white differences in income, leverage, homeownership, and wealth. Given the widespread use of FHA loans by Black households, we calibrate the two housing stocks using FHA eligible and non-FHA eligible homes throughout the US. Our calibration successfully matches a series of targeted moments, including differences in homeownership, leverage, income, and moving rates across household groups and housing stocks.

With the calibrated model in hand, our first step is to consider the impact of home price changes on the Black-white wealth gap. These can be loosely thought of as a “gentrification” shock (Guerrieri *et al.*, 2013), to the extent that it ultimately stems from higher urban demand and has potential displacement consequences. In general, we find that higher house prices have little impact on homeownership for white households, whose leverage increases in lockstep with price increases. However, increases in price have more drastic and non-linear impacts for Black households. For example, price increases in the non-FHA eligible housing stock lead a non-trivial fraction of Black households to either exit homeownership or purchase a home in the FHA eligible stock. This has a non-monotonic impact on wealth: for small changes an increase in home equity among homeowners outpaces the decrease in homeownership, but for large home price changes the extensive margin dominates.

We then use the model to evaluate a series of policy experiments targeted at addressing the Black-white wealth gap. We consider three broad classes of policies: (i) direct reparations policies (explicit interventions to equate initial wealth, income levels, or place of birth across demographic groups) (ii) mortgage market interventions (a change in the LTV limit for the FHA eligible housing stock or a targeted reduction in interest rates) and (iii) place-based policies (equating the labor market returns in the two stocks or lowering the cost of moving between the two). We find that direct reparations are effective in addressing the racial wealth gap, but most strongly influence wealth accumulation at the top of the Black wealth distribution. Furthermore,

the role of reparations highlights the importance of jointly considering leverage and the homeownership choice. Direct wealth provision to black households sharply influences the leverage (and naturally wealth) distributions, but has little impact on homeownership. Alternatively, mandated moves to the non-FHA-eligible stock improve both overall wealth and the non FHA-homeownership rate, but ultimately worsens the leverage distribution.

Mortgage market policies similarly highlight the importance of differentiating between homeownership and leverage. A reduction in the LTV cap in the FHA eligible stock from 95 to 80 percent (matching the cap in the non-eligible stock) surprisingly has little impact on overall homeownership for either white or Black households. However, it naturally shifts the leverage distribution as all borrowers are required to put at least 20 percent down. These down-payments act as a forced savings device, increasing Black wealth. We find less impact of place-based policies on the wealth gap: removing differences in labor market outcomes and moving costs across places is insufficient to address deeper inequalities in wealth or income by race.

Our paper contributes directly to two broad literatures. The first is a resurgence of work studying the Black-white wealth gap generally, and the Black-white housing gap in particular. While there has long been both empirical and theoretical work considering the gap in housing wealth (see, e.g. [Gyourko et al., 1999](#); [Charles & Hurst, 2002](#); [Collins & Margo, 2011](#); [Garriga et al., 2017](#); [Stein & Yannelis, 2020](#)), a new wave of studies using rich historical microdata has brought new insights into both the historical persistence of the racial wealth gap overall ([Derenoncourt et al., 2021](#)), and specific barriers to the accumulation of housing wealth for Black households based on differences in house price appreciation ([Kermani & Wong, 2021](#); [Kahn, 2021](#)), property tax assessments ([Avenancio-Leon & Howard, 2019](#)), and refinancing propensities ([Gerardi et al., 2021a,b](#)). Recent studies have also explored the role of interest rate differences, with mixed results ([Bartlett et al. \(2021\)](#) finds evidence of racial disparities in interest rates; while [Bhutta & Hizmo \(2021\)](#) argues these differences can be accounted for by racial differences in the take-up of mortgage points). We contribute to this literature by providing a sufficiently rich structural framework in which to evaluate explicit counterfactual policies aimed at addressing the racial housing gap via the housing channel. Furthermore, we bring the role of the leverage gap to the forefront in considerations of the Black-white housing gap. Prior literature has emphasized the ambiguous effects of financial variables on wealth inequality; and in particular of lower interest rates on increasing wealth inequality through a discount rate channel: [Gomez & Guin-Bonenfant \(2020\)](#), [Greenwald et al. \(2021\)](#). We also consider the role of valuation effects in the context of variation across groups in the extent to which financial constraints bind.

We also connect to a large literature modeling housing decisions with incomplete markets which analyze mortgage regulation. This includes [Corbae & Quintin \(2015\)](#), [Favilukis et al. \(2017\)](#), [Greenwald \(2018\)](#),

Greenwald *et al.* (2020), Gete & Zecchetto (2018), and Mabilie (2021). The key innovation relative to this literature comes in allowing heterogeneity in both demographic groups and location choice.

Our paper proceeds as follows. In Section 2, we provide some background on our context and describe our data. In Section 3 we present stylized facts on the Black-white leverage gap and the role of the FHA. In Section 4, we present our model. We present our results in Section 5 and discuss policy implications in Section 6. We conclude in Section 7.

## 2 Background and Data

The central problem we overcome in our data analysis is linking individual housing choice over time. Conventional housing datasets, which we draw on extensively for our project, are limited in speaking to broader household wealth accumulation across multiple housing purchases. We begin by using these traditional datasets in order to establish some key stylized facts: on the bimodal leverage distribution, the racial leverage gap, and the role of FHA mortgage products. We additionally use a linkage of housing choice over time to investigate the persistence of wealth accumulation across different housing products and the movement between housing stocks of different quality levels.

In order to establish some key housing facts on as comprehensive of a sample as possible, we make use of HMDA data, which captures close to the full universe of mortgage originations. Financial institutions report HMDA data under a range of reporting requirements, such as assets above a limit, which vary for depository and non-depository institutions. Because HMDA was developed due to concerns about possible disparities in credit access to minority and urban borrowers, it contains comprehensive race information which we use extensively.

Key limitations in HMDA, however, include historic gaps in coverage of LTV (because house price was not collected). This variable was collected from 2018 onwards, allowing us to measure the role of race and leverage in more recent periods.

To connect information on borrowers over time, we use Infutor data (as discussed in Diamond *et al.* (2019)). Unlike most traditional housing datasets, this is distinctive in having information on renters, as well as homeowners, and in measuring transitions in housing stock over time. We use this historical information in order to connect borrower housing stock over time, and measure the extent to which racial differences access to housing lead to persistent differences in wealth accumulation.

We also use Deeds records, taken from Zillow’s Transaction and Assessment (ZTRAX) dataset.<sup>2</sup> We also draw on local income and demographic information the American Community Survey (ACS). And

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<sup>2</sup>See: [www.Zillow.com/data](http://www.Zillow.com/data).

finally, in order to establish racial differences over time, we draw from the Survey of Consumer Finances (SCF) Plus—a recently created compilation of historical extracts of the SCF survey going back to 1949 (as described in [Kuhn \*et al.\* \(2020\)](#)), and used to explore long-term racial differences in wealth in [Derenoncourt \*et al.\* \(2021\)](#)).

### 3 Stylized Facts: The Black-White Leverage Gap and the FHA

#### 3.1 Racial Gaps in Leverage

We show, in Figure 1, a key motivating graph for our analysis: the difference in leverage across racial groups. While the median LTV across all borrowers is 90, it is considerably different across racial categories. The median LTV for Black borrowers, in particular, is 96.5; reflecting high mortgage leverage at baseline. Leverage at origination is also quite high for Hispanic borrowers; while Asian borrowers are particularly likely to have high home equity at the time of purchase.

Origination leverage reflects one of the two main financial constraints faced by borrowers in the mortgage application process. The LTV reflects the extent to which borrowers have pre-existing savings to make down payments. The other main financial constraint faced by borrowers is the Payment-to-Income (PTI), which instead captures constraints relative to current flow income. [Greenwald \(2018\)](#) shows that both constraints, the LTV and the PTI, matter across the time-series. We find, however, that that racial differences in PTI appear to be less salient than for the LTV (Appendix Figure A.I).

While we incorporate both LTV and PTI constraints in our structural model, our key focus is on the LTV constraint because this variable sees far more group variation in the extent to which this variable binds. The ultimate reason that wealth based constraints, rather than income flow constraints, bind more for minority borrowers is related to large variation in wealth-to-income ratios across demographic groups. Many minority borrowers, in other words, have the income flow in order to cover mortgage payments, but lack financial resources in order to cover down payments. Because initial borrower leverage captures differences in pre-existing wealth, it is our primary focus due to our objective in understanding long-term wealth accumulation.

The high concentration of minority borrowers at the top of the leverage distribution—particularly Black borrowers, but also Hispanic borrowers—is particularly stark when examining the racial composition of borrowers across the LTV distribution (Figure 2). White borrowers make up around 80 percent of the total borrowing pool across the distribution up until 90 LTV. However, the minority fraction is considerably higher among borrowers who have particularly low down payments. Among borrowers with close to zero

down payments, racial minority borrowers actually comprise over 50 percent of the borrowing population.

High leverage by Black borrowers reflects long-standing trends. In Figure 3, we plot the average Current LTV, across Black and white borrowers, from 1949 using the SCF+. We are limited, in this dataset, in separating origination leverage from current leverage—the two variables may disagree due to differences in home price appreciation and mortgage amortization. This long survey of household finances suggests, given that limitation, that effective leverage has generally been higher for Black borrowers over the last 70 years. The main exception to this trend were the mid-1980s—this period followed the high inflation era of the 1970s and early 1980s, and saw sizable house price appreciation which resulted in equity gains for existing borrowers.

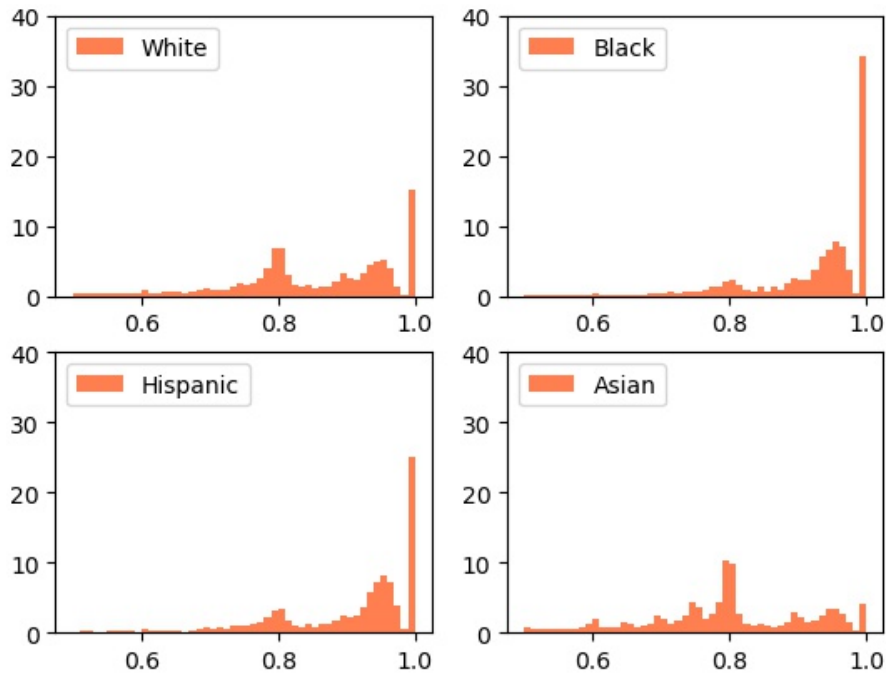


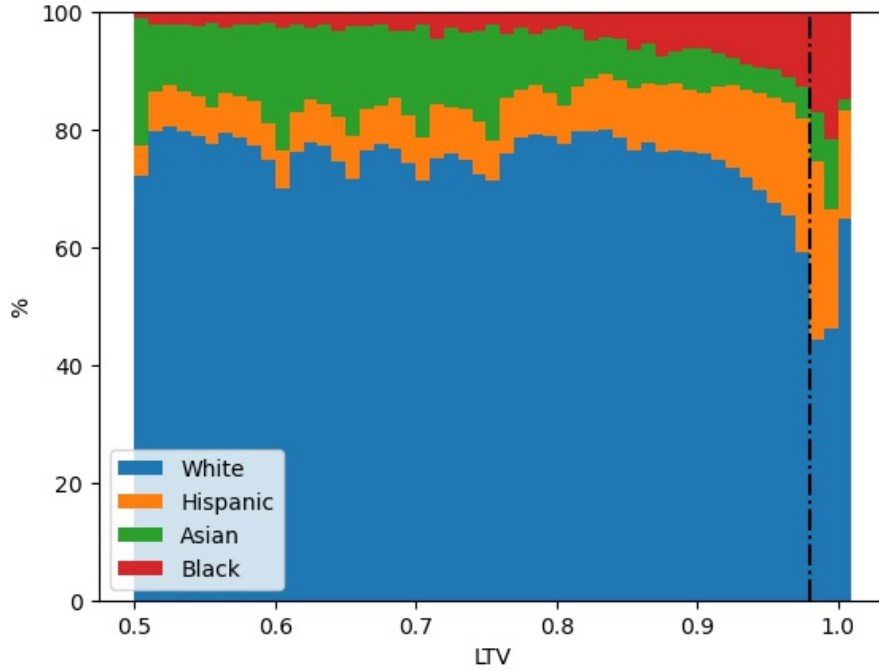
FIGURE 1: LTV BY RACIAL GROUPS

This Figure shows the distribution of LTV for all borrowers with a purchase mortgage, as of 2018, in the HMDA data.

### 3.2 Racial Gaps in Intergenerational Transfers

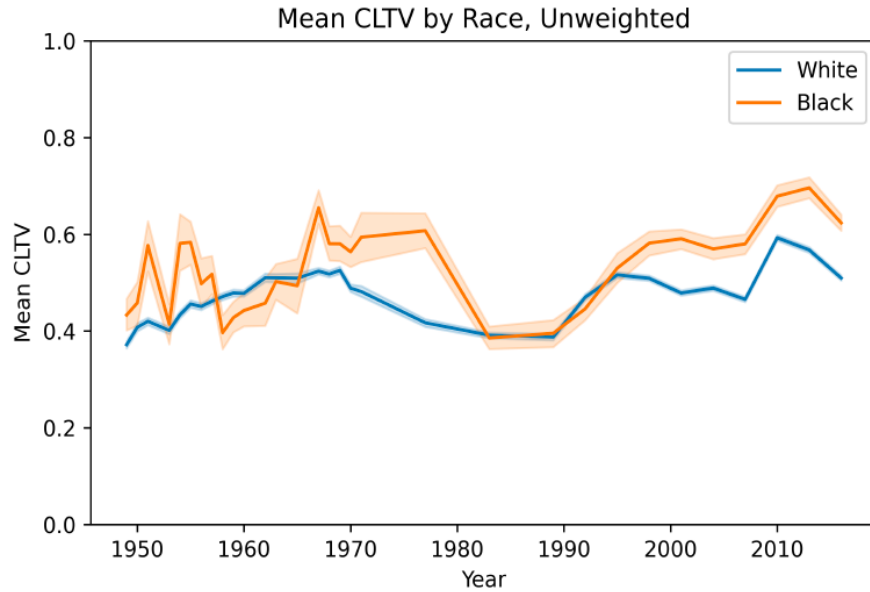
Racial gaps in leverage ultimately reflect pre-existing differences in wealth accumulation, which are impacted by intergenerational transfers and bequests. [Charles & Hurst \(2002\)](#) finds, using PSID data, that differences in home buying are attributed to differences in Black mortgage applications, and are partially driven by access to parental income transfers for down payment assistance. [Avery & Rendall \(2002\)](#) uses SCF data to document that fewer Black households receive inheritance than whites. [Brandsaas \(2021\)](#) high-





**FIGURE 2: RACIAL COMPOSITION OF BORROWERS ACROSS LTV**

This Figure plots the fraction of borrowers, by race, across the distribution of LTV. We use purchase-only mortgages in the 2018 HMDA data. The dotted line corresponds to the maximum LTV limit of 96.5 for FHA loans.



**FIGURE 3: LTV BY FHA ELIGIBILITY**

This Figure plots the average LTV for Black and white borrowers, from 1949–2016, using the SCF+.

lights the role of parental transfers for homeownership among young Americans, with information drawn from the PSID. We draw on these traditional datasets to highlight the role of pre-existing wealth and trans-

fers in driving differences in down payment rates and leverage across racial groups.

