The Credit Supply Channel of Monetary Policy Tightening and its Distributional Impacts*

Joshua Bosshardt
FHFA

Marco Di Maggio
Imperial College Business School
& *NBER*

Ali Kakhbod
UC Berkeley

Amir Kermani
UC Berkeley
& *NBER*

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Abstract

This paper studies how tightening monetary policy transmits to the economy through the mortgage market and sheds new light on the distributional consequences at both individual and regional levels. We specifically examine the sharp increase in mortgage interest rates during 2022 and 2023. We find that almost all of the decline in mortgages compared to prior years was concentrated in loans that would have had a debt-to-income (DTI) ratio above underwriting thresholds. These effects are even more pronounced for minority and middle-income borrowers. Additionally, regions more affected by the thresholds exhibited greater reductions in mortgage originations, house prices, and consumption.

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1 Introduction

The surge in inflation starting in mid-2021, which reached as much as 8% in the United States (U.S.), and the ensuing interest rate hike have reignited interest in understanding the transmission channels of monetary policy tightening to the aggregate economy. As the Federal Reserve increased short-term interest rates and contracted its balance sheet starting near the beginning of 2022, mortgage interest rates climbed from around 3% to a peak within the year of about 7% and remained elevated throughout 2023. During the same time, purchase mortgage originations contracted by 13% from 2021 to 2022, which raises the question of whether this response was primarily driven by either demand or supply channels. In conventional macroeconomic frameworks, a rise in interest rates curtails aggregate demand by discouraging credit and consumption, as illustrated by Smets and Wouters (2007). The potency of this effect hinges on households' elasticity of intertemporal substitution. Conversely, raising interest rates can also influence credit supply, particularly when borrowing constraints cap a household's debt-to-income (DTI) ratio — the proportion of monthly debt payments to income, as highlighted by Greenwald (2018). In this case, the effectiveness is gauged by the extent to which these constraints bind. Identifying the dominant channel of monetary policy tightening is also important to understand its distributional implications, including the extent to which it may disproportionately impact borrowers with historically low homeownership rates.

This paper finds that mortgage supply factors accounted for most of the decline in mortgages during 2022 and 2023. Specifically, we show that almost all the reduction compared to prior years occurred within the set of loans that, due to the increasing interest rates, would have had a DTI ratio above underwriting thresholds. These thresholds are associated with various major market segments, such as loans securitized by the government-sponsored enterprises (GSEs) Fannie Mae and Freddie Mac and loans insured by the Federal Housing Administration (FHA). Furthermore, borrower groups and regions with high exposure to these thresholds experienced the greatest reductions

in originations. Regions with high exposure also experienced relative reductions in house prices and spending, suggesting the transmission of monetary policy to other economic outcomes. We observe these results using a representative sample of all mortgages originated in 2019 through 2023, focusing on purchase loans for single-family, owner-occupied properties.

To uncover the different mechanisms at play, we start by considering a hypothetical scenario in which 2021 borrowers are subjected to 2022 interest rates while maintaining the same loan, allowing us to compare the resulting distribution of counterfactual DTI ratios for loans originated in 2021 with the distribution of observed (i.e., actual) DTI ratios for loans originated in 2022. This initial counterfactual DTI assumes no adjustment for demand on either the intensive margin (i.e., changing the loan size) or extensive margin (i.e., changing the decision about purchasing a home). We find that the 13% decline in the total number of loans from 2021 to 2022 is almost entirely explained by loans with a counterfactual DTI above a key underwriting limit of 50%. By contrast, we observe that the counterfactual and observed distributions are much more similar for DTI ratios below the minimum DTI threshold of 45%. The missing mass of the observed distribution relative to the counterfactual distribution above the DTI thresholds together with a lack of bunching beneath them suggest that the response to the supply constraints was primarily on the extensive margin (i.e., supply-constrained borrowers choosing not to purchase a home) rather than the intensive margin response (i.e., borrowers changing the loan size to maintain eligibility). If we instead compare 2021 to 2023, we find a similar distributional pattern and a larger overall decline.

We then augment this analysis by taking into account the impact of the interest rate spike as well as concurrent changes in income and house prices on the demand for loans. We adjust for these factors by employing the demand elasticity to interest rates in the literature (DeFusco and Paciorek (2017)) and by estimating the predicted changes in loan amounts associated with changes in income and house prices. We also adjust

for factors that affect the extensive margin of demand for housing by assuming that the supply constraints have no effect for DTI ratios sufficiently below the DTI thresholds. Specifically, we scale the counterfactual distribution so that the number of loans with a DTI ratio of 40% or below matches the actual distribution. We find similar magnitudes after including these adjustments, observing a decline in the total number of loans from the counterfactual to the observed distribution in 2022 of about 15% to 18%, largely due to loans with a counterfactual DTI ratio above 50%. By contrast, we find a much smaller reduction in a placebo analysis comparing prior years with less variation in interest rates.

The above analysis assumes the extensive and intensive margins of adjustment for demand are similar across the DTI distribution. To address this concern, we use a methodology similar to the one used by DeFusco, Johnson, and Mondragon (2020) to estimate the effects of DTI constraints on loan quantities.[1] We control for changes in demand for each DTI percentage point near the thresholds based on the growth of loans insured by the Department of Veterans Affairs (VA), which have looser DTI constraints compared to most of the sample. Similar to the previous approach, we find that the decline in the total number of loans from the counterfactual distribution to the observed distribution in 2022 across all DTI ratios was 16% to 19%, most of which is explained by the gap between the observed and counterfactual distributions for DTI ratios above 50%. Overall, consistently across all three approaches for computing the counterfactual DTI distribution, we find that the reduction in lending is primarily driven by supply constraints rather than demand. The relatively weak demand response is consistent with existing estimates of a small elasticity of intertemporal substitution (Best et al. (2020)).

Further, the sudden monetary tightening observed in 2021-2023 also raised the question of whether it disproportionately impacted the most financially constrained households. We are able to investigate the distributional repercussions of the monetary policy tightening and find especially pronounced declines in mortgages for minority and middle-

[1]Note that DeFusco, Johnson, and Mondragon (2020) focus on the introduction of a new DTI threshold, whereas we examine how fixed DTI thresholds interact with increases in interest rates.

income borrowers, groups with a relatively high propensity to experience binding DTI constraints. Black and Hispanic households were 62% and 68%, respectively, more likely to have a counterfactual DTI ratio above 50% compared to white households, which explains most of their 59% and 86% greater percent reductions in the number of loans from 2021 to 2022. Households with annual income below $100,000 were more than twice as likely to have a counterfactual DTI ratio above 50% compared to those with income above $100,000 and accounted for virtually all of the decline in loans from 2021 to 2022. While borrowers could in principle navigate an interest rate hike by pivoting towards lower-priced home to secure a mortgage, our findings indicate that many of such borrowers for whom DTI constraints became binding decided to opt out of the housing market.

Finally, we examine the general equilibrium implications of the credit supply channel of monetary policy tightening for local economies and outcomes beyond just mortgage lending, focusing on the longer-run change from 2021 to 2023. We pool data from 2019 to 2021 and compute the fraction of the population with an observed DTI ratio below the 45% threshold but a counterfactual DTI ratio above it, which corresponds to the borrowers that would have switched to facing the constraint. We find that a 1 standard deviation increase in the share of such borrowers is associated with a .17 to .30 standard deviation lower rate of house price growth from 2021Q4 to 2023Q4, including when controlling for local economic conditions such as employment, income per capita, and the housing supply elasticity. Consistent with their lower house price growth and higher incidence of binding underwriting constraints, regions with higher DTI ratios were further associated with relative reductions in indicators of consumption out of housing wealth, such cash-out refinances and spending. In particular, the growth in credit and debit card spending from 2021 to 2023 decreased by .20 to .26 of a standard deviation for a 1 standard deviation increase in the fraction of switching borrowers. These results confirm the prediction of Greenwald (2018) that the pass-through of monetary policy is a function of the distribution of DTI ratios.

This paper contributes to three major themes in the literature. First, it relates to the body of research that examines the transmission channel of monetary policy through credit supply more generally (Drechsler, Savov, and Schnabl (2017), Drechsler, Savov, and Schnabl (2023)) and mortgage markets more specifically (e.g., Greenwald (2018), Beraja et al. (2018), Di Maggio, Kermani, and Palmer (2020), Berger et al. (2021)), as well as the implications for house prices (e.g., Larson (2022), Greenwald and Guren (2021)) and consumption (e.g., Di Maggio et al. (2017)).

Second, this paper adds to the body of research on credit accessibility in the U.S. mortgage market. This literature covers various aspects, such as interest rates (e.g., Ringo (2023)), race (e.g., Bhutta, Hizmo, and Ringo (2021), Bartlett et al. (2022), and Giacoletti, Heimer, and Yu (2022)), regulations (e.g., Fuster, Plosser, and Vickery (2021), DeFusco, Johnson, and Mondragon (2020), Gete and Reher (2020), Favara and Imbs (2015), Di Maggio and Kermani (2017)), subsidies (e.g., Loutskina and Strahan (2015), Berger, Turner, and Zwick (2020)), lender types (e.g., Mian and Sufi (2021)) repurchases and servicing costs (e.g., Goodman (2017)), fair pricing and credit allocation by region (e.g., Hurst et al. (2016) and Kulkarni (2016)), capacity constraints (e.g., Fuster, Lo, and Willen (2017)), and discretionary screening by lenders for GSE loans (e.g., Bosshardt, Kakhbod, and Kermani (2023)). Bhutta and Ringo (2021) examine interest rate reductions in the context of loans insured by the Federal Housing Administration and also find large extensive margin responses associated with DTI constraints.

Third, this paper also relates to research that uses bunching and missing mass at discrete policy rules to infer responses of borrowers and lenders in mortgage markets, including the mortgage interest rate elasticity (DeFusco and Paciorek (2017)), the intertemporal elasticity of substitution (Best et al. (2020)), credit supply responses to a regulation on DTI ratios (DeFusco, Johnson, and Mondragon (2020)), and responses to taxes (Kleven and Best (2017), Anagol et al. (2023)).

2 What drove the reduction in mortgage lending?

This section infers supply and demand responses to the mortgage interest rate spike by comparing the frequencies of observed debt-to-income (DTI) ratios for mortgages originated in 2022 with the frequencies of counterfactual DTI ratios for mortgages originated in 2021 but hypothetically facing the prevailing interest rates in 2022. We find that the reduction in mortgage volume was almost entirely incident on loans with a counterfactual DTI ratio above underwriting thresholds specific to credit supply.

2.1 Setting

We focus on the monetary policy tightening that started in 2022 in response to the burgeoning inflation. From the beginning to the end of the year, the U.S. Federal Reserve increased the short-term (overnight) interest rates from approximately 0 to 4 percent, while concurrently contracting its balance sheet size by about $214 billion. This maneuver precipitated a spike in mortgage rates from around 3% to as high as 7% in 2022 (Figure A.1a in Appendix A). The number of mortgages decreased by 13% from 2021 to 2022, with the year-on-year decline for quarters in latter half of the year growing to 20%. At the same time, house price growth sharply decelerated (Figure A.1b).

2.2 Data and hypothesis

Our primary dataset is the National Mortgage Database (NMDB), which is a proprietary 5% sample of closed-end first-lien mortgages in the U.S., maintained by the Federal Housing Finance Agency and the Consumer Financial Protection Bureau. For our purposes, some advantages of the NMDB relative to the Home Mortgage Disclosure Act (HMDA) data include precise origination dates, some characteristics that are lacking in HMDA (such as non-mortgage debts and credit score), finer data on characteristics that are sometimes reported as ranges in HMDA (such as the DTI ratio), and precise information on

whether a loan was eventually purchased by Fannie Mae or Freddie Mac. We focus on purchase loans for single-family (specifically one-unit), owner-occupied, site-built properties. We also restrict to loans originated in metropolitan statistical areas (MSAs) since much of our analysis uses MSA-level characteristics, aggregation, or clustering. Table A.1 in Appendix A presents summary statistics for 2021 and 2022. Note that, due to lags in data availability, our 2023 data from the NMDB only extends to September. For comparability, we also restrict to loans originated in January to September in 2021 when comparing loan counts or total loan volume to 2023.

To explain the reduction in mortgages during the monetary policy tightening, we consider the effect of the mortgage interest rate hike on DTI ratios. Higher mortgage rates directly increase interest rate payments, elevating DTI ratios towards underwriting limits. In particular, Figure 1a shows that from 2021 to 2022, there was a shift of DTI ratios towards thresholds at 45%, 50%, and 57% where the mass of originations exhibits discrete declines. These thresholds correspond to credit supply limits for various loan programs. Specifically, the 45% threshold appears to be a soft limit for loans acquired by the government-sponsored enterprises (GSEs) Fannie Mae and Freddie Mac, the 50% threshold is an explicit strict limit for GSE loans (Fannie Mae (2022)), and the 57% threshold appears to be a limit associated with loans insured by the Federal Housing Administration (see Figure A.2 in Appendix A, which shows the DTI distribution for each market segment).[2]

Motivated by this observation, we hypothesize that the interest rate hike led the DTI thresholds to become binding for more borrowers. To test the hypothesis, we develop a counterfactual DTI ratio methodology to control for the direct effect of the mortgage

[2]Note that the higher DTI threshold for FHA loans is largely offset by having to pay a mortgage insurance premium, which undermines incentives for borrowers to substitute. Specifically, FHA loans are required to pay an upfront mortgage insurance premium of 1.75% of the loan balance as well as an ongoing component with an annualized rate of at least 50 basis points for 30-year mortgages, which comprise about 90% of the sample. Given that the average interest rate in our sample in 2022 is 5.08% and assuming a 30-year term, a 50 basis point effective increase in the interest rate leads to about a 5.74% increase in the monthly payment. Hence, the upfront and ongoing components together result in a 7.49% increase in the monthly payment. If a loan initially has a DTI ratio of 50%, then adding the mortgage insurance premium would therefore increase the DTI ratio to 53.75%, eroding much of the difference in DTI limits.

interest rate spike on DTI ratios, thereby isolating the effect of the thresholds as well as adaptations by borrowers and lenders.

2.3 Counterfactual DTI

To analyze the effect of the interest rate spike on mortgage originations, we start with a simple approach of comparing the distribution of observed DTI ratios for loans originated in 2022 to the distribution of counterfactual DTI ratios for loans originated in 2021 but hypothetically simulating the interest rate as if they were originated in 2022, and similarly for 2023. We can then test the hypothesis that the reduction in lending was driven by binding DTI constraints by observing how much of the reduction occurs for counterfactual DTI ratios above the underwriting thresholds. This baseline counterfactual DTI ratio ignores many factors that could have affected loan demand, such as the interest rate spike itself as well as concurrent changes in household income and house prices. Section 2.4 and Section 2.5 show that the main findings are robust to various methods of controlling for such factors.

2.3.1 Counterfactual DTI: methodology

We construct a counterfactual DTI for loans originated in 2021 as if they faced the prevailing interest rates in 2022 as follows.

We first compute the counterfactual interest rate as the observed interest rate plus the percentage point increase in the Freddie Mac Primary Mortgage Market Survey rate from the origination month to the same month in 2022, resulting in an average increase of 2.4 percentage points. This construction is based on the assumption that the interest rate spike similarly affected borrowers with different levels of risk. In support of this assumption, Figure A.3 in Appendix A shows that the interest rate increased by a similar amount across credit scores.

We then compute the counterfactual monthly principal and interest payment using

the amortization formula as a function of the loan amount, number of payments, and counterfactual interest rate, which results in an average increase of $487.[3]

We finally compute the counterfactual DTI as the observed DTI plus the increase in the principal and interest payment divided by monthly income, which results in an average increase of 5.8 percentage points. We round the counterfactual DTI to the nearest percentage point since the recorded DTI in the NMDB is also rounded.

We also compute the counterfactual DTI relative to interest rates in 2023 using an analogous sequence of steps.

2.3.2 Counterfactual DTI: results

Figure 1b shows the frequencies of the counterfactual DTI ratio in 2021 and the observed DTI ratio in 2022, while column (1) of Table 1 summarizes the differences for subsets of the DTI ratio.[4]

For DTI ratios less than or equal to 40%, the number of loans in the observed distribution increased by 3.6% of the total number of 2021 originations. This small increase is unlikely to be directly affected by the DTI thresholds, as intensive margin adjustments to avoid the thresholds, such as borrowers purchasing smaller houses or putting down larger down payments, are unlikely to reduce the DTI ratio by as much as 5% less than the lowest threshold at 45%. The increase could, instead, reflect demand-driven adjustments on either the intensive margin or extensive margin. For example, on the intensive margin, some borrowers might have shifted to smaller loans to offset the higher interest payments. On the extensive margin, concurrent trends in family formation could have generally increased the demand for homeownership and mortgages.

For DTI ratios between 41% and 45%, the number of loans in the observed distribution increased by 2.5% of the total number of 2021 originations. Considering that the

[3]The amortization formula is given by: $P = A\frac{(R/12)}{1-(1+R/12)^{-n}}$, where P is the principal and interest payment, A is the amount of the loan, R is the annualized net interest rate, and n is the contracted number of monthly payments. Note that about 90% of loans in the sample have a 30-year term.

[4]Figure A.4 in Appendix A shows the observed and counterfactual DTI frequencies by market segment.

lowest DTI threshold is at 45%, this modest bunching could indicate supply-driven intensive margin adjustments to avoid the thresholds, although we do not find that this bunching is robust to alternative constructions of the counterfactual DTI distribution in Section 2.4 and Section 2.5 that control for demand.

For DTI ratios from between the two major thresholds at 45% and 50%, the number of loans in the observed distribution decreased by only 0.06% of the total number of 2021 originations. One potential explanation is that some loans may have shifted below 45% due to the previously mentioned intensive margin adjustment while another set of loans may have similarly shifted into this range due to the stricter 50% threshold.

For DTI ratios greater than 50%, the number of loans declined by a substantial 18.7% of all 2021 originations. Some of these borrowers may have adjusted on the intensive margin, in which case they would be counted in the increased mass observed at lower DTI levels. The remaining missing mass would then correspond to the extensive margin effect. Overall, for DTI ratios of 41% and above, which corresponds to the set that is most likely to be affected by the DTI thresholds, the number of loans decreased by 16.2% of the total number of 2021 originations.

Note that the total number of loans decreased by 12.6%, which is slightly smaller in magnitude due to the increase for DTI ratios of 40% and below. By construction, this 12.6% reduction is equal to the growth in the total number of loans from 2021 to 2022 since the baseline counterfactual DTI methodology does not affect the total number of loans. The counterfactual DTI methodology can therefore be interpreted as a decomposition of the change in the number of loans. The observation that the decline in lending occurred almost entirely above the DTI thresholds suggests that the direct impact of these DTI constraints is responsible for almost all of the 12.6% reduction, as it is unlikely that any

demand shocks would generate the sharp reduction in loans right at the DTI thresholds.[5]

Figure 1d and column (2) of Table 1 show that a similar distributional pattern occurs when comparing 2021 to 2023. Namely, the distributions are fairly similar for DTI ratios up to the thresholds whereas almost all of the reduction occurs for DTI ratios above 50%. We also find that the magnitudes are notably larger, as the number of loans with a counterfactual DTI above 41% decreases by 30% the total number of 2021 originations. This stronger result likely reflects the fact that interest rates were climbing in 2022 and relatively low for the first half of the year, whereas they were at least 6% for all of 2023. Put otherwise, the average increase in the interest rate is 2.4% when computing the counterfactual interest rate for 2021 originations based on the prevailing interest rates in 2022, but it increases to 3.9% when using the prevailing interest rates in 2023.

2.4 Demand-adjusted counterfactual DTI

This section shows that the main finding from Section 2.3 – that almost all the reduction in loans occurs for DTI ratios above the underwriting thresholds – is robust to adjusting the counterfactual DTI ratio to reflect time-varying demand factors. We augment the baseline counterfactual DTI construction by including intensive margin changes in loan amounts, which is based on the estimated response to the interest rate spike as well as simultaneously occurring changes in household income and house prices. We also incorporate extensive margin changes in the quantity of loans, which is based on the growth of loans with low DTI ratios that are unlikely to be affected by the underwriting thresholds.

The main benefit of explicitly incorporating demand factors that affect the aggregate

[5]The DTI constraints could have directly contributed to the decline in mortgages. However, an alternative interpretation is that the overall reduction in lending was driven by other credit supply channels like the deposits channel (Drechsler, Savov, and Schnabl (2017)) and the DTI constraints only determined which loans would be excluded. In Appendix E, we develop a reduced form model of the equilibrium for mortgage-backed securities (MBS) and show that, for reasonable values of the elasticity of supply, the 2022 issuance of MBS would have been at least 52-68% lower and MBS yields would have been 13-17 basis points higher in the absence of the DTI constraints.

level of loans is that it validates the magnitude of the reduction in loans attributable to credit supply constraints, albeit at a cost of introducing additional assumptions to model these factors. One notable assumption in this approach is that the intensive and extensive margin adjustments are similar across the DTI distribution.[6] However, Section 2.5 shows that the results are similar when implementing an alternative methodology that relies on a different set of assumptions to model changes in demand.

2.4.1 Demand-adjusted counterfactual DTI: methodology

This section describes our construction of the "demand-adjusted counterfactual DTI" based on loans from a given comparison year, which could be 2019, 2020, or 2021, relative to a given policy year, which could be 2022 or 2023.

Initially, the counterfactual interest rate is computed by adding the observed interest rate and the percentage point increase in the Freddie Mac Primary Mortgage Market Survey rate from the origination month to the same month in the policy year, aligning with the methodology in Section 2.3.1.

The counterfactual loan amount, aimed at capturing the intensive margin of demand, is computed in a two-step process. The first step applies the interest rate semi-elasticity estimated by DeFusco and Paciorek (2017), reducing the observed loan amount by 2 percent for each percentage point increase in the interest rate.[7] The second step incorporates the predicted change in loan amounts associated with changes in income and house prices by regressing the logarithm of the loan amount on the logarithm of household income and on the logarithm of the Federal Housing Finance Agency annual census tract-level house

[6] Specifically, we model the intensive margin of demand, which corresponds to changes in loan amounts from the time of origination until 2022 or 2023, by applying the demand elasticity to interest rates from DeFusco and Paciorek (2017) and by estimating the predicted changes associated with changes in income and house prices, all of which are constant with respect to DTI. We model the extensive margin of demand by scaling the number of loans in the counterfactual DTI distribution to match the observed number of loans for lower DTI ratios that are unlikely to be affected by the underwriting thresholds, using a scaling multiple that is constant with respect to DTI.

[7] DeFusco and Paciorek (2017) report a semi-elasticity in the range of 2 to 3. For brevity, we focus on a semi-elasticity of 2. The results are similar if we use a semi-elasticity of 3, although the reduction in lending becomes slightly smaller as the elasticity increases (see Table A.2 in Appendix A).

price index (also associated with Bogin, Doerner, and Larson (2019)) during 2019-2021, while also including year and census tract fixed effects and adjusting for inflation using annual means of the consumer price index. We estimate this relationship using a sample of mortgage originations from the Home Mortgage Disclosure Act (HMDA) satisfying a similar set of sample restrictions as the baseline NMDB data. The results of this are reported in column (1) of Table 2.[8] Each coefficient is then multiplied by the difference of the logarithm of the MSA-level median house value or median income, respectively, from the comparison year to the policy year, adjusting again for inflation, to determine the predicted change in the loan amount due to these factors.

Subsequently, the counterfactual monthly principal and interest payment is computed using the amortization formula, considering the counterfactual loan amount, number of payments, and counterfactual interest rate. The counterfactual DTI is then computed as the observed DTI plus the increase in the principal and interest payment, divided by monthly income. Monthly income is multiplied by the inflation-adjusted growth in the median income from the comparison year to the policy year.

Lastly, it is assumed, for simplicity, that the extensive margin of demand can be encapsulated by a uniform percentage change in the number of loans across all DTI ratios within each MSA. This step broadly accounts for factors affecting the overall number of loans in a year, such as changes in population. While the assumption of a uniform effect across DTI ratios is consistent with this motivation, note that we relax the uniformity assumption in Section 2.5 when we show that our results are robust to an alternative construction of the counterfactual DTI ratio that independently adjusts for demand at each DTI ratio near the thresholds. The magnitude of the adjustment for each MSA is determined so that the counterfactual distribution derived from a given comparison year

[8]Note that columns (2) and (3) of Table 2 report the coefficients for alternative specifications using different levels of aggregation or house price measures. The final results of this exercise are qualitatively robust to using the alternative estimates. When selecting 2021 as the comparison year and 2022 as the policy year, we find that the total reduction in loans associated with the estimates in each column is, respectively, -15.34% and -15.1%, which is similar to the -14.69% reduction reported in column (2) of Table 1. Additionally, in each case, almost all of the reduction occurs for loans with counterfactual DTI exceeding 50%.

and the observed distribution in the policy year have the same number of loans with DTI less than or equal to 40%. Note that supply channels related to the DTI cutoffs are unlikely to influence this part of the distribution since the lowest cutoff is at 45%.[9]

2.4.2 Demand-adjusted counterfactual DTI: results

Figure A.6 in Appendix A shows the original counterfactual DTI distribution as well as the intensive and extensive demand adjustments in the baseline case where the comparison year is 2021 and the policy year is 2022 (see Table A.4 in Appendix A for a summary of the average adjustment associated with each step in the construction). The intensive margin adjustment leads borrowers to reduce loan amounts by 4.9% on average in response to higher interest rates, although this is partially offset by increases in loan demand associated with increasing income (0.7%) and house prices (0.6%). The extensive margin adjustment results in a uniform increase of 2.5%, which could reflect factors such as population growth and increasing household formation.[10]

Figure 2 shows that, for each policy year, the demand-adjusted counterfactual DTI distribution is similar across comparison years, which suggests that the adjustments adequately control for factors that affect the overall number of loans in each year. Columns (3) and (4) of Table 1 summarize the differences between the observed distribution in the policy year and the demand-adjusted counterfactual distribution based on 2021. Table A.5 in Appendix A also shows these results for each policy year and comparison year combination.

For DTI ratios less than or equal to 40%, there is no difference between the observed and demand-adjusted counterfactual distributions by construction. For DTI ratios between 41% and 45%, the observed distribution in 2022 is slightly higher by 0.7% to 1.4%

[9] We find the results are similar, albeit slightly smaller, if we choose a threshold of 35% instead of 40% for the extensive margin adjustment (see Figure A.5 and Table A.3.)

[10] For comparison, note that the average annual growth of purchase loans relative to the prior year for 2016 through 2019, which is more likely to reflect factors like population growth and household formation compared to the unusual housing market activity during the COVID-19 pandemic, is 4.3%.

of the total number of loans in the demand-adjusted counterfactual distribution, depending on the comparison year. The degree of bunching is weaker compared to the baseline counterfactual DTI ratio without demand adjustments. For DTI ratios between 46% and 50%, the observed distribution is slightly lower by 0.6% to 1.6% of the total number of loans in the demand-adjusted counterfactual distribution.

For DTI ratios greater than 50%, the number of loans in 2022 declines by 14.1% to 16.9% of the total number of loans in the demand-adjusted counterfactual distribution, which is similar to the baseline counterfactual DTI ratio without demand adjustments. The number of loans plausibly affected by the DTI thresholds, or with a DTI ratio of at least 41%, decreases by 14.7% to 17.6%, which is similar compared to the baseline case.[11] The observation that almost all the reduction in originations during the mortgage interest rate spike occurred sharply above the underwriting thresholds even when controlling for demand affirms the importance of the supply channel. The findings for when the policy year is 2023 are generally similar except that the reduction for loans with DTI greater than 50% is larger.

Altogether, the reduction in the number of loans with a counterfactual DTI above the thresholds without a compensating increase in the number of loans below indicates that borrowers were more likely to respond to the binding constraints on the extensive margin (i.e., by choosing to not buy a home) rather than on the intensive margin (i.e., by choosing a less expensive house in order to still qualify for a loan). These findings suggest that households target a specific house size and would rather to postpone their home purchase until interest rates decrease or they can afford a larger down payment instead of buying a smaller home in the meantime, perhaps due to housing transaction

[11]Note that, for this exercise, the change in the number of loans affected by the DTI thresholds is equal to the change in the total number of loans since the extensive margin adjustment equalizes the number of loans with DTI that is likely too small to be affected by the DTI thresholds,

costs associated with the eventual upgrade.[12] Complementary with the lack of intensive margin adjustments based on loan counts, we also find that, conditional on receiving a loan, borrowers with a given level of income do not appear to downsize to a lower house value or loan amount in 2022, although there is a slight reduction in 2023 (Figure 3).

One potential means for borrowers to avoid the DTI constraints without changing the loan amount is to substitute to adjustable-rate mortgages (ARMs). ARMs typically have a lower initial interest rate compared to fixed rate mortgages, which could help offset the overall increase in mortgage interest rates. However, the fraction of ARMs is low: 3.32% in 2019, 1.98% in 2020, 1.71% in 2022, and 3.21%. It increases from 2021 to 2022, but the level in 2022 is similar to that in 2019, before the unusually low interest rates in 2020 and 2021. Additionally, Figure A.7a in Appendix A shows that the fraction of ARMs for each percentage point of the DTI ratio does not exhibit discontinuities below the thresholds. On the contrary, most of the increase in ARMs occurred for relatively low DTI ratios. These findings due not suggest a substantial substitution towards ARMs to achieve lower DTI ratios.

Borrowers could have also reduced their mortgage payments by opting for a 30-year term rather than a shorter term, such as 10, 15, or 20 years. However, we find no decline in the fraction of shorter-term mortgages, which was 6.6% in 2021 and 7% in 2022.[13] Figure A.7b shows that the fraction of shorter-term mortgages near the DTI thresholds was similar for 2021 and 2022.

2.4.3 The role of adjustments for income and house prices

The adjustments for income and house prices have little effect when the comparison year is 2021 but are important to ensure that the demand-adjusted counterfactual distribution

[12]Note that it could take borrowers several years to save enough to avoid the DTI limits assuming no change in interest rates. Appendix D describes a back-of-the-envelope calculation showing that borrowers with a counterfactual DTI above the 50% (45%) threshold would need save a median of $45,000 ($47,000) to reach the threshold. Even assuming an aggressive saving rate over 10%, it would take these borrowers a median of 66 (65) months to reach the limit.