We draw on the latest SCF data from 2019 which shows (Bhutta *et al.*, 2020) that Black and Hispanic families are much less likely to receive inheritances, gifts, and other family support. Close to 30% of White families had received an inheritance in the survey, compared to 10% of Black families and just 7% of Hispanic families. Expected inheritances, as well, were much higher for white households. In addition to formal bequests, receipts of which tend to occur later in the lifecycle, white families also report higher levels of family support; 72% report being able to receive \$3,000 from family or friends, compared to just 41% of Black households. We draw on this data for the purposes of model calibration, and broadly consider intergenerational wealth transfers to be an important driver of initial wealth conditions—and consequently, leverage at the time of asset purchase—across racial groups.

### 3.3 Racial Differences in FHA Mortgage Adoption

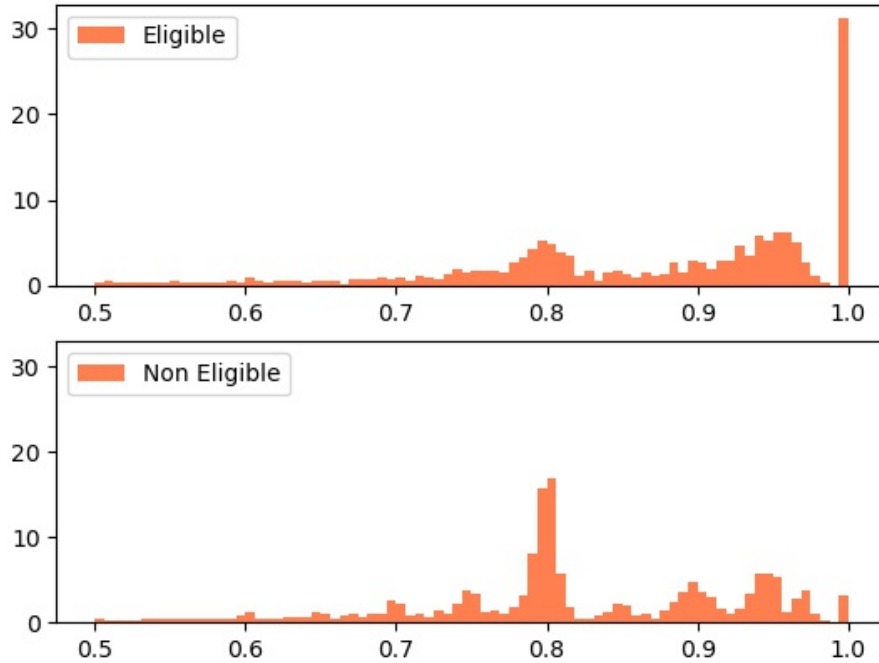
Racial differences in leverage are accommodated through differences in mortgage product choices. While conventional mortgages through Fannie and Freddie do allow high leverage mortgages; down payments of less than 20 percent demand costly mortgage insurance. Mortgages through the FHA system, by contrast, enable down payments as little as 3.5 for borrowers with credit scores of at least 580.<sup>3</sup> While FHA mortgages do also charge mortgage insurance for high leverage borrowers (including both an upfront, as well as a recurring insurance payment)—the size of the insurance payment is inflexible to changes in borrower risk. As a consequence, we observe in Figure (Figure 4) that borrowers with mortgages eligible for the FHA program see strong bunching at around the 96.5 percent LTV limit. Loans which are not eligible for the FHA, by contrast, do not see such a large bunching at such high leverage—instead, the modal part of the leverage distribution is around the typical 80 percent down.

The mortgage market, in other words, comprises of two somewhat segmented and distinct parts of the market which correspond to large differences in leverage. Borrowers who use the FHA mortgage system often cluster at very high leverage levels, consistent with the program’s intention to serve lower-income and first-time home buyers who may not have substantial wealth. By contrast, conventional (and jumbo mortgages, which are originated to borrowers above the conforming loan cutoffs and generally held on bank portfolio balance sheets) loans are issued to borrowers who have higher credit scores and larger down payments.

These differences in leverage and loan product choices result in sorting of the two mortgage products by racial groups. Comparatively few Black borrowers access the conforming loan channel with higher down

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<sup>3</sup>Borrowers with credit scores as low as 500 can also qualify for FHA mortgages, but must have down payments of at least 10 percent.



**FIGURE 4: LTV BY FHA ELIGIBILITY**

This Figure plots a histogram of LTV ratios, breaking out borrowers who qualify for FHA mortgages and mortgages that do not. We focus on purchase only loans in 2018 measured in the HMDA data. We estimate eligible mortgages as those who have a FHA mortgage, or else have loan amounts (based on their specific county limits) which would theoretically enable a FHA loan.

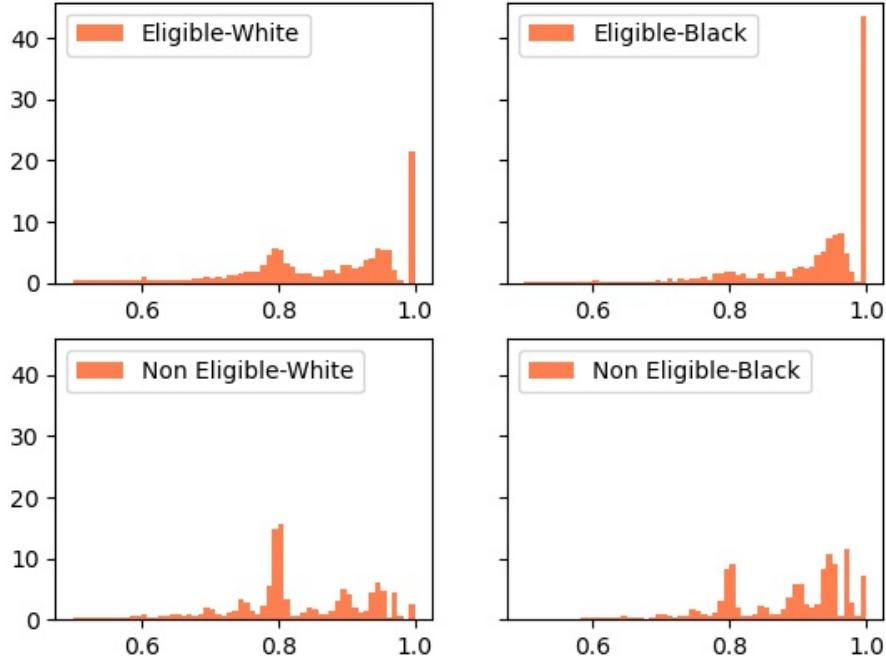
payment rates; this product category is disproportionately white. Instead, Black borrowers sort into the FHA mortgage program at high leverage levels (Figure 5).

### 3.4 FHA Loan Limits

Differences in leverage impact borrowers in three ways: first, on the extensive margin of whether or not they receive a loan; second in the underwriting process to determine which loan they ultimately receive; and finally in the long-run experience borrowers have with high leverage products. In this section we focus on the second set of constraints: the impacts of leverage on loan attributes. We focus on a key attribute of the FHA loan system: that these mortgage products have loan caps which limit the amount of total borrowing. FHA loan caps are similar in spirit to the more commonly studied conforming loan caps separating non-conforming loans (Buchak *et al.*, 2018). Like the conforming loan cap; the FHA loan cap combines a national floor (\$331,760 for the year 2021), as well as specific county-level thresholds to accommodate local variation in house prices.<sup>4</sup>

A consequence of FHA loan limits is that borrowers with high leverage are constrained to access only the

<sup>4</sup>See: [https://www.hud.gov/press/press\\_releases\\_media\\_advisories/HUD\\_No\\_20\\_201](https://www.hud.gov/press/press_releases_media_advisories/HUD_No_20_201). Appendix Figure A.III shows changes in the nationwide limit over time.



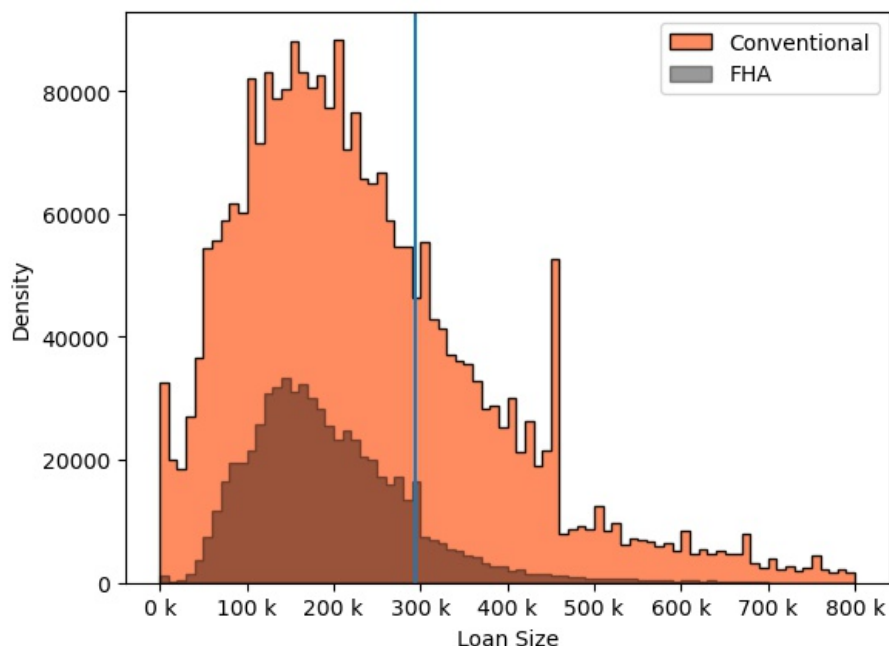
**FIGURE 5: LTV BY FHA ELIGIBILITY AND RACE**

This Figure plots a histogram of LTV ratios, breaking out borrowers who qualify for FHA mortgages and mortgages that do not. We focus on purchase only loans in 2018 measured in the HMDA data. We estimate eligible mortgages as those who have a FHA mortgage, or else have loan amounts (based on their specific county limits) which would theoretically enable a FHA loan.

housing stock eligible through the FHA mortgage program based on loan caps. Because the FHA mortgage system constrains the loan size for borrowers; and because borrowers with low down payments have little additional housing equity to contribute—the house purchase price is, also, effectively constrained by the FHA loan cap.

In practice, many borrowers are constrained at levels far below the formal FHA loan cap limit. But we also observe substantial bunching of borrowers around the FHA loan cap, indicating the value of the FHA mortgage system for such borrowers. If, instead, the FHA were simply one convenient program for accessing high leverage loans; we would instead observe more elasticity in substitution across loan product types around the loan cap. We observe, in Figure 6, substantial bunching of borrowers right around the FHA loan size limit measured using the national limit.

We see further evidence that the FHA program plays an important role in facilitating borrowing by high leverage individuals by directly comparing leverage around the national cutoff, in Figure 7. We observe that leverage is generally decreasing with loan size—higher borrowing amounts correspond to higher down payments. When we focus specifically on the very high leverage amounts ( $\geq 95$  LTV) allowed by the FHA program, we observe particularly high fractions of borrower with such high leverage below the nation-wide



**FIGURE 6: LOAN COUNTS BY LOAN SIZE**

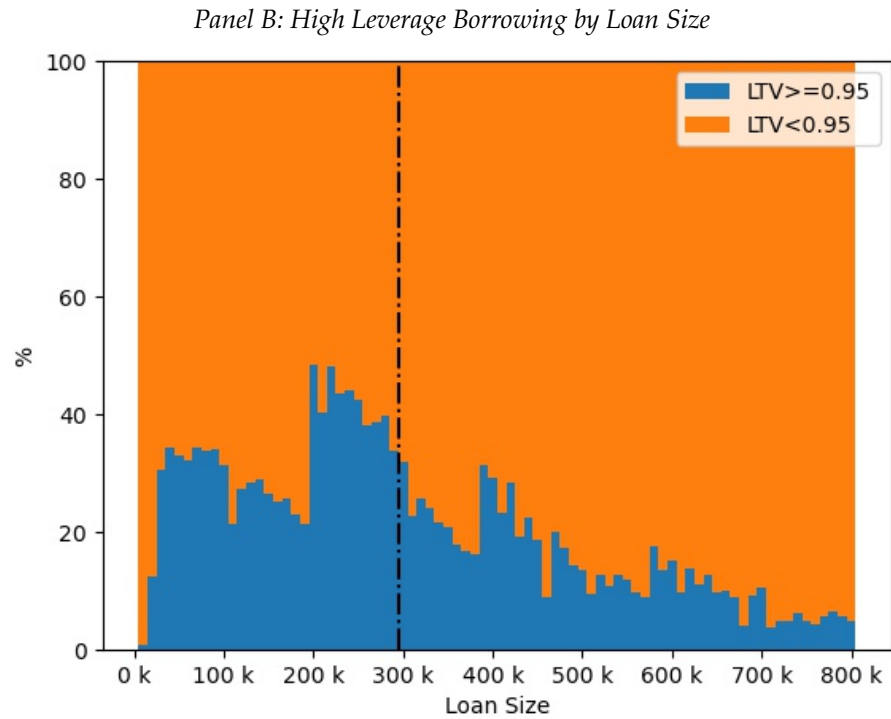
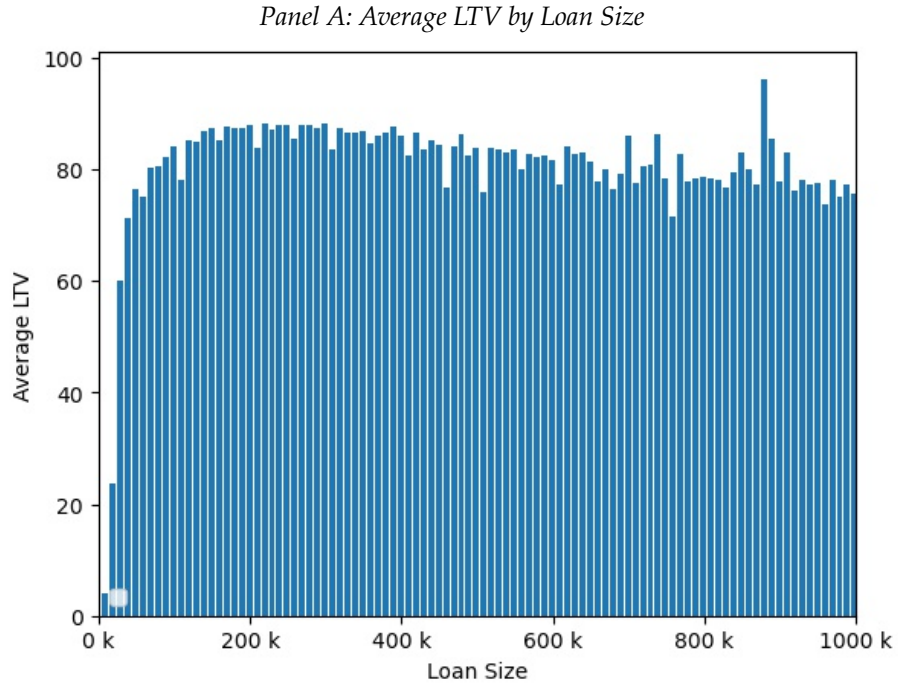
This Figure shows loan counts for borrowers across the conventional and FHA loan product categories using 2018 HMDA data. We restrict to purchase loans, and plot the density of borrowers around the national FHA loan size limit (plotted as the vertical line).

FHA cutoff; compared to many fewer borrowers above this cutoff.

These estimates suggest that borrowers are not neutral across all loan origination channels; but that the FHA plays a unique role in facilitating high leverage borrowing by individuals who, as a consequence, are clustered at lower loan and house sizes. We see further evidence of this sorting in Figure 8, which shows the fraction of borrowers at each part of the loan size distribution by race. Minority borrowers are disproportionately represented in the lower part of the loan size distribution; higher loan sizes largely go to white borrowers.