[13]Note that these fractions are out of mortgages with a term of exactly 10, 15, 20, or 30 years.

is stable for earlier comparison years. To show this, Figure A.8 in Appendix A indicates that adjusting loan amounts only in response to interest rates shifts the DTI distribution slightly to the left, whereas including the effect of income and house prices results in an opposing rightward shift. This rightward shift is modest in 2021 but becomes more pronounced for earlier comparison years due to the greater amount of income and house price growth from then until 2022. Consequently, omitting income and house prices results in a lower average increase in counterfactual DTI ratios, especially for earlier comparison years (compare Table A.4 with Table A.6 in Appendix A). Further, when comparing the counterfactual distribution to the observed distribution in 2022, this omission also results in a lower reduction in the number of loans with DTI exceeding 50%, especially for earlier comparison years (compare Figure 2a and columns (1) through (3) of Table A.5 with Figure A.9 and Table A.7 in Appendix A).

2.4.4 Placebo

To verify that the difference between the counterfactual and observed distributions is in fact driven by the increase in interest rates starting in 2022 rather than an artifact of the counterfactual DTI construction, we show analogous results from a placebo exercise in which we compare the observed distribution in 2021 to the demand-adjusted counterfactual distribution of loans originated in 2020 as if they were subject to the prevailing interest rates in the same month of 2021. We find that the observed and counterfactual distributions are much more similar compared to the baseline results, consistent with interest rates being relatively stable during these years (see Figure A.10 and Table A.8 in Appendix A). Note that there are still relatively small reductions in the number of loans with DTI ratios above the threshold when the observation year is 2021, which may be driven by increasing loan sizes due to the rapid house price appreciation in 2021.[14]

[14]If we remove adjustments of the loan size associated with house price appreciation, then the change in the number of loans with DTI ratios of 41% or larger from the counterfactual distribution in 2020 to the observed distribution in 2021 is 0.197 with a standard deviation of 0.409.

2.5 VA-adjusted counterfactual DTI distribution

The demand-adjusted counterfactual has two notable shortcomings. First, it rests on the assumption that the intensive and extensive margin adjustments for demand are independent of the DTI ratio. Second, the estimated elasticities of demand with respect to income and house prices are based on correlations and may not necessarily have a causal interpretation.

To overcome these shortcomings, this section develops an alternative construction of a counterfactual DTI distribution by extrapolating the change over time of a relatively unaffected group of loans for each DTI percentage point near the thresholds. The approach is analogous to the methodology used by DeFusco, Johnson, and Mondragon (2020) to estimate the effect of the Ability-to-Repay and Qualified Mortgage Rule on the quantity of jumbo loans relative to conforming loans, except that we examine how fixed DTI thresholds interact with increases in interest rates rather than consider the introduction of a new DTI threshold, In our setting, we use loans insured by the U.S. Department of Veterans Affairs (VA) as a control group based on the observation that the DTI thresholds at 45% and 50% appear to have a negligible impact on the frequency of loans (see Figure A.2 in Appendix A). We therefore use the growth in VA loans from 2021 to 2022 to approximate the growth in the total number of loans that would have occurred if all loans faced the same underwriting thresholds as VA loans. This methodology thereby captures demand factors that affect VA and non-VA loans similarly. We then attribute the difference between the observed and counterfactual distributions to credit supply constraints associated with the tighter DTI constraints that affect non-VA loans.

The validity of using VA loans as a control group depends on two main assumptions. First, it requires an insubstantial degree of substitution into VA loans, otherwise the distribution of VA loans could still be indirectly affected by the tighter DTI constraints that apply to other loan groups. Substitution to VA loans is plausibly limited since eligibility only extends to active service members or veterans of the U.S. military. Moreover,

VA loans typically have lower interest rates compared to similar products, which suggests that those who are eligible for VA loans will always choose this program independent of their LTV and DTI.[15] Second, it rests on the assumption that VA and non-VA borrowers are sufficiently similar that they would have responded to the interest rate spike similarly if the DTI thresholds for the latter were relaxed. VA loans have more flexible underwriting criteria, but the distributions of house values and borrower characteristics exhibit significant overlap (Table A.9 in Appendix A).

2.5.1 VA-adjusted counterfactual DTI distribution: methodology

We follow a procedure analogous to the one in DeFusco, Johnson, and Mondragon (2020) to estimate a "VA-adjusted counterfactual DTI distribution" that would have occurred if all loans faced the same underwriting thresholds as VA loans. Note that we conduct this exercise using data from the Home Mortgage Disclosure Act (HMDA) to increase the number of observations, as VA loans only comprise around 9% of the NMDB, which is only a 5% sample of all originations. We restrict to originated loans satisfying similar sample restrictions as the NMDB sample. Note that we only compute the VA-adjusted counterfactual DTI distribution for when the policy year is 2022 due to a lag in the availability of the 2023 HMDA data.

We first determine a cut-off $\bar{d}$ such that the frequency of loans less than or equal to $\bar{d}$ is unlikely to be affected by the DTI thresholds. We set $\bar{d} = 40\%$ based on the observation that the lowest DTI threshold occurs at 45%, as consumers attempting to avoid the thresholds would be unlikely to reduce their DTI ratios so far below the thresholds.

We then compute the number of loans for each DTI percentage point d, group j ($j = c$ for the control group consisting of VA loans and $j = t$ for the treatment group consisting of non-VA loans), and comparison year y, which we denote by n^{y}_{jmd}. Note that HMDA reports some DTI ratios as a range, in which case we apply the same procedure

[15] Figure A.11 shows that the spread between VA and non-VA loans is fairly constant over time.

as for individual DTI ratios.[16] To normalize the scale, we also compute the total number of loans less than or equal to $\bar{d}$ for each group j, MSA m, and year y, which we denote by $N^{y}_{jm\bar{d}}$.

Denote by $\hat{n}^{y,2022}_{tmd}$ the counterfactual number of loans in the treatment group as if the growth from a comparison year y to 2022 were only affected by DTI constraints pertaining to VA loans. We compute it as a ratio of the number of loans unaffected by the thresholds as follows:

$$\underbrace{\frac{\hat{n}^{y,2022}_{tmd}}{N^{2022}_{tm\bar{d}}}}_{\text{counterfactual level of treatment group in 2022}} = \underbrace{\frac{n^{y}_{tmd}}{N^{y}_{tm\bar{d}}}}_{\text{observed level of treatment group in year } y} + \underbrace{\left(\frac{n^{2022}_{cmd}}{N^{2022}_{cm\bar{d}}} - \frac{n^{y}_{cmd}}{N^{y}_{cm\bar{d}}}\right)}_{\text{observed change of control group from } y \text{ to } 2022}$$

We multiply this result by $N^{2022}_{tm\bar{d}}$ to obtain $\hat{n}^{y,2022}_{tmd}$. We then add the observed number of VA loans to obtain the total number of loans for each DTI percentage point d and MSA m in the VA-adjusted counterfactual DTI distribution, i.e. $\hat{n}^{y,2022}_{tmd} + n^{2022}_{cmd}$. Finally, we sum over MSAs to obtain the total number of loans for each DTI percentage point d.

2.5.2 VA-adjusted counterfactual DTI distribution: results

Column (5) of Table 1 summarize the difference between the observed and VA-adjusted counterfactual DTI distributions for subsets of the DTI ratio when the comparison year is 2021 (see Table A.10 in Appendix A for the results for each comparison year, and see Figure A.12 in Appendix A for a comparison by each DTI level or range reported in HMDA). For each comparison year, the decline in lending is concentrated in loans with

[16] Note that HMDA only reports individual DTI ratios for each percentage point from 37% through 49%, whereas it reports composites for $< 20\%$, 20%-30%, 30%-36%, 50%-60%, and $> 60\%$. We omit observations for which the DTI ratio is reported as "NA" or "Exempt". The interval reporting not a problem for this exercise since we can still determine which loans had a DTI ratio less than or equal to 40% as well as which had a DTI above or below each of the thresholds at 45% and 50%.

DTI above the 50% underwriting threshold, similar to the baseline results in Section 2.3.2. The magnitude of the reduction for loans with a DTI ratio of at least 41% ranges from 15.68% to 18.63% of the total number of loans in the VA-adjusted counterfactual DTI distribution, which is also similar to the baseline results. Compared to the baseline results, there is less evidence of bunching below the 45% threshold. The differences between the observed and counterfactual distributions are fairly stable across comparison years, providing evidence that this alternative construction of the counterfactual distribution also controls for factors determining the overall level of loans in each year. In a placebo analysis, we find that the observed and VA-adjusted counterfactual DTI distributions are more similar when restricted to years prior to 2022 (Table A.11 in Appendix A).

3 Which borrowers were most impacted?

This section shows that the most pronounced reductions in credit during the monetary policy tightening occurred for groups with relatively high DTI ratios, including minority and middle-income borrowers. These results underscore potential costs of monetary policy tightening associated with exacerbating existing disparities in homeownership.

In terms of race and ethnicity, we find that Black and Hispanic borrowers exhibited larger reductions in loans compared to white borrowers, which is largely driven by having more borrowers with a counterfactual DTI exceeding the underwriting thresholds, as shown in Table 3, Figure 4, and Figure B.1 in Appendix B.

Figure 5 further summarizes changes in continuous borrower, loan, and property characteristics during the monetary policy tightening. In terms of borrower characteristics, the reduction in lending was concentrated in households making less than about $100,000 annually (Figure 5a). Figure 6 and Figure B.2 additionally show a clear negative association between income and the fraction of households with counterfactual DTI above the thresholds, consistent with these thresholds driving the disproportionate impact on middle-income borrowers. In terms of loan and property characteristics, the reduction

in lending was most pronounced for loan amounts below about $300,000 (Figure 5b) and house values below about $400,000 (Figure 5c).

Some characteristics did not appear to change much during the monetary policy tightening. In particular, we do not find that the reduction in lending was clearly associated with changes in credit scores (Figure 5e) or non-mortgage debt to income (Figure 5d), which we obtain as the back-end DTI ratio minus the front-end payment-to-income ratio. The latter finding is consistent with other results indicating that borrowers did little on the intensive margin to accommodate the monetary policy tightening, such as the lack of bunching below the DTI thresholds and the limited decline in loan amounts or home values, conditional on borrower income, for originated loans (see Section 2.4.2).

4 Local ramifications

Shifting from the impact of higher interest rates on individual borrowing decisions to local general equilibrium effects, this section shows that regions with more binding DTI constraints exhibited relative reductions in house prices and economic activity.

4.1 Local ramifications: empirical approach

We consider the impact of the monetary policy tightening on metropolitan statistical areas (MSAs). Exposure to the interest rate spike is represented by the share of originations in 2019-2021 that have an observed DTI ratio below 50% but a counterfactual DTI above 50% (i.e., the share that switches from below to above the cutoff due to the increasing interest rates), which we call the "high-DTI share". The baseline results use the 50% threshold since it is associated with the most pronounced decline in the loan-level analysis, but for robustness we show that the results are similar when using the 45% threshold (see Tables C.4 and C.5 in Appendix C). We pool originations in 2019-2021 to increase the number of observations per MSA and reduce noise. We use the baseline version of the counterfactual

distribution without demand adjustments to avoid endogenous correlations between the adjustments and local area outcomes. For example, since house price growth is one of the dependent variables, our baseline specification does not also use it to determine the high-DTI share. The results are nonetheless robust to adjusting loan amounts for changes in income and house prices from 2019 or 2020 to 2021 (Tables C.6 and C.7 in Appendix C).

We estimate a cross-sectional regression:

$$\Delta Y_i = \beta highDTI_i + \gamma X_i + \epsilon_i, \tag{1}$$

where ΔY_i is the change from 2021 to 2023 of one of the dependent variables (purchase mortgage volume, house prices, cash-out mortgage volume, or spending) for MSA i, $highDTI_i$ is the high-DTI share, X_i is the control set, and ϵ_i is the error term.[17] We determine purchase and cash-out mortgage volume using the NMDB, house prices using the FHFA all-transactions index, and credit and debt card spending using the Economic Tracker associated with Chetty et al. (2022).[18] The control set X_i includes the one-year lag of the dependent variable, the growth in the number of employees from 2020 to 2021 derived from the U.S. Census Bureau's County Business Pattern data, and the logarithm of per capita annual income in the past 12 months as of 2021 derived using the American Community Survey 1-year estimates. We also show that our results are robust to controlling for housing supply elasticity using the CBSA-level mean of the Wharton Land Use Regulatory Index from Gyourko, Hartley, and Krimmel (2021), which incorporates factors like density restrictions and building project review times. See Table C.1 in Appendix Section C for summary statistics of the MSA-level data used in this exercise.

[17] Note that we focus on the change from 2021 to 2023 due to a potentially lagged effect on house prices and spending. Accordingly, we also compute the high-DTI share based on the counterfactual DTI relative to 2023. We show the results are similar when looking at changes from 2021 to 2022 and using the counterfactual DTI relative to 2022 in Tables C.2 and C.3 in Appendix C.

[18] We collapse the day-county-level data on spending to county-years by taking an average over days and then to MSA-years by taking a population-weighted average over counties.

4.2 Identification

To interpret the associations between high-DTI share and local outcomes causally, the identification assumption is that high-DTI share is not correlated with other determinants of these outcomes outside of the controls. However, a potential concern is that we observed in Section 3 that there are correlations between high counterfactual DTI ratios at the individual level and various demographic characteristics such as race, ethnicity, and income. This could result in analogous correlations at the MSA level and confound the interpretation since such factors are associated with sensitivity to aggregate shocks (e.g., Patterson (2023)). Our baseline specification controls for median income, while Tables C.8 and C.9 show that the results are robust to also controlling for the Black and Hispanic shares in the population as well as the average credit score among borrowers. However, these differences serve to illustrate that high-DTI share is not randomly distributed and may be be associated with other factors we do not control for.

To further examine the variation in high-DTI share at the MSA level, Figure C.1 in Appendix C presents a heat map for all MSAs in the sample. It indicates that high-DTI share tends to be high in the west census region, coastal areas in the northeast census regions, and Florida, whereas it is relatively low throughout much of the midwest and south census regions excluding Florida. This observation is also apparent in Table C.10, which lists high-DTI share for the top 30 MSAs in the sample based on the number of originations in 2019-2021. Table C.11 also shows the correlations between high-DTI share and the controls as well as MSA-level summary statistics of the characteristics considered in Section 3. High-DTI share has a statistically significant correlation with many of these characteristics. Given these patterns in the distribution of high-DTI share, it is difficult to definitively rule out potential alternative explanations with the same level of rigor as the loan-level analysis in Section 2. However, we offer a few considerations to support the interpretation that DTI constraints contributed to the associations between the high-DTI share and local outcomes.

One consideration is that we observe that MSA-level high-DTI share is actually associated with higher incomes and a lower Black share of the population. This observation suggests that the opposite loan-level correlations in Section 3 are driven by variation within rather than across MSAs. The upshot is that these observations suggest that high-DTI share is correlated with lower sensitivity to aggregate shocks, which would most likely bias towards underestimating the effects of the DTI constraints.

As additional evidence that the effects we find are specifically associated with the DTI thresholds, Figure C.2 in Appendix C shows the estimates from (1) but varying the threshold used to determine high-DTI share. For each threshold, we normalize high-DTI share to have a standard deviation of 1. We find that the association is strongest at the 45% threshold, which supports the interpretation that the associations are driven by the DTI thresholds rather than other factors that might be correlated with general increases in DTI ratios. Figure C.3 implements an analogous exercise except restricting to loans with a counterfactual DTI up to 45%. It also controls for the original high-DTI share based on the 45% threshold using the full sample. In this case, none of the loans in the sample is affected by the DTI constraints, and we correspondingly find a smaller and usually insignificant effect associated with the high-DTI share. This exercise also supports the interpretation that our results are specifically driven by the DTI constraints.