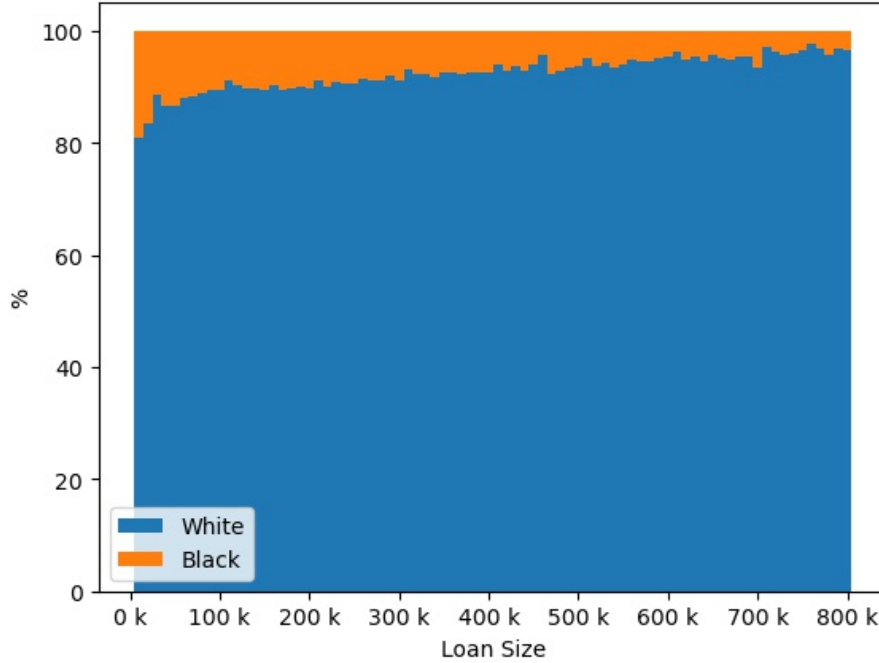
### 3.5 FHA and Geography

The spatial consequences of minority borrower sorting along leverage and sorting imply access to worse quality geographical areas. The idea that minority borrowers face spatial segregation with consequences on labor market participation is a central feature of standard models of urban economics, going back at least to [Kain \(1968\)](#) (see [Glaeser \*et al.\* \(2004\)](#) more a more recent appraisal of this work). Housing markets feature strong segregation, as a complicated consequence both of active discrimination in housing markets as well as borrower sorting. This racial sorting, in turn, disadvantages minority borrowers with respect to accessing high quality jobs and other opportunities within metropolitan areas.



**FIGURE 7: LEVERAGE AMOUNTS BY LOAN SIZE**

This Figure shows the average LTV for borrowers based on loan size (Panel A). We also show on the fraction of borrowers who have extremely high leverage,  $> 95$  LTV, across the loan size distribution (Panel B). The nationwide loan cap limit for FHA loans is plotted on the dotted line. We measure LTV and loan size using purchase-only loans in the 2018 HMDA dataset.

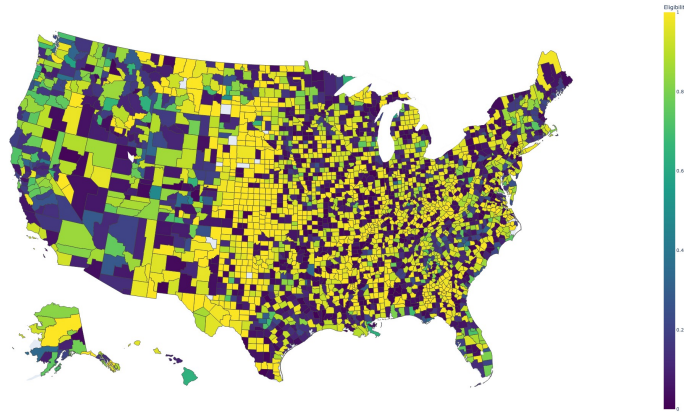


**FIGURE 8: BORROWER RACE BY LOAN SIZE**

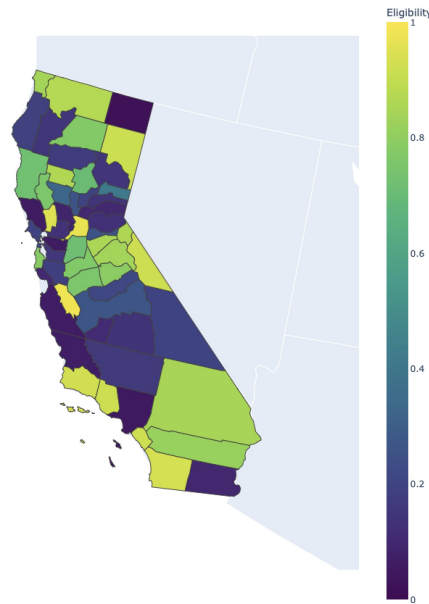
This Figure shows the racial composition of borrowers across different parts of the loan size distribution, focusing on white and Black borrowers. We measure race and loan size using purchase-only loans from the 2018 HMDA dataset.

Our contribution to this literature is to highlight the ways that this sorting is amplified through loan caps inherent in government mortgage programs themselves. In Figure 9, we highlight the fraction of properties across the United States (and California and San Francisco, as an illustrative example) which can be accessible through FHA borrowing. In many counties, especially rural counties, virtually all homes are theoretically accessible through FHA loans, because the federal FHA loan cutoff is not binding. The cutoff, however, is substantially more binding in many urban areas which feature access to high quality jobs. Even despite the fact that high-cost counties have higher localized FHA limits, we still observe that centers of dense high-income metropolitan areas such as San Francisco and Los Angeles have a much smaller fraction of transacting properties which are accessible through the FHA program.

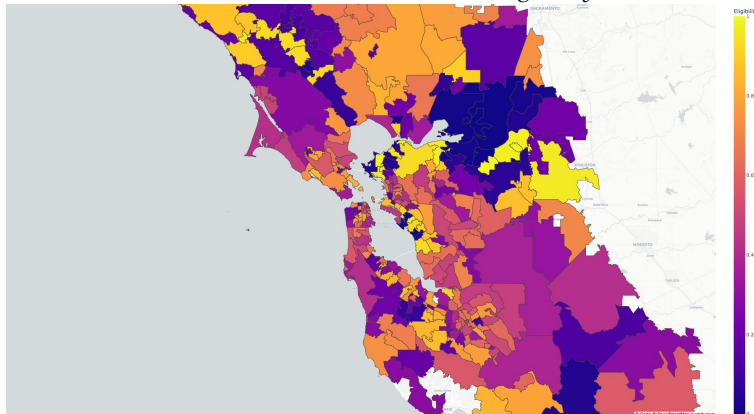
*Panel A: National FHA Eligibility*



*Panel B: California FHA Eligibility*



*Panel C: San Francisco FHA Eligibility*



**FIGURE 9: FHA ELIGIBILITY BY GEOGRAPHY**

This Figure shows the fraction of homes from the HMDA data which can be purchased by fully-levered borrowers using FHA loans. To determine eligibility, we compare the house purchase price against the county-specific FHA loan limit.



A key consequence of these loan limits is on the ability to access better labor market opportunities. Unlike other assets, residential real estate is unique because it combines a financial return as well as a fixed residence. Because individuals are limited in their commute times, access to centrally located housing stock is an essential prerequisite to access these job opportunities. We show, in Figure 10, that more constrained borrowers—as measured by higher LTVs and lower loan sizes—are typically accessing neighborhoods with lower incomes, as measured through the ACS.<sup>5</sup>

Overall, our results point to important consequences of financial constraints on the residential sorting of minority borrowers. Because Black borrowers have access to lower family resources to assist with down payments, they are primarily constrained in their housing purchases by their LTV. High LTVs constrain Black borrowers to rely on the FHA lending channel which, in turn, restricts Black borrowers to smaller sized loans that are more distant from high-quality job opportunities. Because financial constraints limit Black borrowers ability to access income-generation, they may limit the ability of Black borrowers to grow income and wealth over the lifecycle, thereby contributing to persistence in wealth accumulation across racial groups.

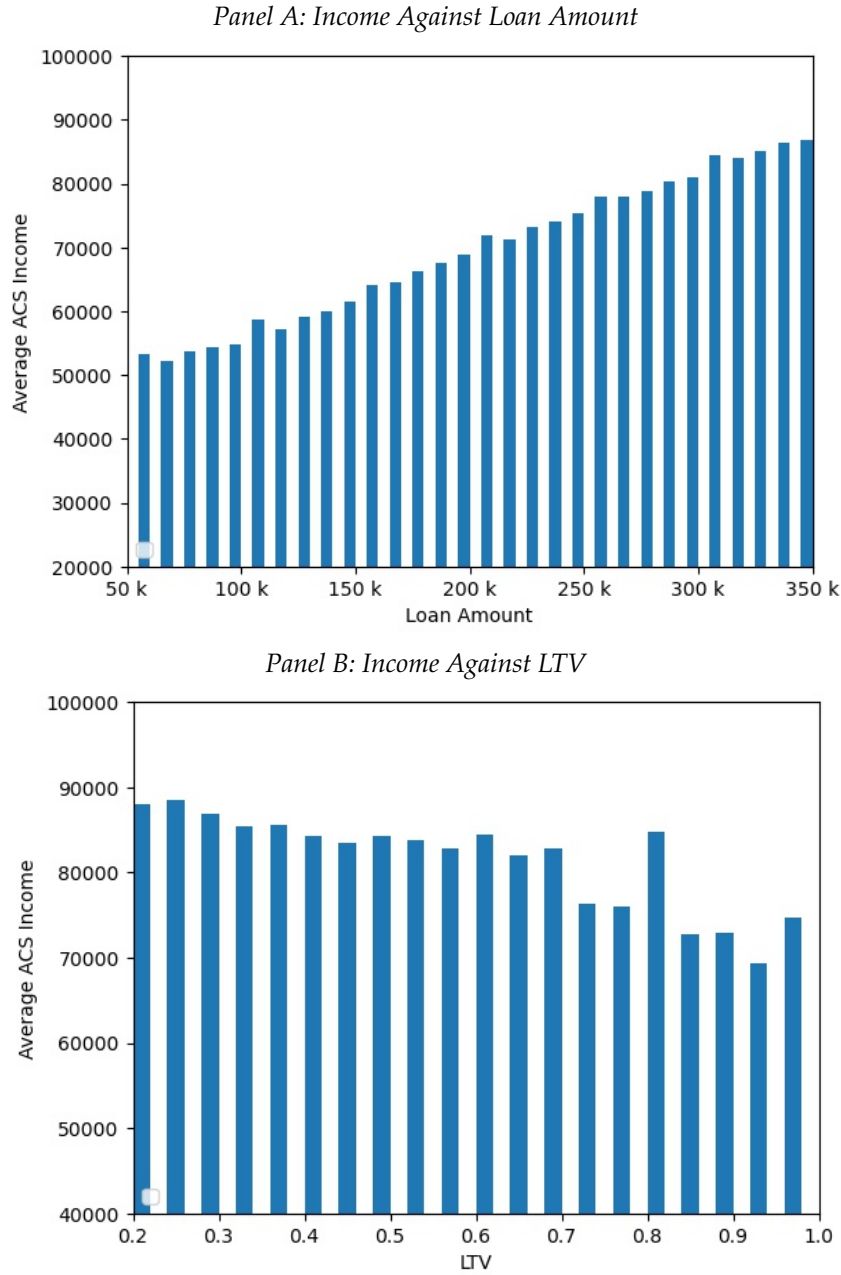
A key caveat to our results, so far, is that we are limited in our ability to casually determine consequences of financial constraints on these outcomes for Black borrowers. Instead, our objective in this section is to first demonstrate the sorting of borrowers along the dimensions of leverage, loan product, and neighborhood income. We then explore the implications of this sorting in the context of our structural model.

## 4 $2 \times 2$ Model of Housing Markets and Calibration

This section describes a  $2 \times 2$  model of the cross-section of housing markets with incomplete markets and heterogeneous investors. Investors *exogenously* belong to two groups, which correspond to Black and white households. They *endogenously* sort across two types of housing stocks, which correspond to FHA-eligible and non-eligible units. Within each group and housing stock, investors differ by age, income, net worth, and home ownership status. By endogenizing investors' responses to price and policy changes, we account for the fact that the rate at which they accumulate wealth depends on those responses, in particular leverage, home ownership, and choice of housing stock. Our micro-founded structural approach complements analyses of the racial wealth gap based on macroeconomic accounting decompositions (e.g., [Derenoncourt et al. \(2021\)](#)).

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<sup>5</sup>We also show, in Appendix Figure A.II, that the same is true for the *individual* income of borrowers accessing high leverage mortgages.



**FIGURE 10: LEVERAGE AND INCOME**

In this Figure, we show the relationship between neighborhood income, measured using the ACS, against loan size (Panel A) and LTV (Panel B). For each property, we measure the ZIP-level household income, and report the average neighborhood income for each part of the loan size and LTV distributions.

## 4.1 Environment

We study an endowment economy populated by overlapping cohorts of heterogeneous investors with a life-cycle. Markets are incomplete, and prices are exogenous.<sup>6</sup> Population size is stationary, and there is a

<sup>6</sup>We study the general equilibrium version of the model in an extension.

continuum of measure 1 of households. Time is discrete.

**Life cycle** Each household lives for three periods: young ( $a = y$ ), middle-aged ( $a = m$ ), and old ( $a = o$ ). Young and middle-aged workers earn exogenous labor income. Old households earn retirement income, which is on average lower than worker income.

**Preferences** Households have a logarithmic utility function over a Cobb-Douglas aggregator of nondurable consumption  $c_t$  and housing services  $h_t$ . The net taste for owning and the moving cost are modeled as additive utility shifters  $\Xi$  and  $m$ . A household's instantaneous utility function is:

$$\log u(c_t, h_t) + \Xi - m \equiv \log c_t^{1-\alpha} h_t^\alpha + \Xi - m \quad (1)$$

Homeowners can only own one home in a single size, which delivers a fixed flow of services  $\bar{h}$ . Renters consume continuous quantities of housing services  $h_t \in (0, \bar{h}]$ .  $\Xi$  depends on the investor group, and  $m$  on whether households switch between housing stocks.

Bequests are a normal good and are redistributed within a given group of investors. They are captured by a warm-glow motive:

$$U(b) \equiv \psi \log b \quad (2)$$

**Endowments and risk** Households face idiosyncratic income risk and mortality risk. The survival probabilities  $\{p_a\}$  vary over the life-cycle. Middle-aged workers have a small probability of dying. Old households die with probability 1, and home owners must fully repay their mortgage before dying. Dead households leave involuntary bequests which are redistributed to young workers from the same group.

The log income of a working-age household  $i$ , of age  $a$ , investor group  $g$  and in housing stock  $j$  is

$$y_{i,j,a,t} = g_a + \mu_g + \mu_j + \varepsilon_{i,t} \quad (3)$$

$$\varepsilon \stackrel{iid}{\sim} \mathcal{N}(0, \sigma_\varepsilon^2)$$

$g_a$  is the logarithm of a deterministic life-cycle income profile.  $\varepsilon_{i,t}$  is the logarithm of the i.i.d. idiosyncratic component of income for household  $i$ , which is drawn from a Normal distribution with mean zero and standard deviation  $\sigma_\varepsilon$ .  $\mu_g$  is a racial income shifter, and  $\mu_j$  is a spatial income shifter. Retirement income has the main features of the U.S. pension system (Güvenen & Smith (2014)).

**Household balance sheets** Households can invest in a risk-free liquid asset with an exogenous rate of return  $r > 0$  and in housing. The discrete choices of home ownership and housing stock lead to inaction

regions (e.g., [Arrow \*et al.\* \(1951\)](#)), whereby households with a given combination of state variables keep their current discrete choices, while others switch between home ownership statuses and housing stocks.

Renters who do not buy a home can invest in the risk-free asset at rate  $r$  and face a no-borrowing constraint. Renters who buy can use long-term mortgages to borrow, subject to LTV and PTI constraints, which only apply at origination. They face an exogenous mortgage rate  $r^b > r$ , which implies that mortgage borrowers first pay back their debt before holding risk-free assets.<sup>7</sup> Denote  $\tilde{r} = r$  if net savings are positive, and  $\tilde{r} = r^b$  otherwise. Mortgages have an exogenous amortization schedule, and must be fully repaid when old households die. For simplicity we assume no default.