4.3 Local ramifications: results

Column (1) of Table 4a shows that a 1 percentage point increase in the high-DTI share is associated with a statistically significant 1.17 percentage point decline in purchase loan growth (see also Figure 7 for a corresponding binned scatterplot). The remaining columns show that this result is similar in magnitude and statistical significance when including the baseline set of controls (column (2)), adding the housing supply elasticity to the controls

(column (3)), and weighting by population as of the 2020 census (column (4)).[19]

Table 4b shows that the high-DTI share was associated with lower house price growth from 2021Q4 to 2023Q4. The reduced mortgage volume due to the DTI-based credit supply constraints could have lessened competition among potential homebuyers, resulting in lower prices. These results link existing studies that focus on the relationship between house prices and either transaction volume (DeFusco, Nathanson, and Zwick (2022) or interest rates (Larson (2022)).

Table 5a shows that the high-DTI share was associated with lower cash-out refinance growth from 2021 to 2023. One explanation is that the reduced house price growth resulted in a lower amount of equity that could be cashed out. Additionally, the high-DTI share could indicate tighter underwriting constraints on cash-out refinances.

Finally, Table 5b shows that the high-DTI share was associated with lower spending growth from 2021 to 2023. This result is consistent with the lower rate of cash-out refinances, which are often used to finance consumption out of housing wealth (e.g. Beraja et al. (2018), Berger et al. (2021), Di Maggio, Kermani, and Palmer (2020)).

5 Conclusion

The empirical evidence presented in this study highlights the mechanisms through which monetary policy tightening manifests in the mortgage market. Notably, we enrich the

[19] We can use these estimates to quantify the aggregate impact of the the DTI constraints. If we assume that the MSAs in the lowest 5% of the high-DTI share (which corresponds to about .15) experienced no reduction in lending due to the DTI constraints, then our estimate in column (2) implies that, for the average MSA with a high-DTI share of .26, the reduction in lending associated with the DTI constraints is about .09 ($.787 \times (.26 - .15)$), which is about 41% of the average reduction of .22. If we use the estimate from the population-weighted specification in column (4) and also use weighted versions of the mean high-DTI share and growth in purchase loans, we find that the average reduction in lending due to the DTI constraints is about .11 ($1.031 \times (.26 - .15)$), which is about 50% of the population-weighted average reduction of .26. If we instead assume that MSAs with hypothetically 0 high-DTI share experienced no reduction in lending due to the DTI constraints and the effect of the DTI constraints is sufficiently linear even for very low values of the high-DTI share, then the average reduction is lending due to the DTI constraints is as high as .20 ($.787 \times .26$), or .26 ($1.031 \times .26$) when weighting by population. The range of these estimates suggests that the DTI constraints contributed to at least 41% of the reduction in loans, which is similar to the lower bound of 52% derived from an independent analysis in Appendix E.

discourse about the effectiveness of monetary policy by showing the predominance of credit supply factors, specifically DTI ratio constraints, as a decisive force in the observed contraction of purchase mortgage originations in 2022 and 2023.

Our analysis also reveals that the negative impact of escalation in interest rates on housing transactions was significantly more pronounced for minorities and middle-income households. We also show how the micro-level effects of monetary policy translate into changes in macroeconomic outcomes at the regional level, which illuminates how credit supply disruptions borne by DTI ratio thresholds translate into wider economic effects. The localized cooling of the housing markets and subsequent decline in consumer spending power highlight the broader economic footprint of DTI constraints. These findings suggest that the impact of monetary policy on the macroeconomy depends on time-varying factors determining the extent to which DTI constraints bind.

Ultimately, this paper contributes to a critical dialogue on the intersection of monetary policy, housing affordability, and financial stability. The implications of these findings are twofold. Firstly, they challenge the traditional focus on demand-side transmission channel of monetary policy. Secondly, they reveal how financial stability regulations such as DTI limits make monetary policy more effective but more heterogeneous with disproportionate declines in loan originations among more constrained households.

The observed alignment between DTI constraints and regional housing market cooldowns provides a new perspective on how monetary policy can inadvertently shape regional economic landscapes, influencing everything from housing affordability to consumer spending. These findings might be instrumental for policymakers, suggesting that adjustments in monetary policy should be accompanied by concurrent, targeted modifications in DTI regulations to avoid exacerbating existing disparities.

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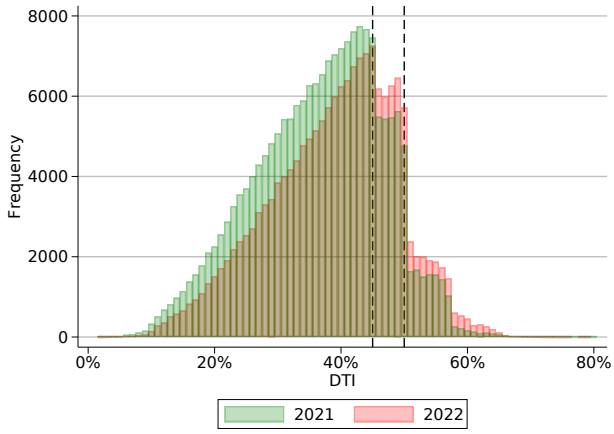
6 Figures

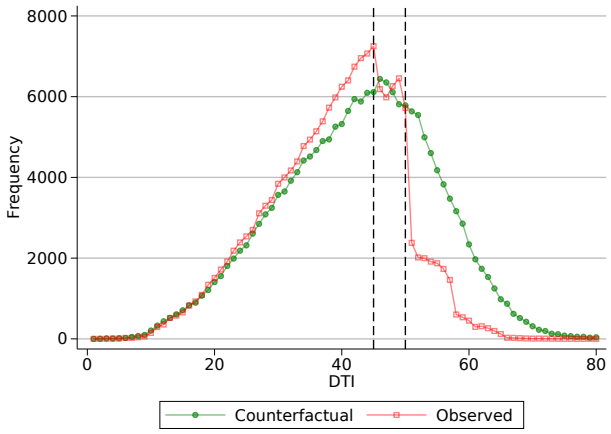
Figure 1: Observed and counterfactual DTI distributions

Figure 1a shows the frequencies of the debt-to-income (DTI) ratio for loans originated 2021 to 2022. Figure 1b shows the frequencies of the counterfactual debt-to-income (DTI) ratio for loans originated 2021 as well as the observed DTI ratio for loans originated in 2022. Figure 1c and Figure 1d are similar except using 2023 as the policy year. The counterfactual DTI ratio is the DTI ratio a loan would have if it was originated in the same month in the policy year, as described further in Section 2.3.1. The distributions are trimmed at a DTI of 80% (omits less than 0.01% of observations). Dashed lines indicate the DTI ratios of 45% and 50%. Source: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties in metropolitan statistical areas.

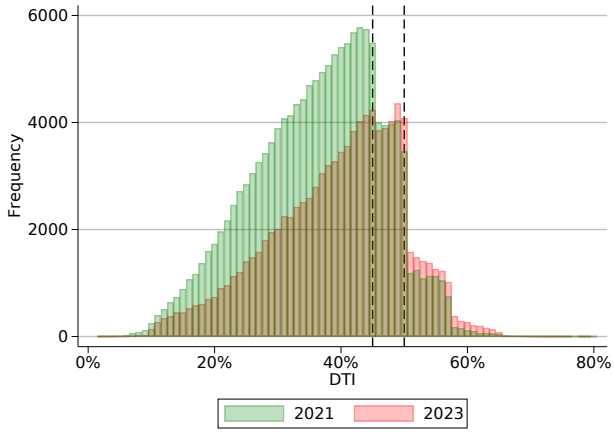
(a) Observed DTI distribution



(b) Counterfactual DTI distribution



(c) Observed DTI distribution



(d) Counterfactual DTI distribution

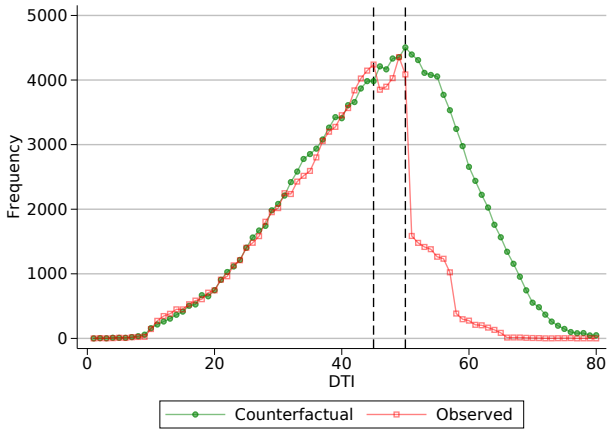
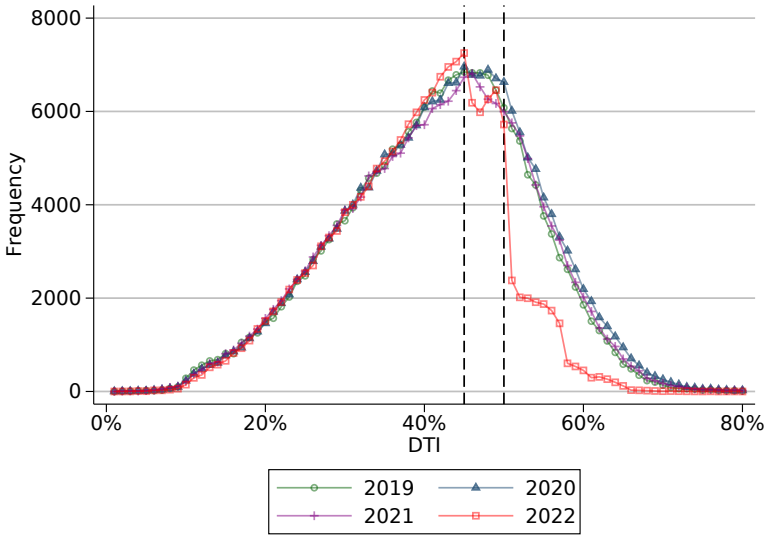


Figure 2: Demand-adjusted counterfactual distribution

Figure 2a shows the frequencies of the demand-adjusted counterfactual DTI ratio for loans originated in 2019, 2020, 2021 as well as the observed DTI ratio for loans originated in 2022. The demand-adjusted counterfactual DTI ratio is the DTI ratio a loan would have if it was originated in the same month in 2022 and then adjusting for demand on the intensive and extensive margins, as described in Section 2.4.1. Figure 2b is similar except using 2023 as the policy year. The distributions are trimmed at a DTI of 80%. Dashed lines indicate the DTI ratios of 45% and 50%. Source: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties in metropolitan statistical areas.

(a) 2019-2021 versus 2022



(b) 2019-2021 versus 2023

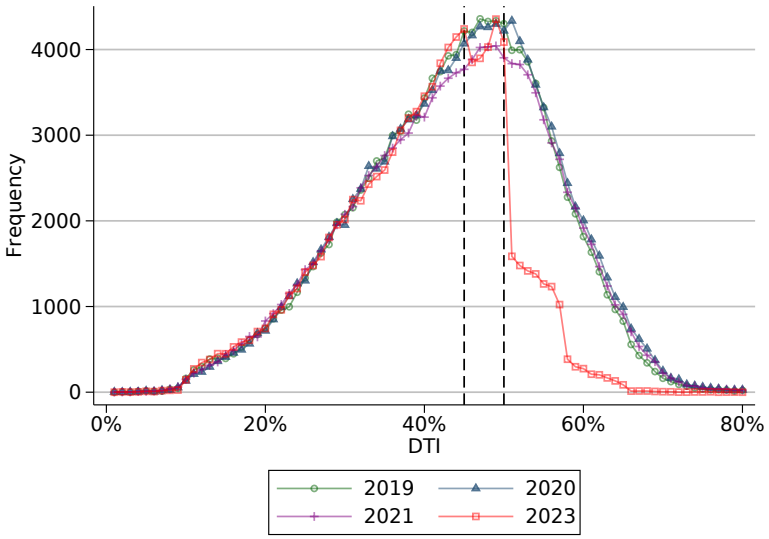
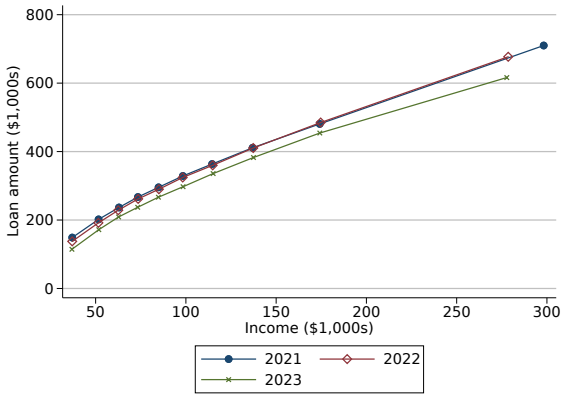


Figure 3: Loan amount and house value by income

This figure shows a binned scatterplot of loan amount (Figure 3a) or house value (Figure 3b) on income in 2021, 2022, and 2023, all expressed in 2021 inflation-adjusted dollars. Source: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties in metropolitan statistical areas.

(a) Loan amount



(b) House value

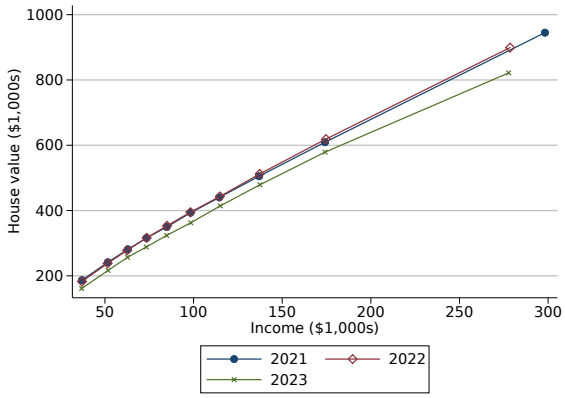


Figure 4: High counterfactual DTI by race and ethnicity

This figure shows the percentage of loans having a counterfactual DTI (CDTI) above 45%, when the policy year is either 2022 or 2023, for subsamples consisting of loans where all the borrowers are non-Hispanic black, Hispanic, or non-Hispanic white. The counterfactual DTI ratio is the DTI ratio a loan would have if it was originated in the same month in 2022, as described further in Section 2.3.1. Source: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties in metropolitan statistical areas.

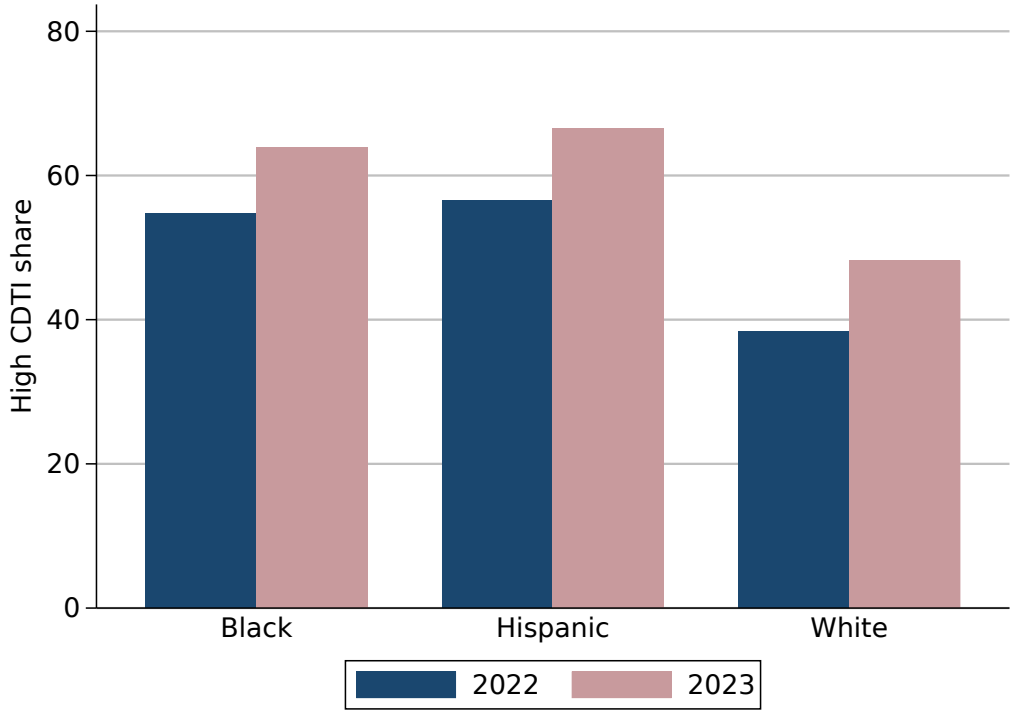
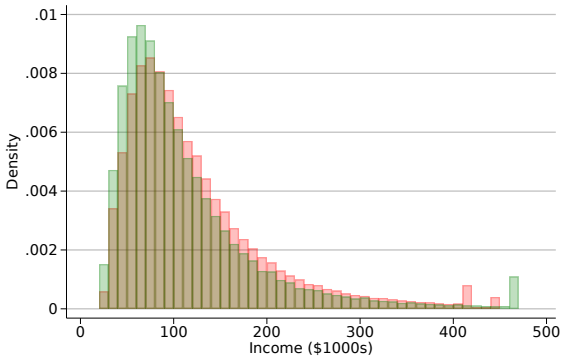


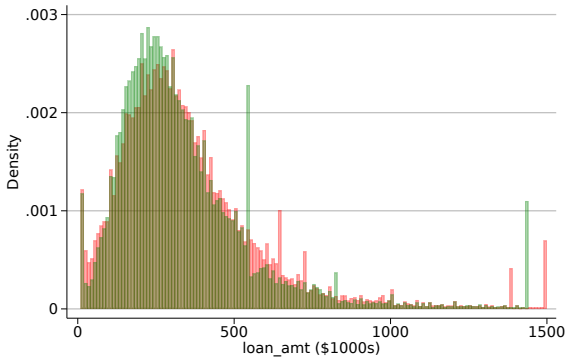
Figure 5: Distributions of borrower characteristics

This figure shows the densities of various borrower, loan, and property characteristics in 2021 (green) and 2022 plus 2023 (red): income (annual household income), loan amount (in $1000s), and house value (minimum of the sale price and appraised value in $1000s), non-mortgage debts (back-end debt-to-income ratio minus the front-end payment-to-income ratio and expressed as a percentage of monthly income), and credit score (minimum credit score among the borrowers on a loan). The top and bottom 1% of each variable is winsorized in each year. Source: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties in metropolitan statistical areas.

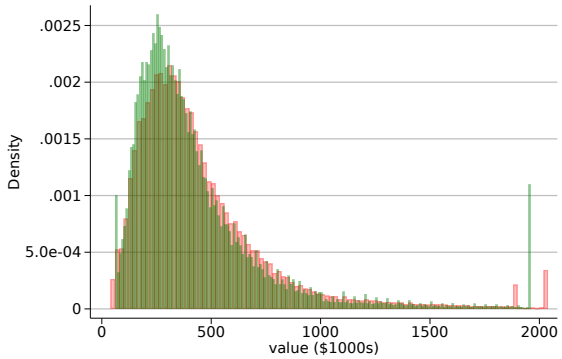
(a) Income



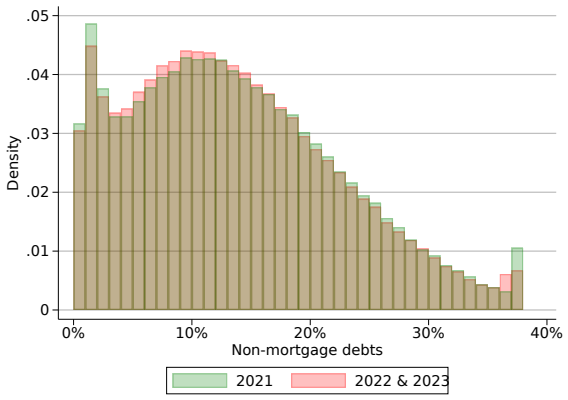
(b) Loan amount



(c) House value



(d) Non-mortgage debts



(e) Credit score

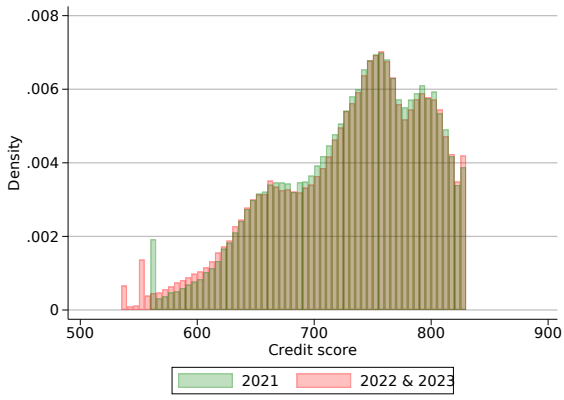


Figure 6: High counterfactual DTI by income

This figure shows a binned scatterplot of an indicator for a loan having a counterfactual DTI (CDTI) above 45%, when the policy year is either 2022 or 2023. The counterfactual DTI ratio is the DTI ratio a loan would have if it was originated in the same month in 2022, as described further in Section 2.3.1. Source: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties in metropolitan statistical areas.

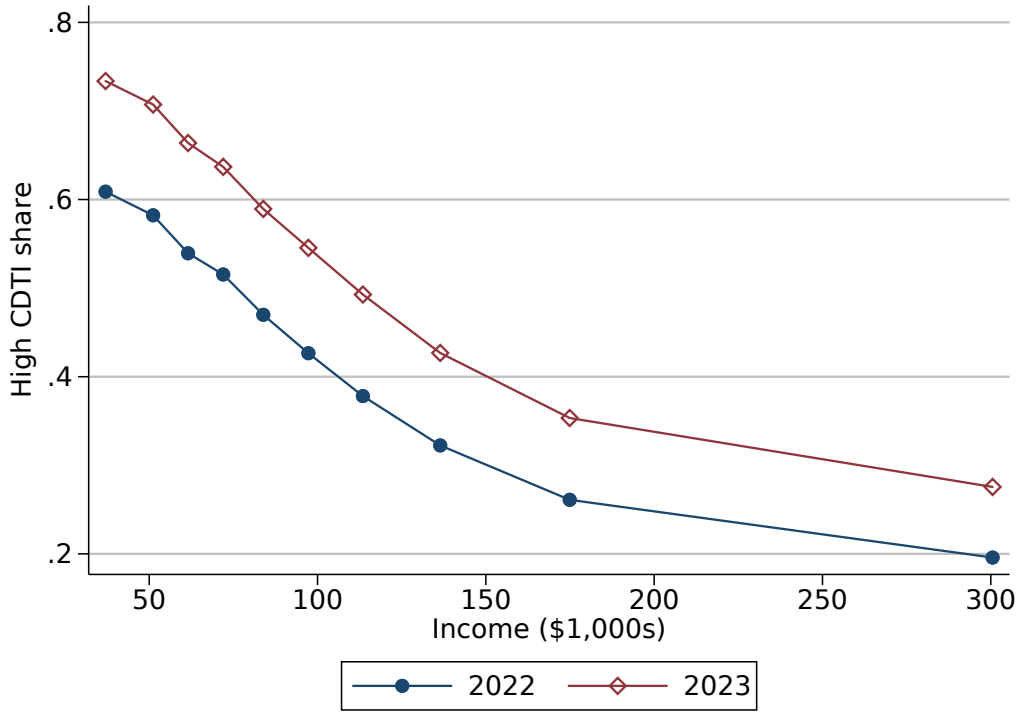
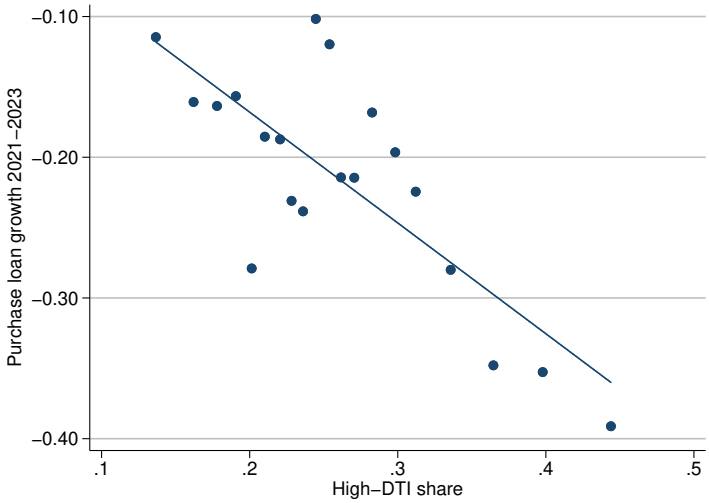


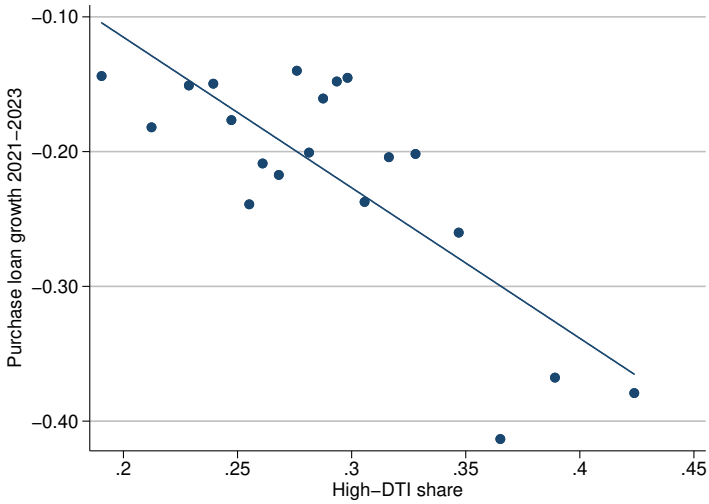
Figure 7: High-DTI share and purchase loan growth

This figure presents an MSA-level binned scatterplot of the growth in the total dollar volume of purchase mortgage originations from 2021 to 2023 on the high-DTI share, which is defined as the fraction of originations in 2019-2021 having a counterfactual DTI greater than 50% and an observed DTI less than 50% (Figure 7a) or similarly defined based on a threshold of 45% (Figure 7b). The counterfactual DTI ratio is the DTI ratio a loan would have if it was originated in the same month in 2023, as described further in Section 2.3.1. Source: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties in metropolitan statistical areas.

(a) High-DTI share based on the 50% threshold



(b) High-DTI share based on the 45% threshold



7 Tables

Table 1: Comparison of counterfactual and observed distributions

	Baseline		Demand-adjusted		VA-adjusted
	(1)	(2)	(3)	(4)	(5)
DTI $\leq$ 40	3.583	–0.740	0	0	0
	(0.297)	(0.384)			
41 $\leq$ DTI $\leq$ 45	2.474	0.496	1.433	1.318	–1.601
	(0.156)	(0.203)	(0.170)	(0.190)	(0.237)
46 $\leq$ DTI $\leq$ 50	0.055	–0.942	–0.592	0.271	–1.318
	(0.196)	(0.258)	(0.193)	(0.296)	(0.197)
50 $<$ DTI	–18.703	–29.926	–15.532	–22.639	–13.978
	(0.369)	(0.571)	(0.411)	(0.577)	(0.717)
41 $\leq$ DTI	–16.174	–30.372	–14.691	–21.051	–16.898
	(0.363)	(0.599)	(0.525)	(0.695)	(0.941)
Observations	359,319	241,433	359,319	242,261	6,957,063
Bootstrap reps.	100	100	100	100	100
Policy year	2022	2023	2022	2023	2022

Note: This table shows the difference between the frequency of loans in 2022 or 2023 with an observed debt-to-income (DTI) ratio within a given range and the frequency of loans from 2021 with a counterfactual DTI ratio, demand-adjusted counterfactual DTI ratio, or VA-adjusted counterfactual DTI ratio in that range as a percentage of the total number of loans in the respective counterfactual distribution. The three types of counterfactual DTI ratios are described further in Section 2.3.1, Section 2.4.1, and Section 2.5.1, respectively. Standard errors computed via bootstrap with 100 replications with replacement and clustered by MSA are reported in parentheses. Source: columns (1) through (4) use the National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties. Column (5) uses the Home Mortgage Disclosure Act, restricting to purchase loans originated in 2019-2021 for one-unit, owner-occupied, site-built properties in metropolitan statistical areas.

Table 2: Loan amount, income, and house prices

	(1)	(2)	(3)
Log(house. income)	0.411	0.531	0.542
	(0.005)	(0.006)	(0.006)
Log(tract HPI)	0.335		
	(0.034)		
Log(MSA HPI)		0.463	
		(0.055)	
Log(MSA med. val.)			0.345
			(0.020)
Observations	331,932	405,171	537,877
R^2	0.676	0.522	0.568
Year FE	Yes	Yes	Yes
Geo. FE	Tract	MSA	MSA

Note: Column (1) regresses the logarithm of the loan amount on the logarithm of household income and the logarithm of the Federal Housing Finance Agency annual price census tract-level house price index (also associated with Bogin, Doerner, and Larson (2019)) while controlling for fixed effects for the year and census tract. Column (2) is similar except using the annual CBSA-level house price index and controlling for fixed effects for the metropolitan statistical area (MSA) or metropolitan division (MD) rather than census tract. Column (3) is similar to column (2) except using the median property value in the corresponding MSA or MD. All variables are adjusted to 2021 prices using the consumer price index retrieved from FRED (series CPIAUCSL). MSA-clustered standard errors are reported in parentheses. Source: Home Mortgage Disclosure Act, 5% random sample, restricting to purchase loans originated in 2019-2021 for one-unit, owner-occupied, site-built properties in metropolitan statistical areas.