**Home ownership** There are three motives for owning in the model. First, the owner-occupied and the rental stocks are segmented (e.g., [Greenwald & Guren \(2021\)](#)), such that owning allows buyers to access larger homes producing more valuable housing services. Second, owning can improve consumption smoothing, since buying with a mortgage allows owners to only pay a fraction of the purchase price in the current period while renters have to pay the full rent, even though it is lower than the price. If the transition between the owner-occupied and rental markets was frictionless, then the price would be a multiple of the rent such that households would be indifferent between renting and owning (user cost equation). However, the user cost equation does not hold with segmented markets, such that buying may be cheaper, hence more attractive, than renting.<sup>8</sup> Third, owning gives households exogenous utility benefits captured by  $\Xi$ . These motives are in line with the literature on home ownership (e.g., [Goodman & Mayer \(2018\)](#), [Sodini \*et al.\* \(2021\)](#)).

**2 × 2 housing markets** Individual investors have an exogenous probability to belong to either group  $g$ . The two groups differ in investors' probabilities to first enter the housing market in either of the two housing stocks, in their initial wealth, average income (racial income shifter), and net taste for owning, which captures unmodeled costs and benefits associated with home ownership. The two housing stocks differ in home prices and rents, average income (spatial income shifter), moving costs across stocks, and they are associated with two types of long-term, fully amortizing mortgages with different LTV limits, which correspond to FHA and non-FHA loans.

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<sup>7</sup>The assumption that mortgage borrowers cannot save accounts for the large fraction of “wealthy hand-to-mouth” households with little liquid assets in the data.

<sup>8</sup>This motive is stronger if the frequency of the model is lower. When one period represents many years, it may be more attractive for buyers to slowly pay for their homes over time with a long-term mortgage than for renters to pay for many years worth of rent at once. Because it implies that owning allows households to better smooth their expenses relative to renting, this motive proxies for the idea that owner-occupied housing is a hedge against rent risk ([Sinai & Souleles \(2005\)](#)).

**Household choices** Every period, households choose to either rent or own. Owner-occupied units come in a single size  $\bar{h}$  (normalized to 1) at price  $P_j$  in housing stock  $j$ . Rental size can be chosen continuously in  $(0, \bar{h}]$  at rent  $R_j$ . Households choose whether to move between stocks. If they do, they incur additive fixed moving costs  $m$  in utility terms. Finally, they choose nondurable consumption  $c_t$ , and save in a risk-free liquid asset  $b_t > 0$  or borrow with a long-term mortgage  $b_t < 0$ .

**Timing** A household in a given housing stock makes discrete choices for home ownership and housing stock, earns labor and financial income in its housing stock of origin, and then makes consumption, debt or savings, and housing size choices.

## 4.2 Household Problem

This section describes the household problem in recursive form. The individual state variables are the investor group  $g$ , tenure status  $\mathcal{H} = r, o$  (renter or owner), location  $j = L, H$  (low-price or high-price stock), age  $a$ , assets or debt  $b$ , and endowment  $y$ . We describe the renter and the owner problems for the low-price stock  $L$  and a given investor group  $g$ , since the problem is similar for the high-price stock  $H$ .

### 4.2.1 Renter

Denote the date  $t$  value function of a renter of fixed investor group  $g$ , age  $a$ , with savings  $b_t$  and income  $y_t$ , who starts the period in stock  $L$ , as  $V_t^{rgL}(a, b_t, y_t)$ . First, a renter chooses the stock where it will move at the end of the period, and whether to rent or own in this new stock. The envelope value of the value functions for each option is:

$$V_t^{rgL}(a, b_t, y_t) = \max \left\{ V_t^{rgL,rgL}, V_t^{rgL,rgH}, V_t^{rgL,ogL}, V_t^{rgL,ogH} \right\} \quad (4)$$

Denote  $d_t^{rgL} \in \{rgL, rgH, ogL, ogH\}$  the resulting policy function for the discrete choice problem. Then, renters choose nondurable consumption, housing size, and savings or mortgage debt if they borrow to purchase a house.

**Inactive renter** The value of being inactive and staying a renter in stock  $L$  is given by the Bellman equation

$$V_t^{rgL,rgL}(a, b_t, y_t) = \max_{c_t, h_t, b_{t+1}} \log u(c_t, h_t) + \beta \left( p_a \mathbb{E}_t \left[ V_{t+1}^{rgL}(a+1, b_{t+1}, y_{t+1}) \right] + (1 - p_a) U_{t+1} \right), \quad (5)$$

subject to the constraint that expenses on nondurable consumption, rented housing services, and savings, must be no lower, and at the optimum equal to, resources from labor income and financial income from

risk-free assets

$$c_t + R_{L,t}h_t + b_{t+1} = y_t + (1+r)b_t, \quad (6)$$

and subject to a no-borrowing constraint on assets, as well as a constraint on the size of rental housing

$$b_{t+1} \geq 0, \quad h_t \in (0, \bar{h}]. \quad (7)$$

Expectations are taken with respect to the conditional distribution of idiosyncratic income shocks at date  $t$ . Since the household does not own a house, the warm-glow bequest motive is over financial wealth,  $U_{t+1} = \psi \log b_{t+1}$ .

**Mobile renter** When moving to stock H and staying a renter, a household incurs a moving cost  $m$  in utility terms and faces the continuation value function in stock H:

$$\begin{aligned} V_t^{rgL,rgH}(a, b_t, y_t) &= \max_{c_t, h_t, b_{t+1}} \log u(c_t, h_t) - m + \beta \left( p_a \mathbb{E}_t \left[ V_{t+1}^{rgH}(a+1, b_{t+1}, y_{t+1}) \right] + (1-p_a)U_{t+1} \right) \\ \text{s.t. } c_t + R_{L,t}h_t + b_{t+1} &= y_t + (1+r)b_t \\ b_{t+1} &\geq 0, \quad h_t \in (0, \bar{h}] \end{aligned} \quad (8)$$

**Home buyer** When buying a house in the same stock, the renter's value function is

$$V_t^{rgL,ogL}(a, h_t, b_t, y_t) = \max_{c_t, h_t, b_{t+1}} \log u(c_t, h_t) + \beta \left( p_a \mathbb{E}_t \left[ V_{t+1}^{ogL}(a+1, b_{t+1}, y_{t+1}) \right] + (1-p_a)U_{t+1} \right). \quad (9)$$

In addition to rental services purchased at rate  $R_{L,t}$ , the household buys owner-occupied housing at price  $P_{L,t}$ ,

$$c_t + R_{L,t}h_t + F_m + P_{L,t}\bar{h}(1+f_m) + b_{t+1} = y_t + (1+r)b_t, \quad h_t \in (0, \bar{h}], \quad (10)$$

using a mix of savings accumulated over the life-cycle, and of long-term mortgage debt  $b_{t+1}$  borrowed at rate  $r^b$ , subject to fixed and proportional origination fees  $F_m$  and  $f_m$ , and to LTV and PTI constraints,

$$b_{t+1} \geq -\theta_{LTV,t}P_{L,t}\bar{h} \quad \text{and} \quad b_{t+1} \geq -\frac{\theta_{PTI,t}}{(1+r^b-\theta)}y_t. \quad (11)$$

$\theta_{LTV}$  is the maximum fraction of the house price in stock  $L$  which the household can borrow, so  $1 - \theta_{LTV}$  is the down payment requirement.  $\theta_{PTI}$  is the maximum fraction of its income that a household is allowed to spend on mortgage payments each period. These constraints only apply at origination, and may be

violated in subsequent periods in response to income shocks and house price movements. Every period, homeowners with a mortgage pay interests and roll over their current debt subject to the requirement that they repay at least a fraction  $1 - \theta$  of the principal,

$$b_{t+1} \geq \min [\theta b_t, 0]. \quad (12)$$

The lowest payment that households can make in a period therefore equals  $(1 + r^b - \theta) b_t$ .

The bequest motive includes housing wealth,  $U_{t+1} = \psi \log \left( (1 + \tilde{r})b_{t+1} + P_{L,t}\bar{h} \right)$ .

**Mobile home buyer** The value of moving to stock H and buying a house is similar, with the addition of the moving cost  $m$ :

$$V_t^{rgL,ogH}(a, b_t, y_t) = \max_{c_t, h_t, b_{t+1}} \log u(c_t, h_t) - m + \beta \left( p_a \mathbb{E}_t \left[ V_{t+1}^{ogH}(a + 1, b_{t+1}, y_{t+1}) \right] + (1 - p_a) U_{t+1} \right), \quad (13)$$

subject to the budget and borrowing constraints

$$\begin{aligned} c_t + R_{L,t}h_t + F_m + P_{H,t}\bar{h}(1 + f_m) + b_{t+1} &= y_t + (1 + r)b_t, \quad h_t \in (0, \bar{h}], \\ b_{t+1} &\geq -\theta_{LTV,t}P_{H,t}\bar{h} \quad \text{and} \quad b_{t+1} \geq -\frac{\theta_{PTL,t}}{(1 + r^b - \theta)}y_t. \end{aligned} \quad (14)$$

#### 4.2.2 Home Owner

The home owner problem has the same structure. Denote the date  $t$  value function of an owner starting the period in stock L, as  $V^{oL}(a, b_t, y_t)$ . It chooses to either remain an owner, or sell its house and become a renter, and the stock where it moves over the period:

$$V_t^{ogL}(a, b_t, y_t) = \max \left\{ V_t^{ogL,ogL}, V_t^{ogL,ogH}, V_t^{ogL,rgL}, V_t^{ogL,rgH} \right\} \quad (15)$$

Denote the resulting policy function for the discrete choice problem as  $d_t^{ogL} \in \{ogL, ogH, rgL, rgH\}$ .

**Inactive owner** The value of staying a home owner in stock L is given by the Bellman equation with fixed housing services  $\bar{h}$ ,

$$V_t^{ogL,ogL}(a, b_t, y_t) = \max_{c_t, b_{t+1}} \log u(c_t, \bar{h}) + \Xi + \beta \left( p_a \mathbb{E}_t \left[ V_{t+1}^{ogL}(a + 1, b_{t+1}, y_{t+1}) \right] + (1 - p_a) U_{t+1} \right), \quad (16)$$

subject to the budget constraint

$$c_t + b_{t+1} = y_t + (1 + \tilde{r})b_t, \quad (17)$$

and the loan amortization constraint

$$b_{t+1} \geq \min [\theta b_t, 0]. \quad (18)$$

The bequest motive includes housing wealth,  $U_{t+1} = \psi \log((1 + \tilde{r})b_{t+1} + P_{L,t}\bar{h})$ .

**Mobile owner** When selling its house and purchasing a house in the other stock H, an owner incurs the moving cost  $m$ :

$$V_t^{ogL,ogH}(a, b_t, y_t) = \max_{c_t, b_{t+1}} \log u(c_t, \bar{h}) + \Xi - m + \beta \left( p_a \mathbb{E}_t \left[ V_{t+1}^{ogH}(a + 1, b_{t+1}, y_{t+1}) \right] + (1 - p_a) U_{t+1} \right) \quad (19)$$

The new house is purchased with a mix of housing equity, savings in liquid assets (if it holds no debt), and a new mortgage  $b_{t+1}$ , subject to the same origination fees  $F_m$  and  $f_m$  and borrowing constraints as a renter, In addition, there are sales transaction costs  $f_s$  on the house sold in stock L,

$$\begin{aligned} c_t + F_m + P_{H,t}\bar{h}(1 + f_m) + b_{t+1} &= y_t + (1 + \tilde{r})b_t + (1 - f_s) P_{L,t}\bar{h}, \\ b_{t+1} &\geq -\theta_{LTV,t} P_{H,t}\bar{h} \quad \text{and} \quad b_{t+1} \geq -\frac{\theta_{PTL,t}}{(1+r^b-\theta)} y_t. \end{aligned} \quad (20)$$

**Home seller** An owner selling its house and becoming a renter in the same stock incurs the proportional selling transaction cost  $f_s$ :

$$V_t^{ogL,rgL}(a, b_t, y_t) = \max_{c_t, b_{t+1}} \log u(c_t, \bar{h}) + \Xi + \beta \left( p_a \mathbb{E}_t \left[ V_{t+1}^{rgL}(a + 1, b_{t+1}, y_{t+1}) \right] + (1 - p_a) U_{t+1} \right), \quad (21)$$

subject to the budget and no-borrowing constraints

$$\begin{aligned} c_t + b_{t+1} &= y_t + (1 + \tilde{r})b_t + (1 - f_s) P_{L,t}\bar{h}, \\ b_{t+1} &\geq 0 \end{aligned} \quad (22)$$

Because the owner sells its house during the period, the bequest only includes financial wealth,  $U_{t+1} = \psi \log((1 + r)b_{t+1})$ .

**Mobile home seller** The value of selling its house to move and become a renter in the other stock H is identical the previous one, with the addition of the moving cost  $m$ .



### 4.3 Spatial Steady State

We compute the stationary steady state of the  $2 \times 2$  economy taking house prices, rents, the risk-free rate, and the mortgage rate as given.

**Definition** A recursive stationary spatial steady state consists of the following objects, for investor group  $g$  stocks  $j = L, H$  and home ownership  $\mathcal{H} = r, o$ :

- (i) value functions  $\{V_t^{\mathcal{H}gj}, V_t^{\mathcal{H}'gj'}\}$ ,
- (ii) policy functions  $\{d_t^{\mathcal{H}gj}, c_t^{\mathcal{H}gj}, h_t^{\mathcal{H}gj}, b_{t+1}^{\mathcal{H}gj}\}$ ,
- (iii) a law of motion for the cross-sectional distribution of households  $\lambda_t(\mathcal{H}, g, ja, b, y)$  between stocks, ownership statuses, and idiosyncratic states (investor groups are fixed),

such that households optimize given prices, and the law of motion for the distribution of households is consistent with their choices and prices.

### 4.4 Computation

The solution method for computing the steady state of the model under multiple discrete choices associated with home ownership and housing stocks extends [Mabille \(2021\)](#) to the case of two investor groups with fixed prices.

### 4.5 Calibration

All moments are jointly determined, but some parameters have a larger effect on a set of moments (e.g., [Andrews et al. \(2017\)](#)). We exploit this feature for the internal calibration of the model. We proceed in four steps:

1. Fix the externally calibrated parameters from the data.
2. Choose the internally calibrated parameters to match empirical targets.
3. Choose the remaining free parameters to obtain the best fit across all internal calibrations.
4. Check that the resulting parameters make sense in the data.

Table 1 describes the results. At the aggregate level, we calibrate the discount factor  $\beta$  to match the average wealth to income ratio of 6 in the economy (SCF). We also choose the Cobb-Douglas preference parameter for housing  $\alpha$  to match the average rent to income ratio of 0.24 (decennial Census data, [Davis &](#)

Ortalo-Magne (2011)), and the maximum PTI ratio  $\theta_{PTI}$  to match the 90<sup>th</sup> percentile of the distribution of PTI of 0.28 (HMDA).

To match differences between housing stocks, we calibrate the maximum LTV ratios for FHA-eligible and in the non-FHA-eligible loans  $\theta_L$  and  $\theta_H$  to match the 90<sup>th</sup> percentiles of the two distributions of LTV of 0.95 and 0.80 (HMDA). We also choose the spatial income shifter  $\mu_H$  in the non-eligible stock to match the ratio of average incomes between stocks of 1.20 (Infutor and HMDA), and the utility moving cost  $m$  to match the ratio of moving rates of 3 from one stock to the other (Infutor and HMDA).

Finally, we choose the racial income shifter  $\mu_W$  for white households to match the ratio of average incomes between white and Black households of 2.07 (ACS), and investors' tastes for owning to match the residual differences in home ownership rates, which are 0.72 for white households and 0.44 for Black households (SCF).