Table 3: Comparison of counterfactual and observed distributions by race and ethnicity

	(1)	(2)	(3)	(4)	(5)	(6)
DTI $\leq$ 40	0.109	0.383	–1.850	–0.735	0.122	–4.685
	(0.648)	(0.649)	(0.739)	(0.482)	(0.399)	(0.523)
41 $\leq$ DTI $\leq$ 45	0.442	–0.209	0.821	0.088	0.748	–1.731
	(0.514)	(0.520)	(0.419)	(0.540)	(0.158)	(0.185)
46 $\leq$ DTI $\leq$ 50	–2.800	–1.891	–2.511	–1.344	–1.428	–3.226
	(0.671)	(0.720)	(0.383)	(0.546)	(0.194)	(0.228)
50 $<$ DTI	–25.710	–39.868	–29.156	–42.894	–17.062	–27.523
	(0.672)	(0.820)	(0.833)	(1.145)	(0.394)	(0.623)
41 $\leq$ DTI	–28.067	–41.967	–30.846	–44.151	–17.742	–32.479
	(1.105)	(1.212)	(1.012)	(1.285)	(0.501)	(0.648)
Observations	26,854	18,183	45,848	31,848	220,492	147,153
Bootstrap reps.	100	100	100	100	100	100
Subsample	Black	Black	Hispanic	Hispanic	White	White
Policy year	2022	2023	2022	2023	2022	2023

Note: This table shows the difference between the frequency of loans in 2022 or 2023 with an observed debt-to-income (DTI) ratio within a given range and the frequency of loans from a given comparison year with a counterfactual DTI ratio in that range as a percentage of the total number of loans in the respective counterfactual distribution for subsamples consisting of loans where all the borrowers are non-Hispanic black, Hispanic, or non-Hispanic white. The counterfactual DTI ratio is the DTI ratio a loan would have if it was originated in the same month in the policy year, as further described in Section 2.3.1. Standard errors computed via bootstrap with 100 replications with replacement and clustered by MSA are reported in parentheses. Source: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties in metropolitan statistical areas.

Table 4: Local impact of high-DTI share on purchase loans and house prices

(a) High-DTI share and purchase loan growth

	(1)	(2)	(3)	(4)
High-DTI share	-0.833	-0.787	-0.871	-1.031
	(0.128)	(0.124)	(0.138)	(0.138)
Observations	381	381	302	302
R^2	0.115	0.159	0.198	0.424
DTI type	CDTI>50%	CDTI>50%	CDTI>50%	CDTI>50%
Base controls	No	Yes	Yes	Yes
Elasticity	No	No	WRLURI	WRLURI
Weighted	No	No	No	Yes

(b) High-DTI share and house price growth

	(1)	(2)	(3)	(4)
High-DTI share	-0.246	-0.387	-0.430	-0.289
	(0.037)	(0.045)	(0.052)	(0.104)
Observations	381	381	302	302
R^2	0.100	0.190	0.234	0.178
DTI type	CDTI>50%	CDTI>50%	CDTI>50%	CDTI>50%
Base controls	No	Yes	Yes	Yes
Elasticity	No	No	WRLURI	WRLURI
Weighted	No	No	No	Yes

Note: Column (1) regresses the MSA-level growth in the total dollar volume of purchase mortgage originations from 2021 to 2023 (Table 4a) or the MSA-level growth of the FHFA all-transactions house price index from 2021Q4 to 2023Q4 (Table 4b) on the high-DTI share, which is defined as the fraction of originations in 2019-2021 having a counterfactual DTI (CDTI) greater than 50% and an observed DTI below 50%. The counterfactual DTI ratio is the DTI ratio a loan would have if it was originated in the same month in 2023, as described further in Section 2.3.1. Column (2) adds the following control variables: the lagged dependent variable (growth of purchase loan volume from 2020 to 2021 or house price growth from 2020Q4 to 2021Q4), the growth in the number of employees from 2020 to 2021 (using the County Business Pattern data provided by the US Census Bureau), and per capita income in the past 12 months (in 2021 inflation-adjusted dollars) as of 2021 (using the American Community Survey 1-year estimates). Column (3) adds the CBSA-level mean of the Wharton Land Use Regulatory Index (WRLURI) from Gyourko, Hartley, and Krimmel (2021) to control for housing supply elasticity. Column (4) weights by population based on the 2020 census. Robust standard errors are reported in parentheses. Source for mortgage data: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties in metropolitan statistical areas.

Table 5: Local impact of high-DTI share on cash-out refinance loans and spending

(a) High-DTI share and cash-out refinance growth

	(1)	(2)	(3)	(4)
High-DTI share	-0.903	-0.752	-0.818	-0.806
	(0.094)	(0.094)	(0.121)	(0.078)
Observations	381	381	302	302
R^2	0.134	0.208	0.232	0.398
DTI type	CDTI>50%	CDTI>50%	CDTI>50%	CDTI>50%
Base controls	No	Yes	Yes	Yes
Elasticity	No	No	WRLURI	WRLURI
Weighted	No	No	No	Yes

(b) High-DTI share and spending growth

	(1)	(2)	(3)	(4)
High-DTI share	-0.289	-0.316	-0.340	-0.371
	(0.039)	(0.043)	(0.049)	(0.058)
Observations	342	340	273	273
R^2	0.132	0.154	0.169	0.271
DTI type	CDTI>50%	CDTI>50%	CDTI>50%	CDTI>50%
Base controls	No	Yes	Yes	Yes
Elasticity	No	No	WRLURI	WRLURI
Weighted	No	No	No	Yes

Note: Column (1) regresses the MSA-level growth in the total dollar volume of cash-out refinance originations from 2021 to 2023 (Table 5a) or the MSA-level change in debt and credit card spending (relative to January 6 to February 2nd, 2020) from 2021 to 2023 (Table 5b) on the high-DTI share, which is defined as the fraction of originations in 2019-2021 having a counterfactual DTI (CDTI) greater than 50% and observed DTI less than 50%. The counterfactual DTI ratio is the DTI ratio a loan would have if it was originated in the same month in 2023, as described further in Section 2.3.1. Column (2) adds the following control variables: the lagged dependent variable (growth of cash-out refinance volume from 2020 to 2021 or change in spending from 2020 to 2021), the growth in the number of employees from 2020 to 2021 (using the County Business Pattern data provided by the US Census Bureau), and per capita income in the past 12 months (in 2021 inflation-adjusted dollars) as of 2021 (using the American Community Survey 1-year estimates). Column (3) adds the CBSA-level mean of the Wharton Land Use Regulatory Index (WRLURI) from Gyourko, Hartley, and Krimmel (2021) to control for housing supply elasticity. Column (4) weights by population based on the 2020 census. Robust standard errors are reported in parentheses. Source for mortgage data: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties in metropolitan statistical areas.

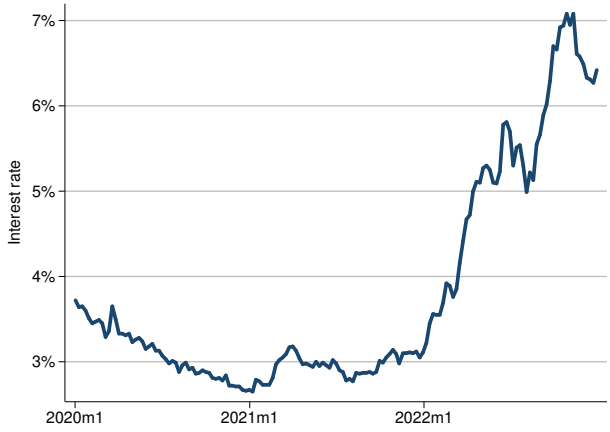
Appendix

A Additional material for Section 2

Figure A.1: Interest rates, mortgage volume, and house prices

Figure A.1a shows the typical 30-year fixed rate mortgage interest rate according to the Freddie Mac Primary Mortgage Market Survey, retrieved from FRED at the Federal Reserve Bank of St. Louis. Figure A.1b shows the all-transactions national house price index from the Federal Housing Finance Agency relative to 2021Q4 (left axis) and the natural logarithm of the number of loans after partialling out the quarter (i.e. 1,2,3 or 4), to account for seasonality, and indicators for 2020Q1 and 2020Q2, to account for fluctuations associated with the onset of the COVID-19 pandemic. Source for mortgage data: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties in metropolitan statistical areas.

(a) Interest rate



(b) Mortgage volume and house prices

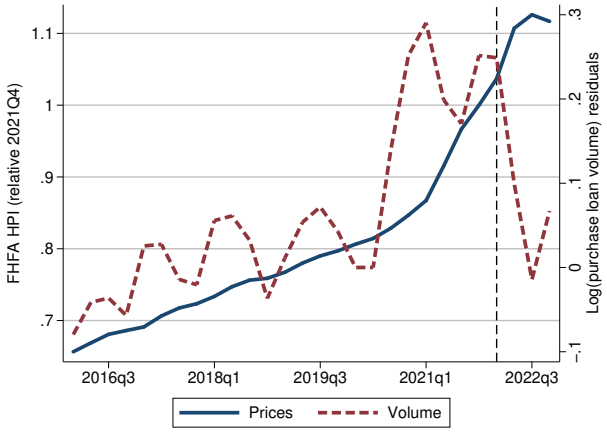


Table A.1: Summary statistics

(a) Summary statistics for 2021

	N	Mean	SD	P25	P50	P75
Interest rate (%)	191,730	3.05	0.52	2.75	3.00	3.25
Debt-to-income (%)	191,730	36.67	10.12	30.00	38.00	44.00
Loan-to-value (%)	191,730	83.68	17.24	79.00	90.00	96.00
Credit score	191,730	731.44	61.64	689.00	742.00	781.00
Loan amount ($1000s)	191,730	342.16	232.61	196.28	289.66	421.95
House value ($1000s)	191,730	424.09	317.18	230.00	340.00	506.00
Non-mortgage debts (%)	191,492	13.07	8.96	6.00	12.00	19.00
Age	191,730	40.72	12.62	31.00	38.00	49.00
Income ($1000s)	191,730	112.41	78.62	61.00	90.00	135.00
VA (%)	191,730	8.77	28.29	0.00	0.00	0.00

(b) Summary statistics for 2022

	N	Mean	SD	P25	P50	P75
Interest rate (%)	167,589	5.07	1.27	4.00	5.12	6.00
Debt-to-income (%)	167,589	38.89	10.07	32.00	40.00	46.00
Loan-to-value (%)	167,589	81.44	17.54	75.00	87.00	95.00
Credit score	167,589	730.35	63.44	687.00	742.00	780.00
Loan amount ($1000s)	167,589	362.08	248.98	201.29	307.84	450.00
House value ($1000s)	167,589	455.54	333.79	245.00	370.00	550.00
Non-mortgage debts (%)	167,300	12.12	9.98	5.00	12.00	19.00
Age	167,589	41.40	12.91	31.00	39.00	50.00
Income ($1000s)	167,589	119.51	75.78	68.00	98.00	147.00
VA (%)	167,589	8.63	28.09	0.00	0.00	0.00

Note: These tables present summary statistics for 2021 and 2022. *Interest rate* is the annualized interest rate at origination. *Debt-to-income* (DTI) is the ratio of all debt payments to household income. *Loan-to-value* (LTV) is the ratio of the loan amount to the lesser of the appraised value and the sale price. *Credit score* is the minimum credit score among the borrowers on a loan. *Loan amount* is self-explanatory. *House value* is the minimum of the sale price and appraised value. *Non-mortgage debts* is the back-end debt-to-income ratio minus the front-end payment-to-income ratio. *Age* is the mean age among the borrowers on a loan. *Income* is the annual household income. *VA* indicates whether a loan insured by the U.S. Department of Veterans Affairs. Continuous variables are winsorized at 1% in each year. Source: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties in metropolitan statistical areas.

Figure A.2: Observed DTI distribution by market segment

This figure shows the frequencies of the debt-to-income (DTI) ratio for loans originated 2021 to 2022 in each market segment: loans insured by the Federal Housing Administration (FHA), loans purchased and securitized by government-sponsored enterprises (GSE), loans retained in portfolio by lenders or securitized in the private market (Private), loans insured by the U.S. Department of Agriculture (USDA), and loans insured by the U.S. Department of Veterans Affairs (VA). The distributions are trimmed at a DTI of 80% (omits less than 0.01% of observations). Dashed lines indicate the DTI ratios of 45% and 50%. Source: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties in metropolitan statistical areas.

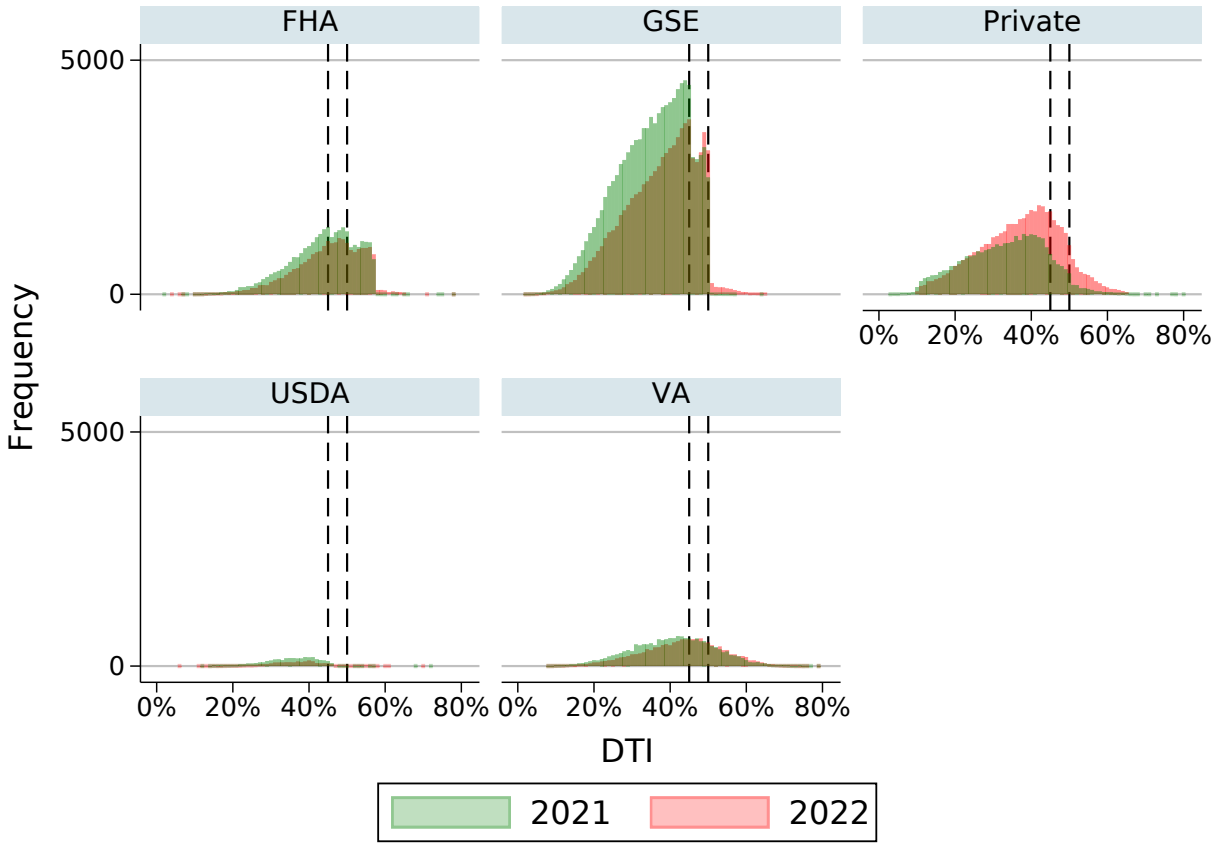


Figure A.3: Interest rate and credit score

This figure shows binned scatterplots of interest rate on the credit score (specifically the minimum credit score among borrowers for a loan) in 2021 and 2022. Source: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties in metropolitan statistical areas.

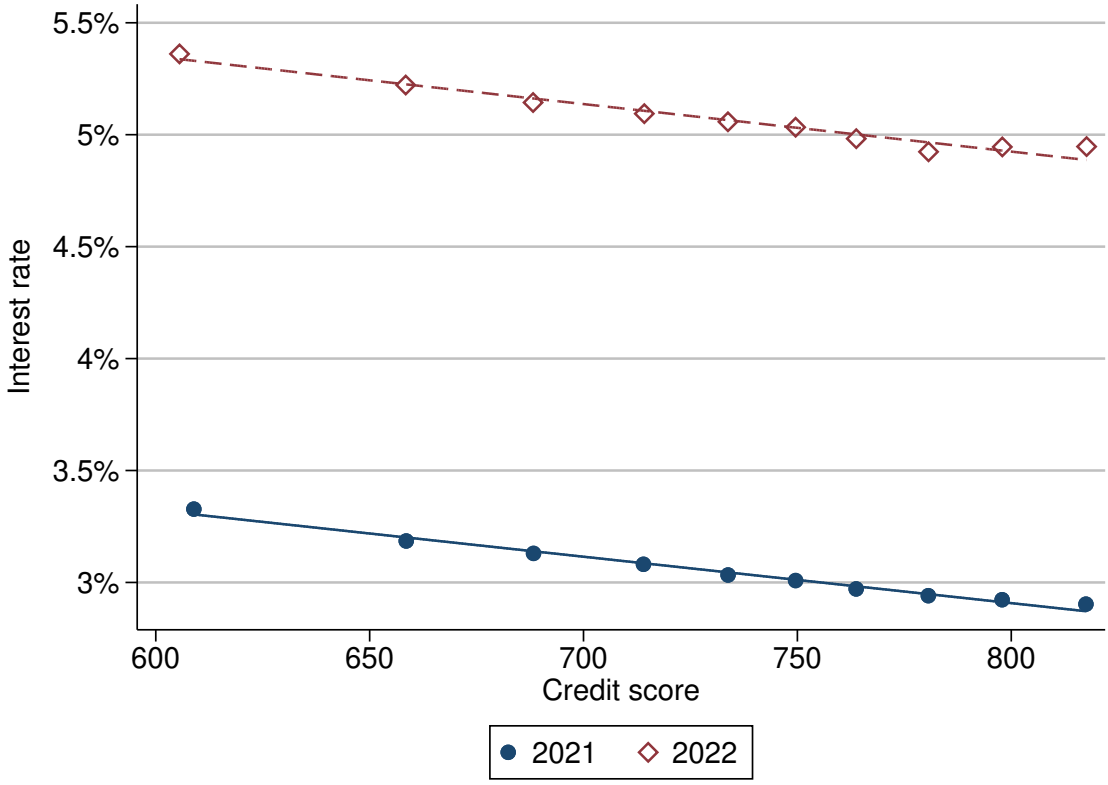


Figure A.4: Counterfactual DTI distribution by market segment

This figure shows the frequencies of the counterfactual debt-to-income (DTI) ratio for loans originated 2021 as well as the observed DTI ratio for loans originated in 2022 in each market segment: loans insured by the Federal Housing Administration (FHA), loans purchased and securitized by government-sponsored enterprises (GSE), loans retained in portfolio by lenders or securitized in the private market (Private), loans insured by the U.S. Department of Agriculture (USDA), and loans insured by the U.S. Department of Veterans Affairs (VA). The counterfactual DTI ratio is the DTI ratio a loan would have if it was originated in the same month in 2022, as described further in Section 2.3.1. The distributions are trimmed at a DTI of 80% (omits less than 0.2% of observations). Dashed lines indicate the DTI ratios of 45% and 50%. Source: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties in metropolitan statistical areas.

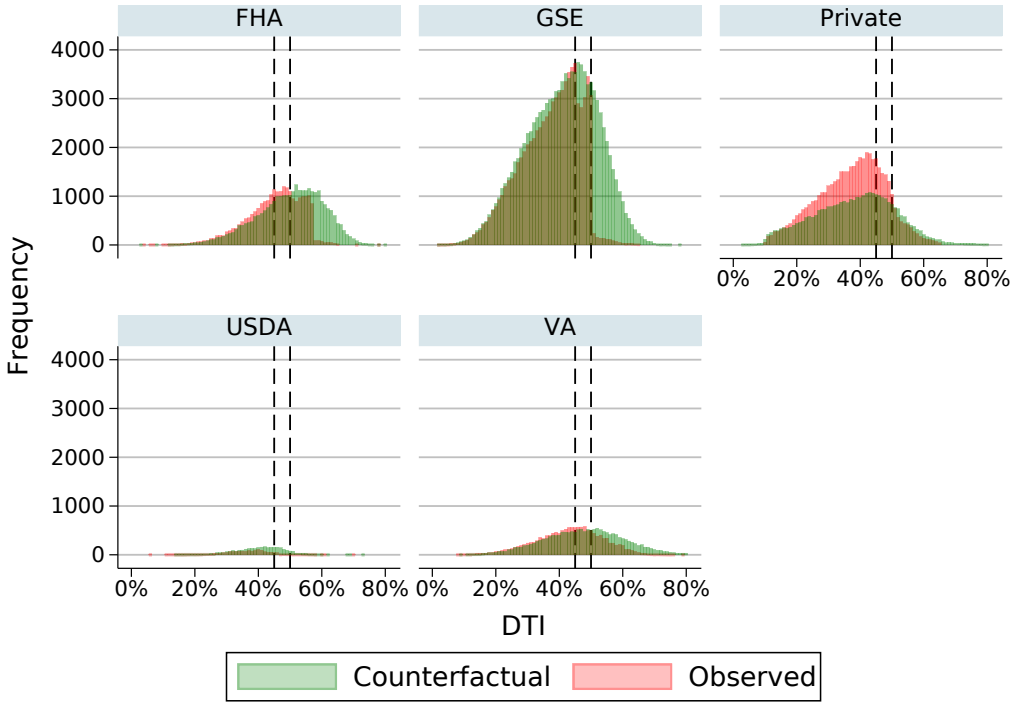


Table A.2: Variation with respect to the interest rate semi-elasticity

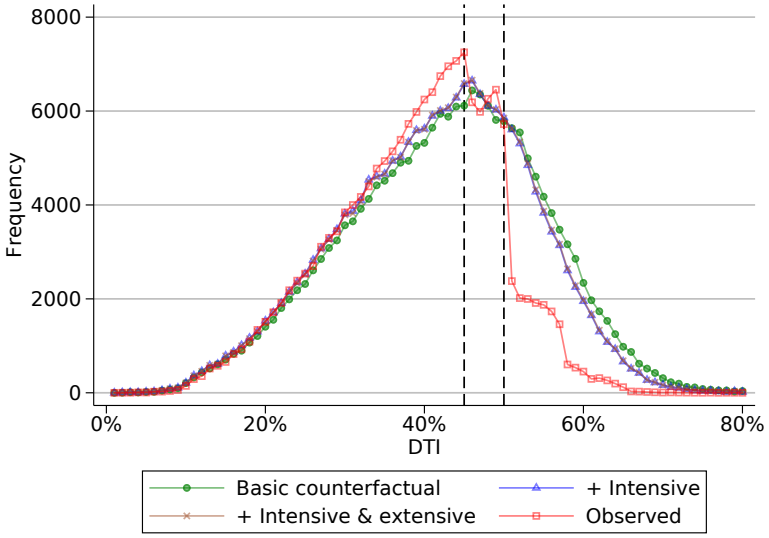
	(1)	(2)	(3)
DTI $\leq$ 40	0	0	0
41 $\leq$ DTI $\leq$ 45	1.433	1.284	1.608
	(0.170)	(0.161)	(0.180)
46 $\leq$ DTI $\leq$ 50	–0.592	–0.804	–0.084
	(0.193)	(0.184)	(0.200)
50 $<$ DTI	–15.532	–16.772	–13.072
	(0.411)	(0.420)	(0.391)
41 $\leq$ DTI	–14.691	–16.292	–11.549
	(0.525)	(0.519)	(0.548)
Observations	359,319	359,319	359,319
Bootstrap reps.	100	100	100
IR semi-elasticity	2	1.5	3

Note: This table shows the difference between the frequency of loans in 2022 with an observed debt-to-income (DTI) ratio within a given range and the frequency of loans from a given comparison year with a demand-adjusted counterfactual DTI ratio in that range as a percentage of the total number of loans in the respective counterfactual distribution. The demand-adjusted counterfactual DTI ratio is the DTI ratio a loan would have if it was originated in the same month in 2022 and then adjusting for demand on the intensive and extensive margins, as described in Section 2.4.1. The comparison year is 2021 for all columns. The columns differ by the interest rate semi-elasticity used in the intensive margin adjustment. Standard errors computed via bootstrap with 100 replications with replacement and clustered by MSA are reported in parentheses. Source: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties in metropolitan statistical areas.

Figure A.5: Demand-adjusted counterfactual distribution with 35% extensive margin threshold

Figure A.5a shows frequencies of the following for loans originated in 2021: the counterfactual debt-to-income (DTI) ratio ("Counterfactual"), the counterfactual DTI ratio after adjusting the intensive margin of demand ("+ Intensive"), and the final demand-adjusted counterfactual DTI after adjusting both the intensive and extensive margins of demand ("+ Intensive & extensive"). It also shows frequencies of the observed DTI ratio for loans originated in 2022 ("Observed"). This figure follows the construction of the demand-adjusted counterfactual DTI ratio described in Section 2.4.1 except using a threshold of 35% for the extensive margin adjustment instead of 40%. Figure A.5b shows the frequencies of the demand-adjusted counterfactual DTI ratio for loans originated in 2019, 2020, 2021 as well as the observed DTI ratio for loans originated in 2022. The distributions are trimmed at a DTI of 80%. Dashed lines indicate the DTI ratios of 45% and 50%. Source: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties in metropolitan statistical areas.

(a) 2021 (with decomposition) and 2022



(b) 2019-2021 versus 2022

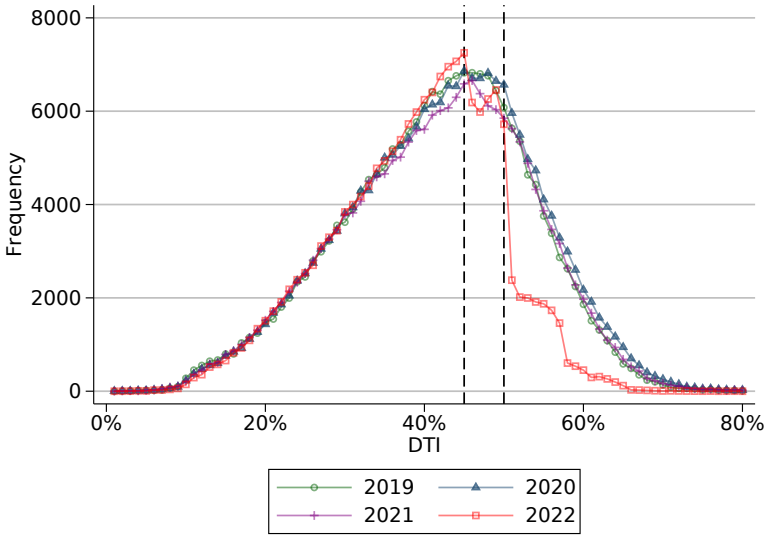


Table A.3: Comparison of counterfactual and observed distributions with 35% extensive margin threshold

	Baseline	Demand-adjusted		
	(1)	(2)	(3)	(4)
DTI $\leq$ 35	1.816	0	0	0
	(0.220)			
36 $\leq$ DTI $\leq$ 45	4.241	2.884	1.583	0.998
	(0.252)	(0.288)	(0.251)	(0.278)
46 $\leq$ DTI $\leq$ 50	0.055	–0.221	–1.410	–1.174
	(0.196)	(0.212)	(0.216)	(0.230)
50 $<$ DTI	–18.703	–15.333	–16.894	–14.216
	(0.369)	(0.414)	(0.644)	(0.644)
36 $\leq$ DTI	–14.407	–12.670	–16.722	–14.393
	(0.441)	(0.622)	(0.840)	(0.887)
Observations	359,319	359,319	337,503	328,990
Bootstrap reps.	100	100	100	100
Comparison year	2021	2021	2020	2019

Note: This table shows the difference between the frequency of loans in 2022 with an observed debt-to-income (DTI) ratio within a given range and the frequency of loans from a given comparison year with a demand-adjusted counterfactual DTI ratio in that range as a percentage of the total number of loans in the respective counterfactual distribution. This table follows the construction of the demand-adjusted counterfactual DTI ratio described in Section 2.4.1 except using a threshold of 35% for the extensive margin adjustment instead of 40%. Standard errors computed via bootstrap with 100 replications with replacement and clustered by MSA are reported in parentheses. Source: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties.

Figure A.6: Demand-adjusted counterfactual distribution adjustments

This figure shows frequencies of the following for loans originated in 2021: the counterfactual debt-to-income (DTI) ratio ("Counterfactual"), the counterfactual DTI ratio after adjusting the intensive margin of demand ("+ Intensive"), and the final demand-adjusted counterfactual DTI after adjusting both the intensive and extensive margins of demand ("+ Intensive & extensive"). It also shows frequencies of the observed DTI ratio for loans originated in 2022 ("Observed"). This figure follows the construction of the demand-adjusted counterfactual DTI ratio described in Section 2.4.1. The distributions are trimmed at a DTI of 80%. Dashed lines indicate the DTI ratios of 45% and 50%. Source: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties in metropolitan statistical areas.

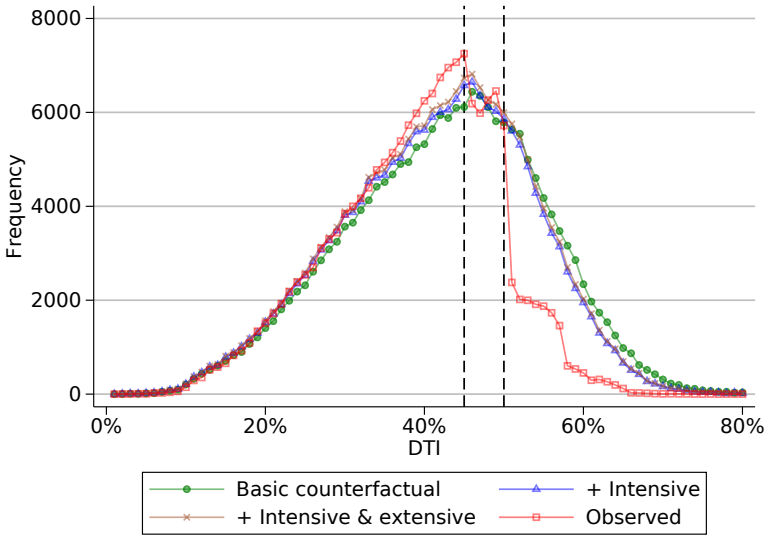


Table A.4: Demand-adjusted counterfactual distribution: summarize adjustments

	Interest diff.	Interest adj.	Income diff.	Income adj.	Value diff.	Value adj.	P&I diff.	DTI diff.	Ext.
2021	2.437	-4.875	1.742	.716	1.776	.595	415.015	4.841	2.462
2020	2.416	-4.833	2.397	.985	10.325	3.459	437.931	5.199	19.678
2019	1.531	-3.063	2.203	.905	16.584	5.556	327.43	3.89	21.711

Note: This table summarizes the series of adjustments from the observed DTI distribution in a given comparison year to the demand-adjusted counterfactual DTI distribution, following the procedure described in Section 2.4.1. "Diff." refers to the average difference in a given variable from the comparison year to 2022 (percentage point difference for interest rate and DTI ratio, percent change for income and property value, dollar amount for principal and interest payment). "Adj." refers to the average percent adjustment of the loan amount on the intensive margin associated with a given variable. "Ext." refers to the average percent change from the comparison year to 2022 on the extensive margin. Source: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties in metropolitan statistical areas.