TABLE 1: CALIBRATION

| Parameter              | Explanation                                  | Value          | Source/Target                                   |
|------------------------|--|----------------|---|
| <b>External</b>        |  |                |   |
| $\rho$                 | Persistence log income                       | 0              | i.i.d. income shocks                            |
| $r^f$                  | Risk-free rate                               | 5%             | Avg 30-year Treasury since 1975 (Fred)          |
| $r^m$                  | Mortgage rate                                | 6%             | Avg 30-year mortgage rate since 1975 (Fred)     |
| $\bar{Y}$              | Avg worker income                            | 1/4            | Share of buyers with mortgages                  |
| $F_b$                  | Selling transaction cost (proportional)      | 0.06           | 6% purchase price                               |
| $F_s$                  | Buying transaction cost (proportional)       | 0.006          | 0.6% loan                                       |
| $f_s$                  | Buying transaction cost (fixed)              | 0.002          | \$2,000   |
| $P_H$                  | House price non-FHA-eligible stock           | 0.24           | 100% buyers have mortgage                       |
| $P_L$                  | House price FHA-eligible stock               | 0.08           | Price ratio FHA-eligible/non-eligible           |
| $R_H$                  | Rent non-FHA-eligible stock                  | 0.24           | Price/rent non-FHA-eligible stock = 20 (annual) |
| $R_L$                  | Rent FHA-eligible stock                      | 0.08           | Price/rent FHA-eligible stock = 20 (annual)     |
| $b_0^W, b_0^B$         | Initial wealth                               | 0.0250, 0.0013 | Ratio of white (\$100k)/Black wealth of 20      |
| $\pi_H^W, \pi_H^B$     | Prob to enter in non-eligible vs FHA stock   | 0.78, 0.58     | Shares of white, Black in non-FHA stock         |
| $\pi^B$                | Prob to enter Black                          | 0.18           | Share of Black buyers                           |
| <b>Internal</b>        |  |                |   |
| <b>Aggregate</b>       |  |                |   |
| $\beta$                | Discount factor                              | 0.8046         | Wealth/income=6 (SCF)                           |
| $\alpha$               | Cobb-Douglas pref for housing                | 0.2401         | Avg rent / avg income=0.24                      |
| $\theta_{PTI}$         | Max PTI                                      | 0.4181         | P90 PTI distribution=28%                        |
| $\theta$               | Amortization                                 | 0.75           | Overall fit (repay min 25% per 20 years)        |
| $\sigma_\epsilon$      | Std. dev. log income shocks                  | 0.15           | Overall fit                                     |
| <b>Housing stocks</b>  |  |                |   |
| $\theta_{LTV,H}$       | Max LTV non-FHA-eligible stock               | 0.8050         | P90 LTV distribution=80%                        |
| $\theta_{LTV,H}$       | Max LTV FHA-eligible stock                   | 0.9501         | P90 LTV distribution=95%                        |
| $\mu_H$                | Income shifter non FHA-eligible stock        | 0.79           | Avg income ratio non-eligible/FHA 1.20          |
| $m$                    | Moving cost (utility) from FHA- to non-elig. | 1.7571         | Moving rates ratio of 3                         |
| <b>Investor groups</b> |  |                |   |
| $\mu^W$                | Income shifter white                         | 0.79           | Avg income ratio white/Black 2.07               |
| $\Xi_o^W, \Xi_o^B$     | Taste for owning white, Black                | 7.86, 0.48     | Home ownership 72%, 44%                         |

Notes: One model period corresponds to 20 years.

## 5 Results

### 5.1 Model Fit

Table 2 shows that the  $2 \times 2$  model successfully matches differences in home ownership, leverage, income, and moving rates between investor groups and housing stocks.

As shown in Table 3, the model also comes close to matching key non-targeted moments. It generates substantial racial inequality in households' balance sheets. Black households have lower average wealth than white households (the ratio of average wealth for Black households relative to white households is 0.33), higher average LTV (the ratio is 1.27), median LTV (the ratio is 1.10), and 90<sup>th</sup> percentile of LTV, and leave on average lower bequests (the ratio is 0.27).

**TABLE 2: TARGETED MOMENTS**

| Variable  | Data | Model |
|---|------|-------|
| Aggregate   |      |       |
| Avg wealth / avg income ratio                     | 6    | 6.20  |
| Avg rent/avg income                               | 0.24 | 0.24  |
| P90 PTI   | 0.28 | 0.24  |
| Housing stocks                                    |      |       |
| P90 LTV non-eligible                              | 0.80 | 0.80  |
| P90 LTV FHA                                       | 0.95 | 0.95  |
| Avg income non-eligible/ FHA                      | 1.20 | 1.20  |
| Fraction moves non-elig. to FHA/ FHA to non-elig. | 3    | 3     |
| Investor groups                                   |      |       |
| Avg income white/ Black                           | 2.07 | 2.07  |
| Home ownership white                              | 0.72 | 0.66  |
| Home ownership Black                              | 0.44 | 0.42  |

Notes: Moments are annualized. See text for sources.

**TABLE 3: NON-TARGETED MOMENTS**

| Variable          | Data | Model |
|-------------------|------|-------|
| Black/White Ratio |      |       |
| Avg wealth        | 0.51 | 0.33  |
| Avg LTV           | 1.20 | 1.27  |
| Median LTV        | 1.07 | 1.19  |
| P90 LTV           | 1.02 | 1.10  |
| Avg bequest       | 0.33 | 0.27  |

Sources: Survey of Consumer Finances (2019), Home Mortgage Disclosure Act (2018). Wealth is measured as home equity. In the data, average bequest by race is computed as conditional median inheritance times the probability of receiving an inheritance. These numbers are respectively \$88,500 and 29.9% for white households, and \$85,800 and 10.1% for Black households.

## 5.2 Persistent Effect of Initial Wealth

We start by showing evidence of the persistent effect of households' initial wealth on average home ownership rates, leverage, wealth, and income. In Figure 11, we compute these variables for Black households after accounting for households' wealth accumulation over the life cycle.

Despite life-cycle wealth accumulation, which partly allows Black households to overcome the effect of their low initial wealth relative to white households (on average twenty times lower), increasing their initial wealth has a strong effect on their future average wealth. Home ownership increases in the housing stock with higher income, and slightly decreases in the other stock. Average leverage decreases, but the 90<sup>th</sup> percentile decreases less. As a result average wealth increases, but much less than one for one with initial wealth.

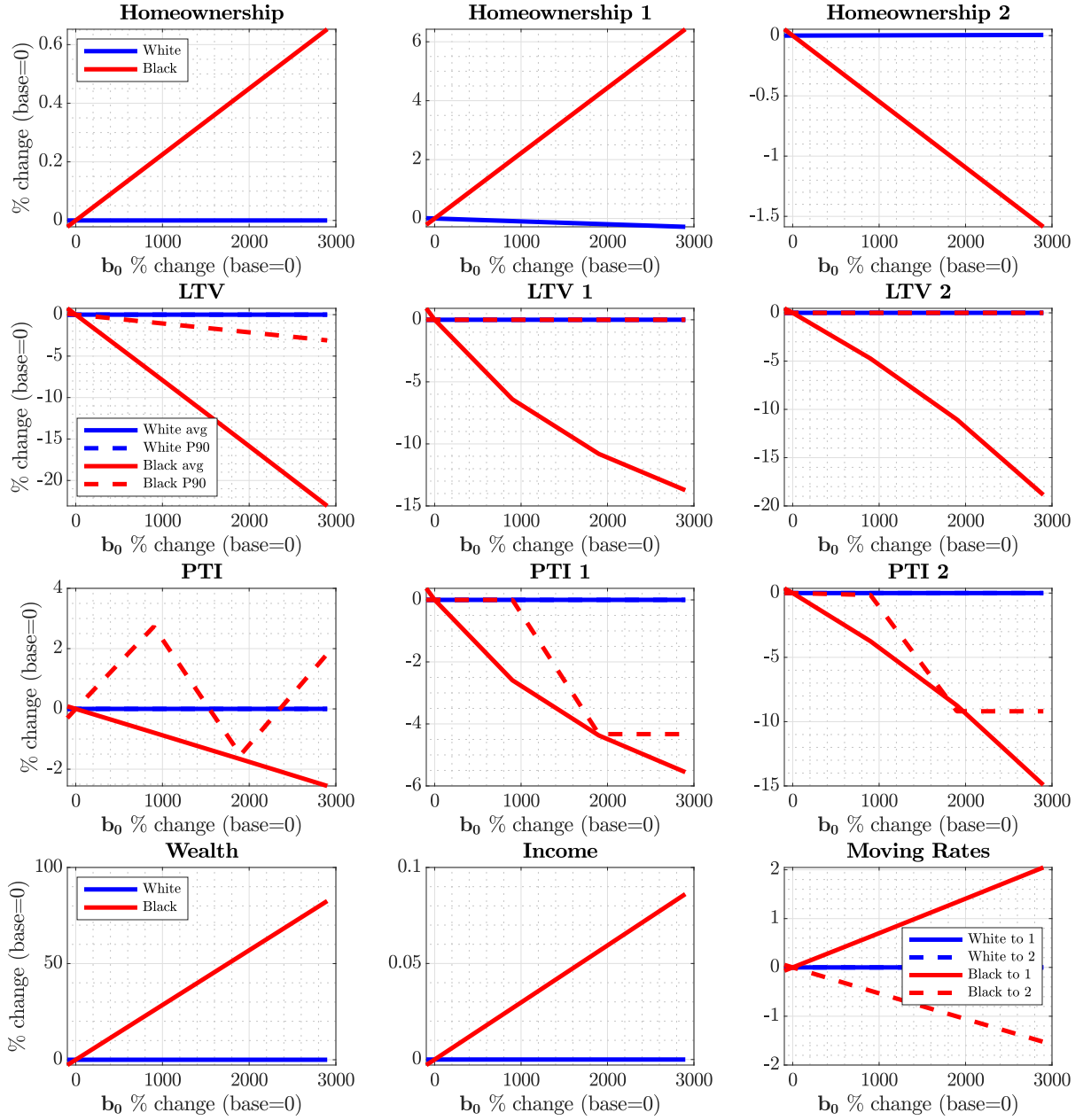
## 5.3 House Price Impact on Leverage

We study the effects of house price changes on households' home ownership rates, leverage, wealth, and income. These effects crucially depend on the features of the  $2 \times 2$  housing markets. First, because investor groups have different characteristics, price changes have quantitatively and even sometimes *qualitatively* different effects on Black and white households. Second, because investors endogenously sort across housing stocks, price changes in a single housing stock have spillover effects to the entire housing market as they modify households' moving rates. These results, like Berger *et al.* (2017) and Bailey *et al.* (2019), assume exogenous house prices and rents, whose increases can be interpreted as a gentrification shock. They complement Lustig & Van Nieuwerburgh (2005) and Lustig & Van Nieuwerburgh (2010), who show that house price decreases lead to less borrowing. They also complement Adelino *et al.* (2016) and Adelino *et al.* (2018), who show that expectations of future price increases led to an increase in leverage for a wide range of households.

Figures 12 and 13 plot the percentage changes in the main components of households' balance sheets' compared to the baseline calibration, in response to a percentage change in prices, respectively in the non-FHA-eligible and eligible housing stocks. Red lines depict the variable of interest for Black households, and blue lines for white households. For LTV and PTI, solid lines plot the average changes, and dashed lines the changes in the 90<sup>th</sup> percentiles. For moving rates, solid lines plot changes in moving rates to the non-FHA-eligible housing stock, and dashed lines to the FHA-eligible.

**Leverage vs. home ownership** We start by highlighting a general result. An increase in house prices can have a *non-monotonic* effect on investors' wealth due to two effects which go in opposite directions.

FIGURE 11: EFFECT OF INITIAL WEALTH CHANGE FOR BLACK HOUSEHOLDS



Notes: variables are conditional averages ("P90" indicates 90<sup>th</sup> percentile) in percentage deviation from the steady state of the baseline model. Each line describes a household balance sheet variable in the steady state of an alternative model where initial wealth differs from the baseline.

First, all else equal, an increase in prices decreases home ownership because it makes owning more costly relative to renting. It reduces home equity and household wealth. Second, because it makes it harder to access home ownership, it leads to selection among buyers, who need higher wealth and income to buy the same house. It leads to a lower leverage distribution, which implies an improvement in home equity and household wealth, boosted by higher prices among existing owners. Which effect dominates depends on

how financially constrained investors are, which in turn depends on investors' groups and housing stocks.

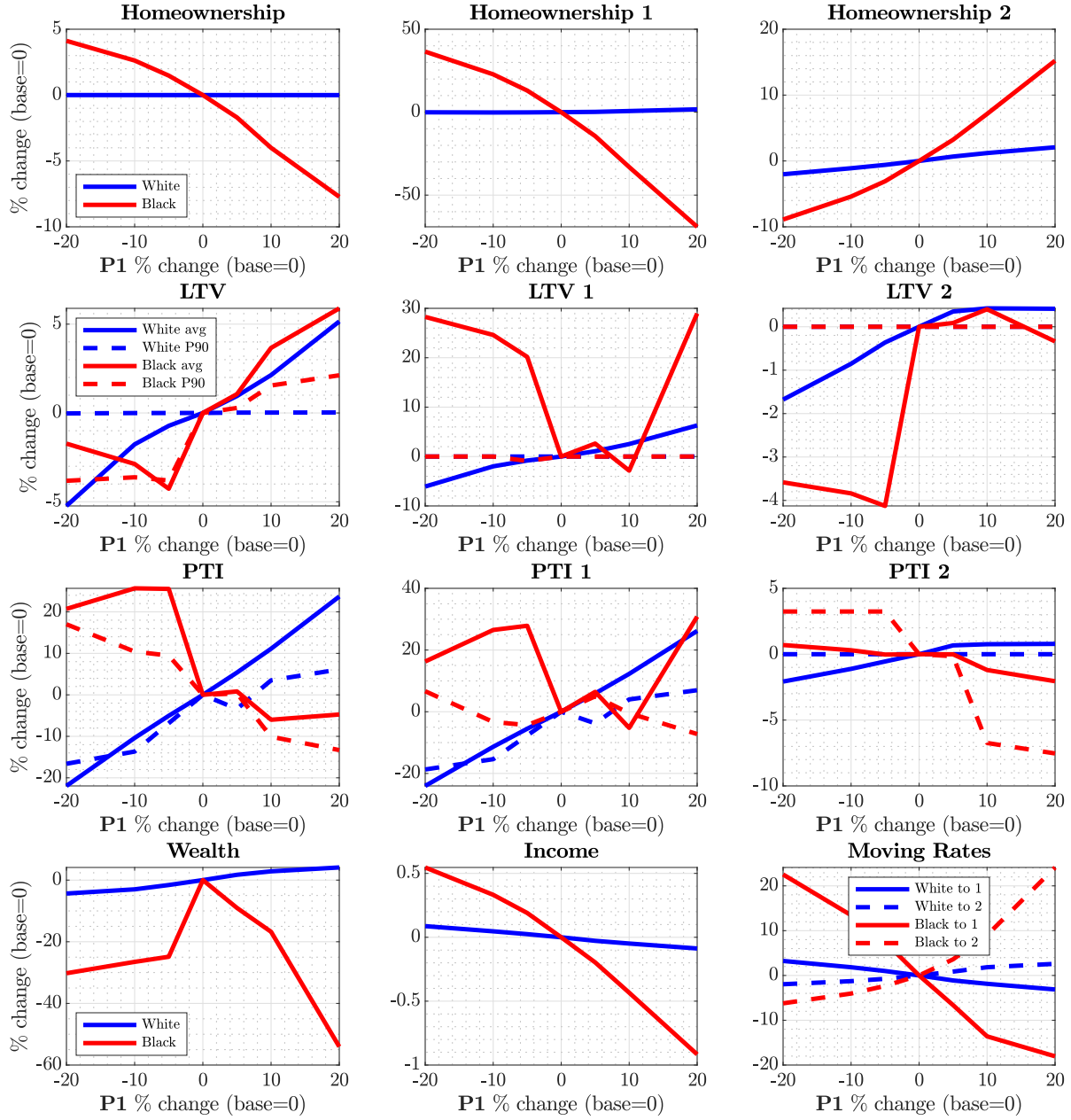
A simple model of mortgage borrowing with a representative household gives the intuition for this result. In such a model, house prices can have a positive or negative impact on leverage. Our model combines the two responses. Indeed, consider a house with price  $P$ . A buyer with resources  $W_0$  pays for  $P$  with a mix of a down payment  $W \leq W_0$  and debt  $D = P - W$ . Leverage is defined as the loan to value ratio, i.e.,  $LTV = D/P = (P - W)/P = 1 - W/P$  (one minus the home equity ratio).

Now consider an increase in house prices  $\Delta P > 0$ . There are three cases. First, if the household's down payment  $W$  stays the same (e.g., because it was already spending its entire wealth,  $W = W_0$ ), then higher house prices lead to *higher* leverage. Intuitively, it is because the household needs to use more debt to buy a more expensive house, since it cannot or does not use more of its wealth, such that its home equity stays the same and eventually it owns relatively less of this more valuable house. To prove it, note that higher leverage  $(P + \Delta P - W)/(P + \Delta P) > (P - W)/P$  is equivalent to  $1 - W/(P + \Delta P) > 1 - W/P$ , i.e.,  $W/P > W/(P + \Delta P)$ , which is true because  $\Delta P > 0$ . Second, if the down payment  $W$  adjusts to match the price increase  $\Delta P$  (for which a necessary condition is  $\Delta P \leq W_0 - W$ ), then higher house prices lead to *lower* leverage. Intuitively, it is because the household owns a more valuable house without having to pay for it with more debt. To prove it, note that the new leverage ratio is  $(P + \Delta P - (W + \Delta P))/(P + \Delta P) = (P - W)/(P + \Delta P) < (P - W)/P$  because  $\Delta P > 0$ . Third, if  $W = 0$  (e.g., because  $W_0 = 0$ ) and the household only buys the house with debt, then an increase in house prices leaves leverage unchanged, since debt increases at the same rate as house prices. Formally, the new LTV ratio is  $(D + \Delta P)/(P + \Delta P) = (P + \Delta P)/(P + \Delta P) = 1$ . Finally, in the presence of borrowing constraints which become binding following a price increase, the household drops out of home ownership altogether.

## 5.4 Implications for the Racial Wealth Gap

This result has several implications for the racial housing gap. First, higher house prices have little effect on home ownership for white households, but a large negative for Black households in the housing stock where prices increase. Second, a price increase in one of the two housing stocks leads to an improvement in home ownership for Black households in the *other* housing stock, as endogenous relocation of Black buyers to the relatively cheaper stock lead to spillover effects. For Black households, these effects are positive for home ownership, but slightly negative for income, which is hurt by the low spatial income shifter in the cheaper stock. Third, the impact of higher house prices on average leverage is increasing and linear for white buyers but *U-shaped* for Black buyers. At low price levels, an increase in prices leads to selection among buyers and an improvement in the leverage distribution, since buyers must have higher wealth and

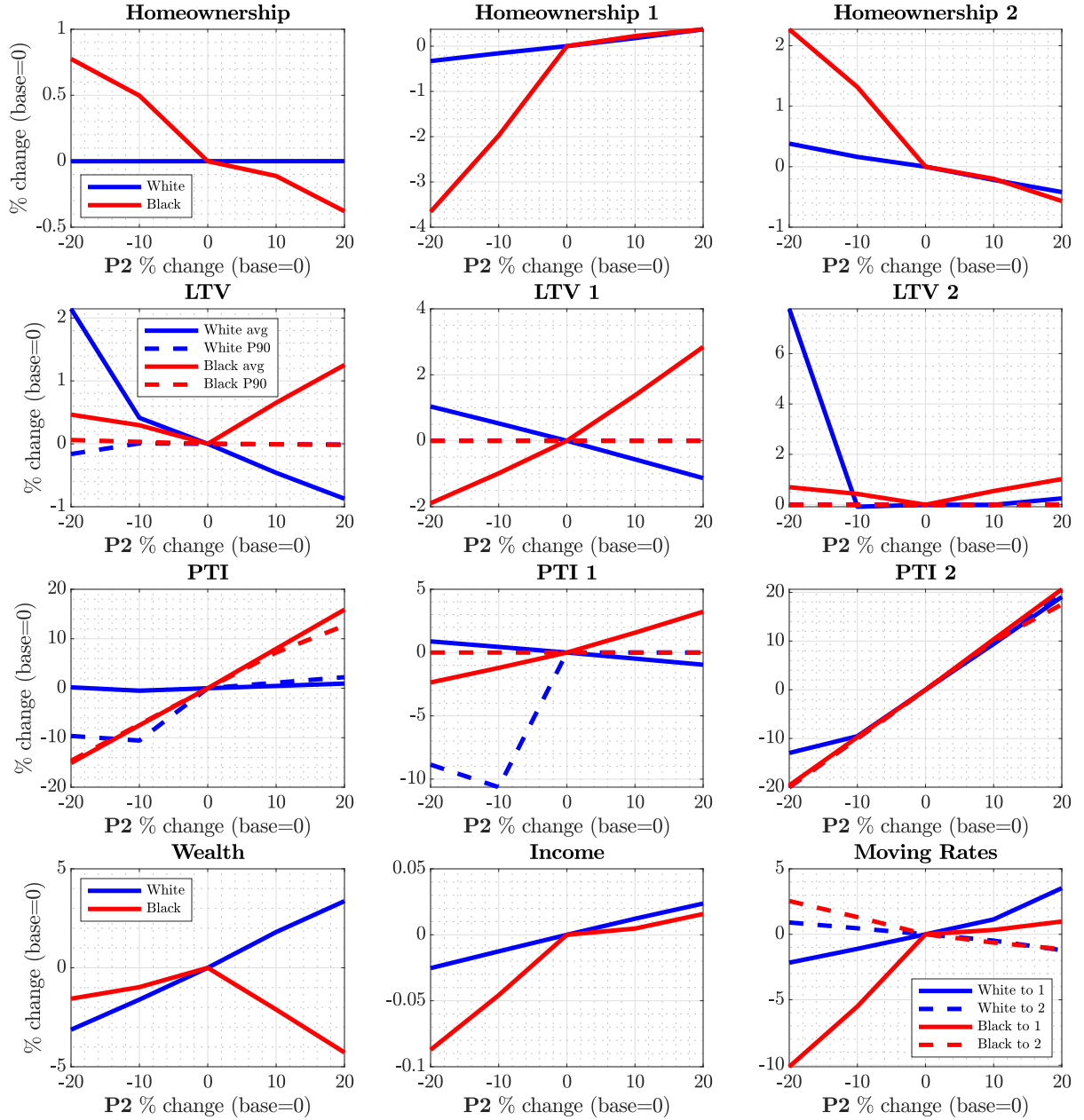
FIGURE 12: EFFECT OF PRICE CHANGE IN NON-FHA-ELIGIBLE HOUSING STOCK



Notes: variables are conditional averages ("P90" indicates 90<sup>th</sup> percentile) in percentage deviation from the steady state of the baseline model. Each line describes a household balance sheet variable in the steady state of an alternative model where house prices differ from the baseline.

income to buy the same house as previously. At high price levels, however, selection is maximal and an increase in prices only leads existing borrowers to take on more debt, while those already at the borrowing limits drop out of the owner-occupied market. In contrast, an increase in prices only increases white buyers' average leverage without altering their home ownership, as existing buyers take on more debt to buy at the same rate as previously. The impact on buyers' average PTI ratio is similar. This result highlights that

FIGURE 13: EFFECT OF PRICE CHANGE IN FHA-ELIGIBLE HOUSING STOCK



Notes: variables are conditional averages (“P90” indicates 90<sup>th</sup> percentile) in percentage deviation from the steady state of the baseline model. Each line describes a household balance sheet variable in the steady state of an alternative model where house prices differ from the baseline.

the “naive” intuition that investors’ leverage increases in the price of the asset purchased fails to hold when investors are heterogeneous, subject to borrowing constraints, and when the purchase of the asset is discrete rather than continuous.

As a result, higher house prices unambiguously increase white households’ wealth but have a non-monotonic impact on Black households’ wealth (hence on the racial wealth gap), which is inversely U-



shaped and mirrors its impact on Black buyers' leverage. Higher prices first increase the average wealth of Black buyers as their leverage distribution improves faster than the reduction in home ownership, but then they decrease it as lower home ownership more than offsets the improvement in leverage due to buyers' selection. The central roles of leverage and home equity suggest that, while home ownership differences are crucial (e.g., [Charles & Hurst \(2002\)](#), [Collins & Margo \(2011\)](#), [McCargo & Choi \(2020\)](#)), it can be misleading to only focus on them as the main driver of the racial housing gap. In particular, at low house price levels the average wealth of Black households tracks their average home equity (the opposite of leverage) in response to house price changes, and they are disconnected from home ownership since they increase whereas it decreases. The responses of home ownership and home equity, which negatively affect average Black wealth, only go in the same direction at high price levels. Overall, despite significant negative effects on Black households' income,<sup>9</sup> most of the change in Black wealth comes from home equity on households' balance sheets rather than income. Together, these findings highlight the importance of jointly modeling home ownership and leverage for wealth accumulation.

**Heterogeneous housing stocks** Black buyers are significantly less likely than white buyers to enter the housing market in the more expensive non-FHA-eligible housing stock (20 percentage points). Nevertheless, our previous results imply that an increase in house prices in that housing stock has a larger effect on their average wealth – more positive at low price levels and more negative at high ones – than in the eligible stock where they are relatively more likely to buy. The effects are qualitatively similar, but quantitatively smaller when house prices increase in the cheaper eligible stock because it is easier to access and build home equity. Because house price levels are low, Black households do not massively drop out of home ownership when prices increase, even up to 20% relative to the baseline.

These effects are even smaller in the case of rent changes (Figures [A.IV](#) and [A.V](#)), for which households can choose to consume continuously lower housing services to reduce their expenses, further illustrating the previous point. Interestingly, an increase in rents slightly increases average Black wealth due to a positive effect on home ownership, which becomes relatively more attractive. This suggests that housing affordability crises centering on prices and on rents may have different effect on households' wealth accumulation.

However, larger price increases in the FHA-eligible housing stock, such as a 100% increase which would amount to that stock quickly catching up to the non-eligible one, have a much larger, negative impact on the racial wealth gap. In that case (results available upon request), Black home ownership decreases significantly, while the leverage distribution among buyers improves due to the selection of richer borrowers. The large price increase in the eligible stock increases moving to the non-eligible stock, which offers bet-

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<sup>9</sup>These households "sell their location" when local prices increase (e.g., [Bilal & Rossi-Hansberg \(2021\)](#)).

ter income. The resulting impact on leverage in the non-eligible housing stock differs between Black and white buyers: it increases for Black buyers but decreases for white buyers. The net effect is that a doubling of prices in the eligible stock, where Black households disproportionately live, benefits average wealth for white households but hurts it for Black households, and therefore significantly worsens the racial wealth gap.

**House price trap** Finally, the quantitative predictions of our model imply that Black households are in a *house price trap*. As our comparative statics shows, house price deviations from the baseline in both the FHA-eligible and non-eligible housing stocks, lead to a decrease in wealth for the average Black household. In contrast, they both lead to an increase for the average white household. This implies that shocks and policies which only lead to a change in house prices (or house prices and rents at the same rate), for instance in areas with a strongly inelastic housing supply, will only worsen the racial housing gap. Interestingly, it is not only true for house price increases, but also for decreases, such that improvements in housing affordability may paradoxically be detrimental to Black wealth accumulation.

## 6 Policy Implications

We use the model as a laboratory to study policies for which there is no counterfactual in the data. We classify policy experiments into three types of interventions: reparation-style, mortgage market, and housing market policies. We contrast them with a classical tax-based policy conducted at the aggregate level.

### 6.1 Reparation Policies

The reparation-style policies that we analyze specifically target Black households and seek to equate their initial conditions for asset purchases with white households. Figure 14 describes the results.

**Initial wealth** This policy gives Black households the same initial wealth as white households, which corresponds to a twenty-fold increase. The policy does not significantly improve Black home ownership, but it improves their leverage distribution in both housing stocks. Therefore, despite small changes in home ownership, Black wealth increases on average, which reduces the racial wealth gap. It highlights the importance of *both* home ownership and leverage for wealth accumulation patterns between investor groups.

The policy has strongly heterogeneous impacts on wealth accumulation across the distribution of Black households. As shown below, this feature is common to several reparation policies. The policy mostly

benefits the upper part of the wealth distribution of Black buyers, and fails to improve wealth accumulation for the median Black household. This suggests that such policies, even though they improve wealth accumulation at the top, are not the most effective way to help the majority of disadvantaged investors.

**Labor market** This policy gives Black households the same income shifter as white households, which corresponds to a large 207% increase in average income. It corresponds to, for instance, targeted human capital development policies coupled with a reduction in labor market discrimination. The policy significantly improves Black wealth and reduces the racial housing gap, through a combination of lower Black leverage in the cheaper FHA-eligible housing stock and higher homeownership in the more expensive non-eligible stock. Its effects are heterogeneous since it benefits Black buyers at the top of the wealth and income distribution even more than the wealth-based reparation policy.

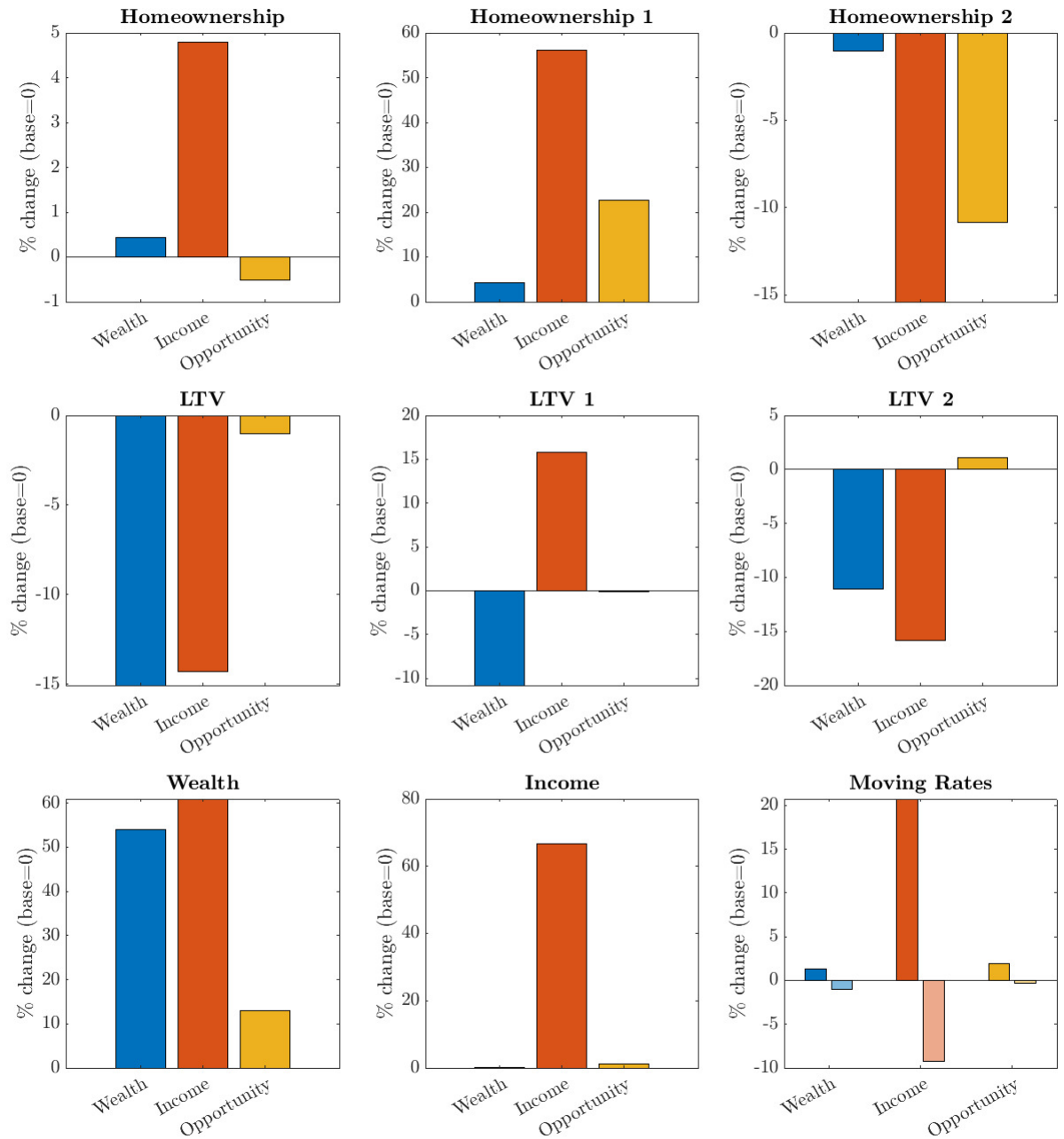
**Moving to housing opportunity** This policy mandates Black households moving at no cost to the non-FHA-eligible housing stock before they first enter the housing market, such that they enter this housing stock, which brings better income, in the same proportion as white households. In other words, it induces Black households to “move to opportunity”. It corresponds to a 35% increase in the share of Black households who first enter the housing market in the non-eligible stock. The policy significantly improves Black wealth, helping closing the racial gap, again through wealth accumulation in the upper part of the distribution of Black buyers. Black home ownership improves in the better, non-eligible housing stock because Black buyers benefit from the higher local income and avoid the moving cost from the eligible stock. This improvement happens at the expense of the leverage distribution, which deteriorates because more Black buyers face higher prices. In this policy, home ownership drives Black buyers’ wealth accumulation more than leverage, illustrating their disconnect.

## 6.2 Mortgage Market Policies

The following two sets of experiments are targeted housing policies. Such policies have been at the center of lively public discussions and are increasingly studied (e.g., [Kopczuk & Munroe \(2015\)](#), [Han \*et al.\* \(2021\)](#)). The first set of policies, mortgage market policies, modifies features of mortgages in the two dimensions of our  $2 \times 2$  model: first, between housing stocks; then, between investor groups. Figure 15 describes the results.

**Phasing out FHA mortgages** This policy phases out FHA mortgages by reducing the maximum LTV ratio in the FHA-eligible housing stock from 95% to the same 80% level as in the non-eligible stock. The policy

**FIGURE 14: EFFECT OF REPARATION POLICIES ON BLACK HOUSEHOLDS' BALANCE SHEETS**



Notes: variables are conditional averages in percentage deviation from the steady state of the baseline model without policy. Each bar describes a household balance sheet variable in the steady state of an alternative model with the policy. "Wealth": Black households have the same initial wealth as white households. "Income": Black households have the same income shifter as white households. "Opportunity": Black households have the same probability as white households to first enter the housing in the high-opportunity, non-FHA-eligible housing. For moving rates, dark color shows moving from FHA-eligible to non-eligible housing stock, light color from non-eligible to eligible.

leads to a slight decrease in home ownership, especially for Black households, who rely heavily on FHA mortgages. However, it also acts like forced savings for these buyers and therefore improves their leverage distribution, such that its net impact on wealth accumulation is positive for Black buyers. Interestingly, a symmetric policy which raises the maximum LTV ratio from 80% in the non-eligible stock to 95% as in the eligible stock has little effect on Black households.

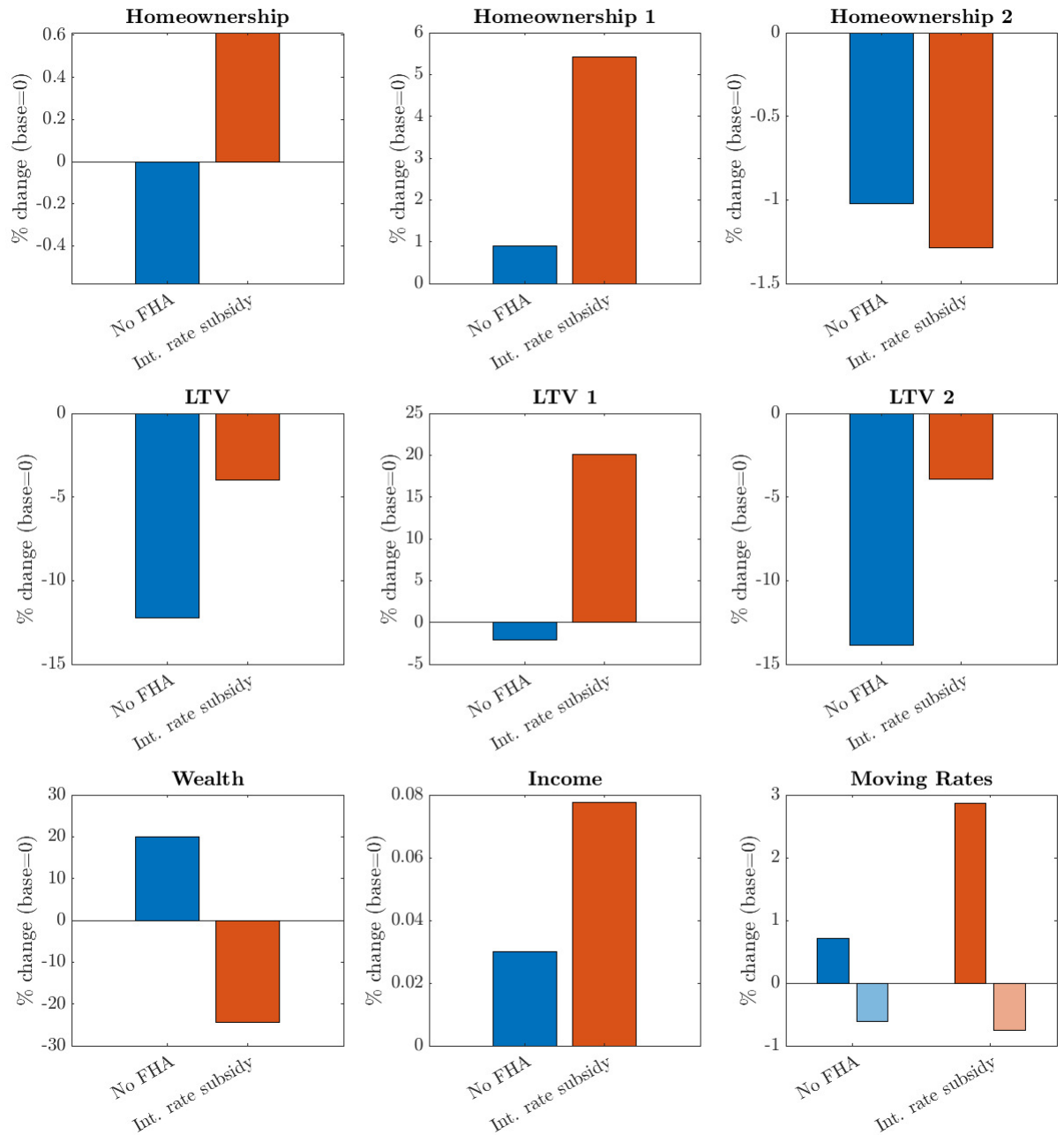
**Mortgage rate subsidy** This policy decreases the mortgage rate faced by Black borrowers from the same 6% as white households to a lower 5%. It is akin to a targeted version of first-time buyers programs which allow borrowers to benefit from lower rates. Black homeownership increases in the non-FHA-eligible housing stock but slightly decreases in the eligible one. This is because the policy induces more moving to the former, as a lower rate allows buyers to buy in the non-eligible stock, which has better income prospects. However, these moves result in a higher leverage distribution in the non-eligible housing stock, such that the policy eventually fails to improve Black wealth accumulation. Importantly, it happens despite Black homeownership improving in the better, non-eligible housing stock. Like the “moving to opportunity” experiment, but in the opposite direction, this policy highlights the disconnect between home ownership and leverage in driving wealth accumulation. Here, Black home ownership improves in the non-eligible stock and falls in the eligible one, while leverage deteriorates. It shows that both home ownership and home equity are crucial for wealth accumulation. Policies which promote home ownership at all cost can hamper wealth accumulation for disadvantaged buyers. These findings formalize the intuition shared by many economists that even though they are widely adopted, home ownership policies may not be an optimal way to improve wealth accumulation for most households (e.g., [Glaeser \(2011\)](#), [Jeske et al. \(2013\)](#)).

### 6.3 Housing Market Policies

This second set of targeted policies modifies features of the housing stocks underlying the FHA and non-FHA segments of the mortgage market. Figure 16 describes the results.

**Local labor market** This policy equalizes the spatial income shifter in the FHA-eligible housing stock to the non-eligible stock. It corresponds to a 20% increase in average local income in the FHA-eligible stock, and can be interpreted as an improvement in local labor market conditions due, e.g., to place-based policies. Because relatively more Black households first enter the housing market in the FHA-eligible stock, the policy has a qualitatively similar impact to the reparation policy and increases Black households’ average income. Quantitatively, its impact on wealth accumulation is lower, because it only indirectly benefits Black households. Because it also improves income prospects for white households in the eligible stock, it is less

**FIGURE 15: EFFECT OF MORTGAGE MARKET POLICIES ON BLACK HOUSEHOLDS' BALANCE SHEETS**



Notes: variables are conditional averages in percentage deviation from the steady state of the baseline model without policy. Each bar describes a household balance sheet variable in the steady state of an alternative model with the policy. "No FHA": the maximum LTV ratio is the same in the FHA-eligible stock as in the non-eligible stock. "Interest rate subsidy": Black households can borrow at a 1 percentage point lower mortgage rate than white households. For moving rates, dark color shows moving from FHA-eligible to non-eligible housing stock, light color from non-eligible to eligible.

effective at closing the racial wealth gap.

**Easing moving** This policy lowers the costs of “moving to opportunity,” by halving moving costs from the FHA-eligible housing stock to the non-eligible stock. It succeeds in inducing more moving to the housing stock with better income prospects, and higher home ownership in that more valuable stock. By lowering frictions to moving, the policy reduces spatial misallocation, and allows to significantly increase the average wealth of Black households. It also increases the average wealth of white households, through an increase in income and home ownership. Even though its net effect on the racial wealth gap is close to zero, the policy helps lift many households out of poverty.

## 6.4 Progressive Taxes and Transfers as a Benchmark

We conclude by comparing the impacts of these three sets of policies to a classical progressive tax and transfer policy conducted at the aggregate level, across investor groups and housing stocks in our  $2 \times 2$  model. Since it is often advocated as an optimal policy in heterogeneous household models, such a policy is a useful benchmark. As in [Heathcote et al. \(2017\)](#), we assume that income is subject to a progressive tax and transfer schedule,

$$T(Y) = Y - \varphi Y^{1-\tau}, \quad (23)$$

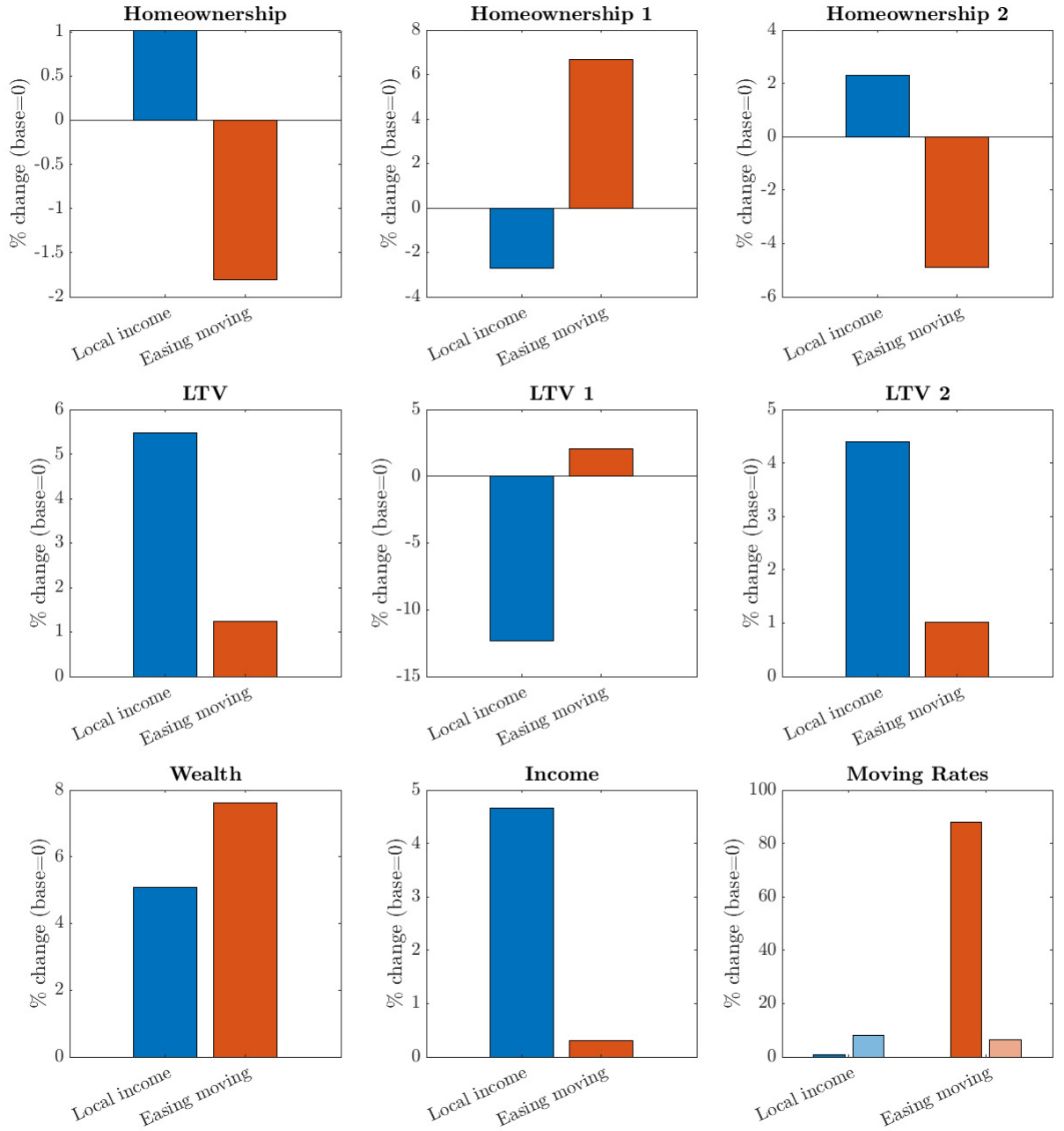
where  $\tau$  and  $\varphi$  respectively control the progressivity and level of taxes.

We find that introducing small progressive income taxes and transfers (increasing  $\tau$  and lowering  $\varphi$  from 0 and 1), which are identical across investor groups, reduces the racial wealth gap by lowering average wealth for white households and increasing it for Black households. This effect is due to a small increase in Black home ownership in the more expensive, non-eligible housing stock, which happens again mostly at the top of the distribution of Black buyers. However, the impact of progressive taxes and transfers on Black wealth accumulation is *non-monotonic*. A larger increase in taxes and transfers has a negative impact on Black wealth accumulation. This is because the resulting transfers fail to increase home ownership in the bottom part of the distribution of Black buyers, but the resulting taxes are strongly detrimental to Black buyers at the top.

## 7 Conclusions

Our paper highlights the role of financial constraints, and housing leverage specifically, in helping to explain important differences in wealth accumulation across racial groups. Our work exists in the context of a

**FIGURE 16: EFFECT OF HOUSING MARKET POLICIES ON BLACK HOUSEHOLDS' BALANCE SHEETS**



Notes: variables are conditional averages in percentage deviation from the steady state of the baseline model without policy. Each bar describes a household balance sheet variable in the steady state of an alternative model with the policy. "Local income": the income shifter in the FHA-eligible stock is the same as in the non-eligible stock. "Easing moving": the utility cost of moving is 50% lower for all households. For moving rates, dark color shows moving from FHA-eligible to non-eligible housing stock, light color from non-eligible to eligible.



large literature which has emphasized the importance of racial housing gaps as a part of racial wealth gaps broadly. We contribute to this literature through a structural modeling approach which accounts for the fact that access to housing is a necessary condition to access high-quality job opportunities. Leverage differences result in minority borrowers disproportionately picking FHA mortgages, which restrict them to smaller and less valuable homes and areas with less opportunity.

Our structural model fits these underlying stylized facts, and we use it to study the implications of leverage gaps on the persistence of wealth accumulation. We find that the housing market works to amplify initial differences in wealth, suggesting that the so-called “housing ladder” has been an important route for wealth accumulation and upward mobility with unequal access across racial groups. We also find that house price shocks, which have been an important feature of housing markets in recent decades, have important distributional consequences across racial groups. House price shocks are generally positive for white borrowers, but lead to inequality among Black households, with the less wealthy finding homeownership and access to high income areas more challenging after home price appreciation amplifies pre-existing financial constraints.

A central insight from our findings lies in the joint consideration of housing and leverage gaps. While many traditional housing policies are intended to address gaps in Black homeownership; we show that such policies often have adverse consequences when failing to consider racial differences in leverage. In particular, policies which promote homeownership can amplify leverage, leaving Black borrowers more overextended in their overall financial position. These results point to an important tension in considering the role of home ownership: while our results confirm that access to housing is indeed crucial for wealth accumulation, we find that incremental home ownership policies do not have unambiguously positive consequences for minority borrowers, and typically fail to address problems faced by poorer borrowers in particular.

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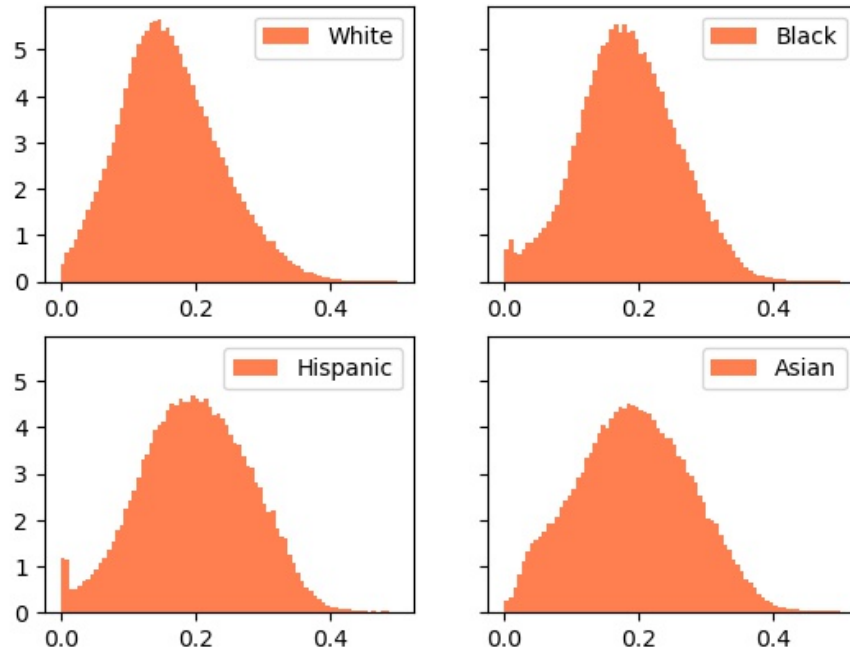
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## Appendix

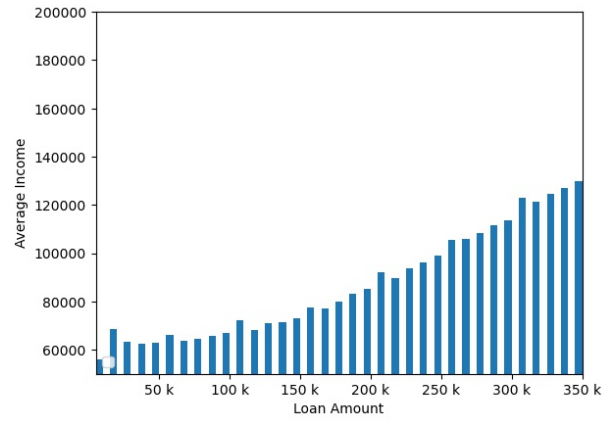
PTI Histogram by Race - PDF



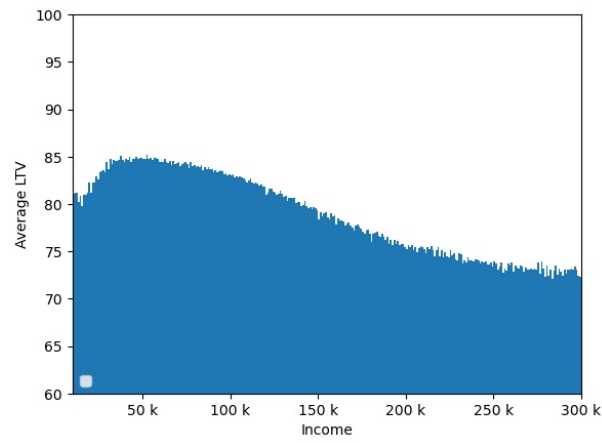
**FIGURE A.I: PAYMENT-TO-INCOME BY RACE**

This graph shows the Payment-to-Income ratio (PTI) across racial groups in the HMDA data. We focus on purchase-only loans in 2018, and measure the front-end payment based on a fully-amortizing mortgage payment. We measure total payments relative to borrower income reported in HMDA.

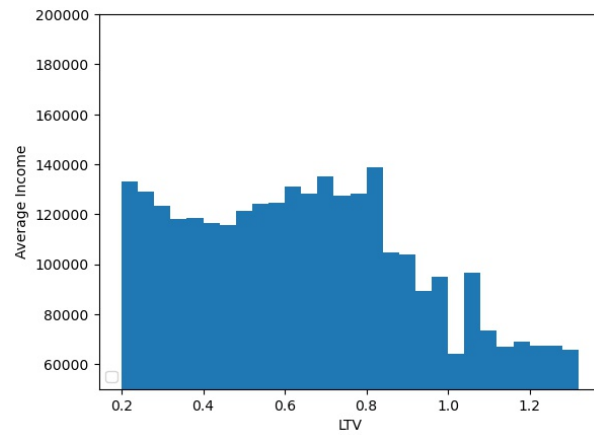
*Panel A: Personal Income Against Loan Amount*



*Panel B: Loan Amount Against Personal Income*

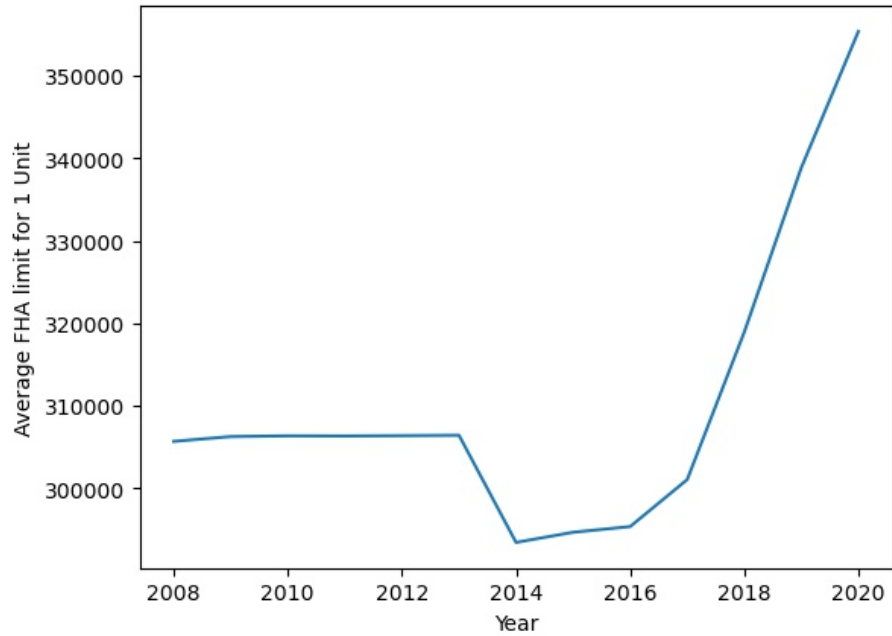


*Panel C: LTV Against Personal Income*



**FIGURE A.II: LEVERAGE AND INCOME**

This Figure shows the relationship between individual income, as reported in the HMDA mortgage application against loan size (Panel A), and LTV (Panel C). Panel B shows the average income across different levels of the loan size distribution. We measure all variables using purchase-only loans from the 2018 HMDA dataset.

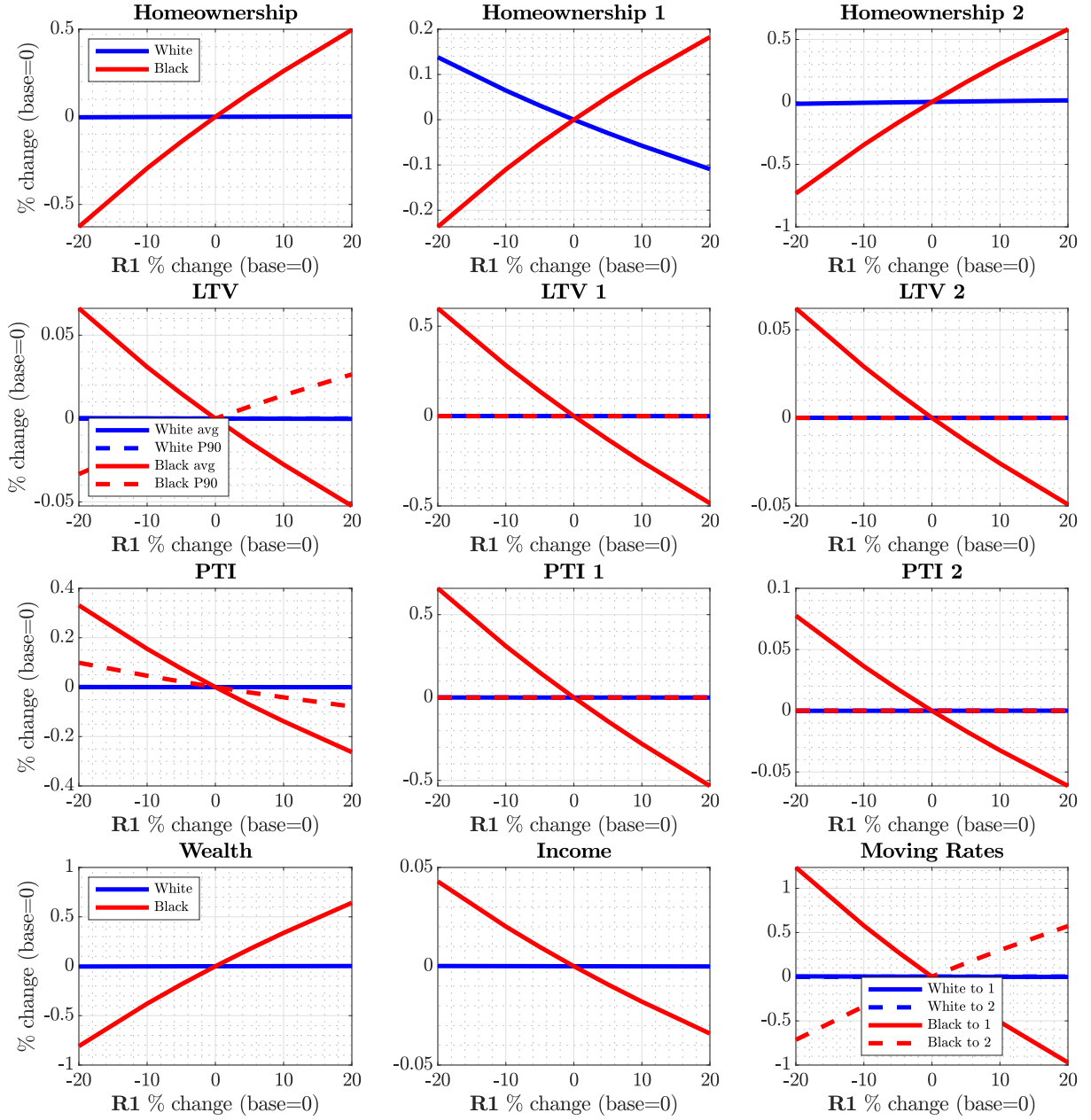


**FIGURE A.III: FHA LOAN CUTOFF OVER TIME**

This graph shows the change in the nationwide FHA loan cutoff over time. This cutoff determines the maximum size of FHA loans. The nationwide limit determines the national base for the FHA cutoff; high-housing cost counties have location-specific FHA cutoffs that apply to specific areas.

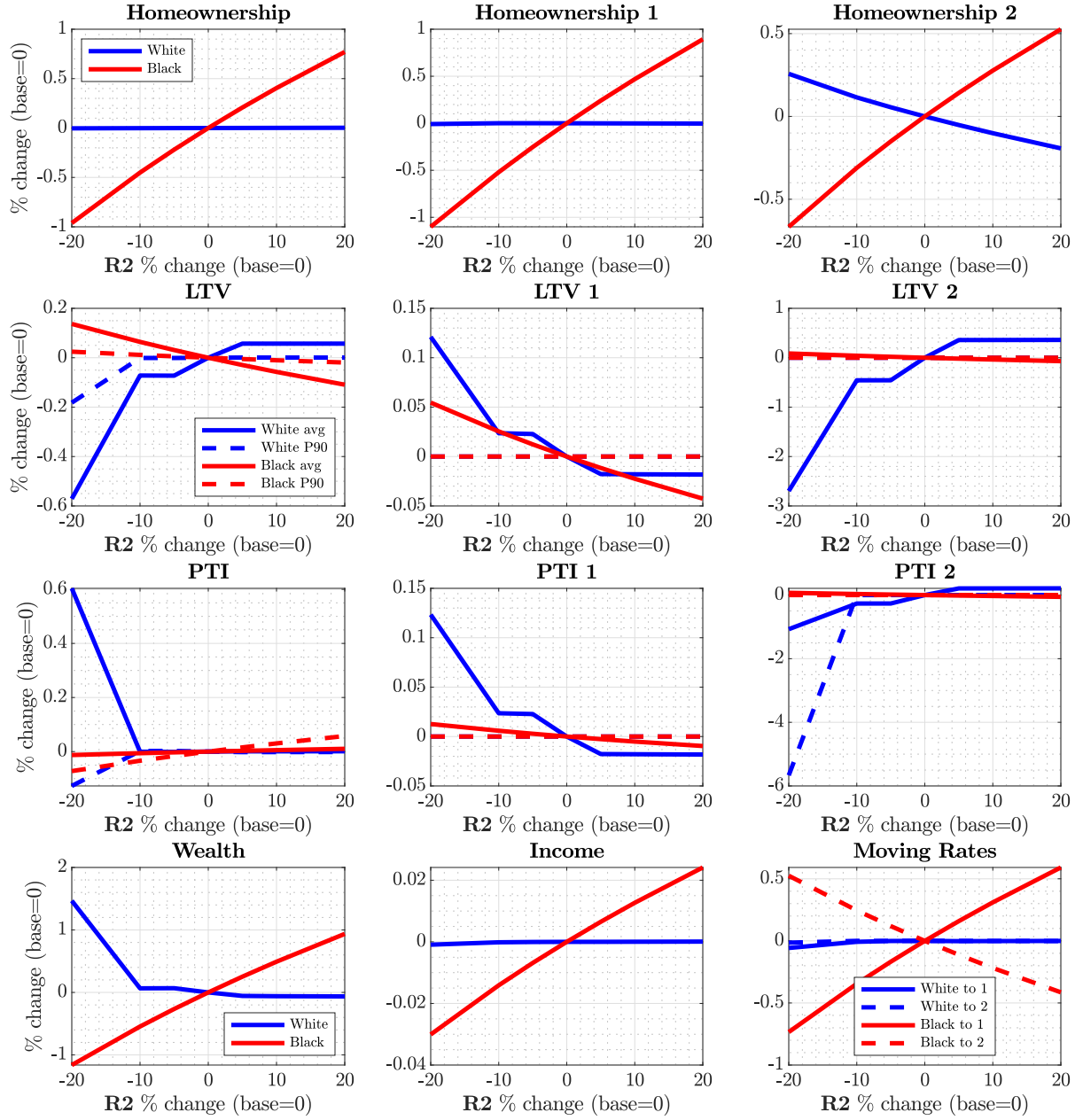


FIGURE A.IV: EFFECT OF RENT CHANGE IN NON-FHA-ELIGIBLE HOUSING STOCK



Notes: variables are conditional averages ("P90" indicates 90<sup>th</sup> percentile) in percentage deviation from the steady state of the baseline model. Each line describes a household balance sheet variable in the steady state of an alternative model where rents differ from the baseline.

FIGURE A.V: EFFECT OF RENT CHANGE IN FHA-ELIGIBLE HOUSING STOCK



Notes: variables are conditional averages ("P90" indicates 90<sup>th</sup> percentile) in percentage deviation from the steady state of the baseline model. Each line describes a household balance sheet variable in the steady state of an alternative model where rents differ from the baseline.