Table A.5: Comparison of demand-adjusted counterfactual and observed distributions

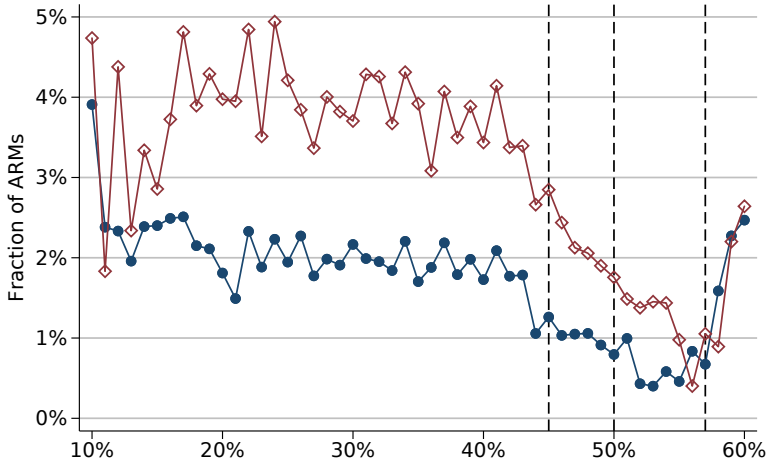
	(1)	(2)	(3)	(4)	(5)	(6)
DTI $\leq$ 40	0	0	0	0	0	0
41 $\leq$ DTI $\leq$ 45	1.433	0.872	0.657	1.318	0.628	0.255
	(0.170)	(0.181)	(0.163)	(0.190)	(0.225)	(0.210)
46 $\leq$ DTI $\leq$ 50	–0.592	–1.558	–1.201	0.271	–0.766	–1.026
	(0.193)	(0.208)	(0.220)	(0.296)	(0.276)	(0.284)
50 $<$ DTI	–15.532	–16.927	–14.150	–22.639	–23.698	–21.704
	(0.411)	(0.639)	(0.645)	(0.577)	(0.757)	(0.786)
All DTI	–14.691	–17.612	–14.695	–21.051	–23.836	–22.475
	(0.525)	(0.788)	(0.829)	(0.695)	(0.864)	(0.848)
Observations	359,319	337,541	329,002	242,261	220,058	220,803
Bootstrap reps.	100	100	100	100	100	100
Policy year	2022	2022	2022	2023	2023	2023
Comparison year	2021	2020	2019	2021	2020	2019

Note: This table shows the difference between the frequency of loans in 2022 or 2023 with an observed debt-to-income (DTI) ratio within a given range and the frequency of loans from 2021, 2020, or 2019 with a counterfactual DTI ratio, demand-adjusted counterfactual DTI ratio, or VA-adjusted counterfactual DTI ratio in that range as a percentage of the total number of loans in the respective counterfactual distribution. The demand-adjusted counterfactual DTI ratio is the DTI ratio a loan would have if it was originated in the same month in 2022 and then adjusting for demand on the intensive and extensive margins, as described in Section 2.4.1. Standard errors computed via bootstrap with 100 replications with replacement and clustered by MSA are reported in parentheses. Source: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties. Column (5) uses the Home Mortgage Disclosure Act, restricting to purchase loans originated for one-unit, owner-occupied, site-built properties in metropolitan statistical areas.

Figure A.7: Fraction of adjustable-rate and short-term mortgages

Figure A.7a shows the fraction of adjustable-rate mortgages (ARMs) for loans originated in 2021 and 2022. We focus on DTI ratios from 10% to 60% to avoid DTI ratios with a low observation count. Dashed lines indicate the DTI ratios of 45%, 50%, and 57%. Figure A.7b is similar except showing the fraction of mortgages with a term of 10, 15, or 20 years among mortgages with a term of exactly 10, 15, 20, or 30 years. Source: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties in metropolitan statistical areas.

(a) Fraction of ARMs



(b) Fraction of shorter-term mortgages

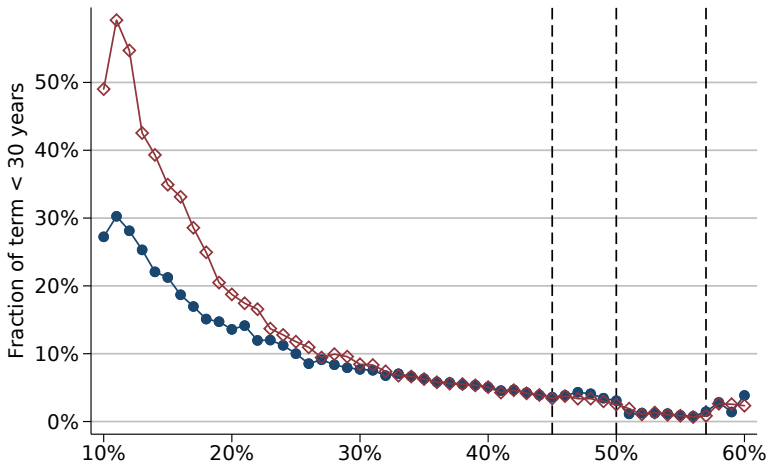
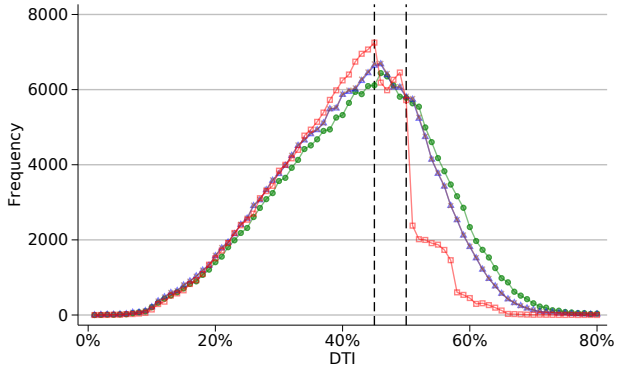


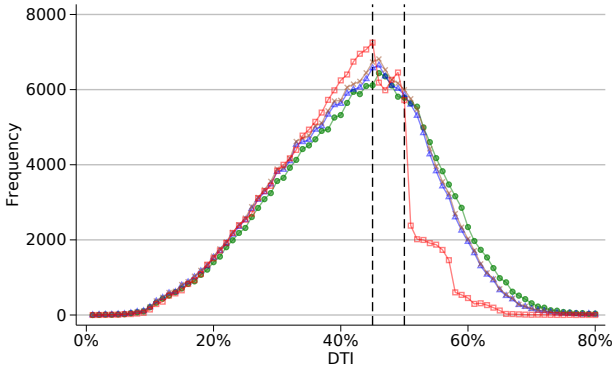
Figure A.8: Demand-adjusted counterfactual distribution without income and house prices

The right subfigures show frequencies of the following for loans originated in 2021: the counterfactual debt-to-income (DTI) ratio ("Counterfactual"), the counterfactual DTI ratio after adjusting the intensive margin of demand ("+ Intensive"), and the final demand-adjusted counterfactual DTI after adjusting both the intensive and extensive margins of demand ("+ Intensive & extensive"). They also show frequencies of the observed DTI ratio for loans originated in 2022 ("Observed"). See Section 2.4.1 for further details on the construction of the demand-adjusted counterfactual DTI ratio. The left subfigures are similar except omitting the demand adjustments for income and house prices. The distributions are trimmed at a DTI of 80%. Dashed lines indicate the DTI ratios of 45% and 50%. Source: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties in metropolitan statistical areas.

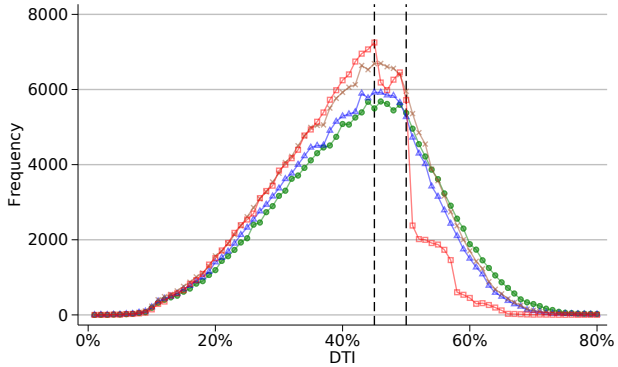
(a) 2021: without income and house prices



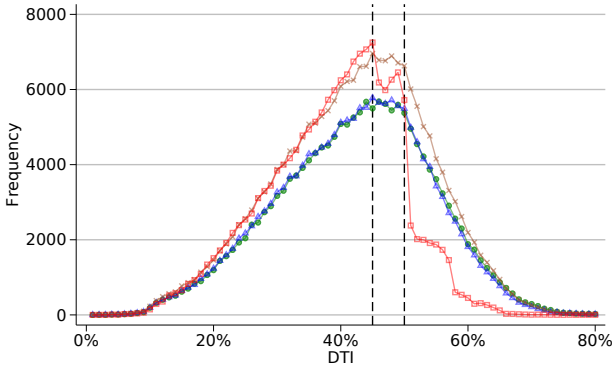
(b) 2021: with income and house prices



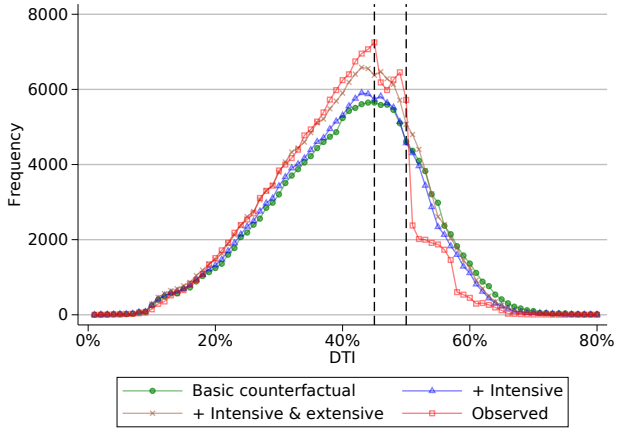
(c) 2020: without income and house prices



(d) 2020: with income and house prices



(e) 2019: without income and house prices



(f) 2019: with income and house prices

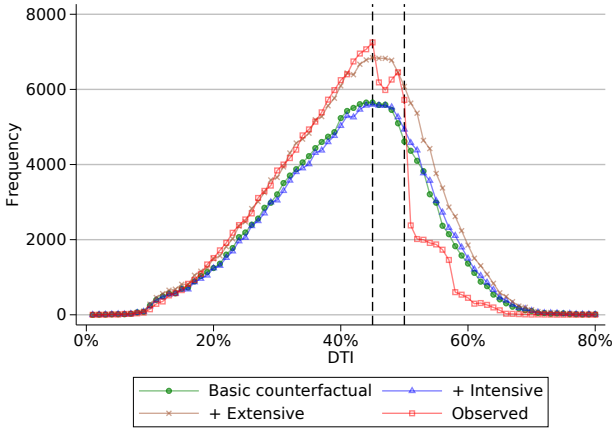


Table A.6: Demand-adjusted counterfactual distribution without income and house prices: summarize adjustments

	Interest diff.	Interest adj.	P&I diff.	DTI diff.	Ext.
2021	2.437	-4.875	400.08	4.574	.397
2020	2.416	-4.833	364.417	4.273	12.605
2019	1.531	-3.063	224.029	2.601	11.122

Note: This table summarizes the series of adjustments from the observed distribution in a given comparison year to the demand-adjusted counterfactual distribution, following the procedure described in Section 2.4.1 except omitting intensive margin adjustments for income and house prices. "Diff." refers to the average difference in a given variable from the comparison year to 2022 (percentage point difference for interest rate and DTI ratio, percent change for income and property value, dollar amount for principal and interest payment). "Adj." refers to the average percent adjustment of the loan amount on the intensive margin associated with a given variable. "Ext." refers to the average percent change from the comparison year to 2022 on the extensive margin. Source: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties in metropolitan statistical areas.

Figure A.9: Demand-adjusted counterfactual distribution without income and house prices: compare years

This figure shows the frequencies of the demand-adjusted counterfactual DTI ratio (omitting adjustments for income and house prices) for loans originated in 2019, 2020, 2021 as well as the observed DTI ratio for loans originated in 2022. See Section 2.4.1 for further details on the construction of the demand-adjusted counterfactual DTI ratio, except in this case we omit the demand adjustments for income and house prices. The distributions are trimmed at a DTI of 80%. Dashed lines indicate the DTI ratios of 45% and 50%. Source: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties in metropolitan statistical areas.

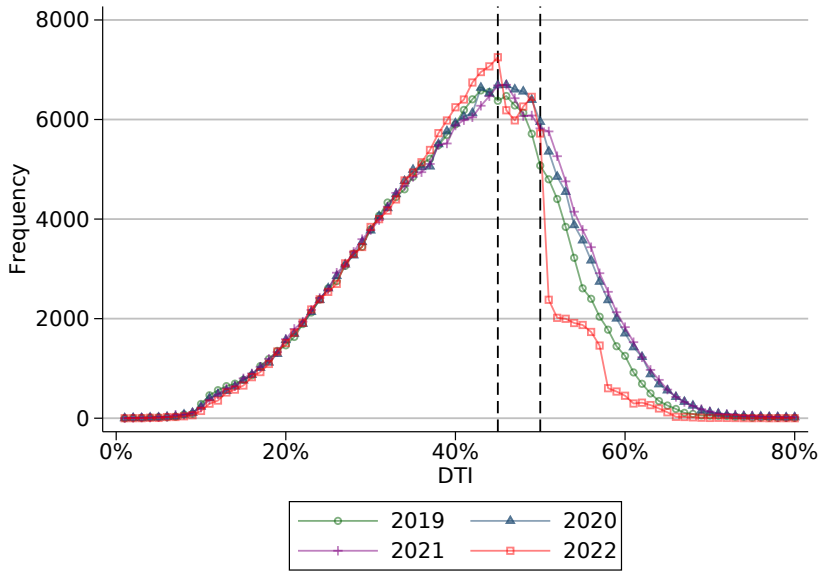


Table A.7: Demand-adjusted counterfactual distribution without income and house prices: comparison with observed

	(1)	(2)	(3)
DTI $\leq$ 40	0	0	0
41 $\leq$ DTI $\leq$ 45	1.538	1.242	1.286
	(0.172)	(0.166)	(0.189)
46 $\leq$ DTI $\leq$ 50	–0.254	–0.837	0.518
	(0.181)	(0.214)	(0.169)
50 $<$ DTI	–14.220	–12.842	–8.370
	(0.314)	(0.359)	(0.362)
41 $\leq$ DTI	–12.937	–12.437	–6.566
	(0.386)	(0.456)	(0.520)
Observations	359,319	337,541	329,002
Bootstrap reps.	100	100	100
Comparison year	2021	2020	2019

Note: This table shows the difference between the frequency of loans in 2022 with an observed debt-to-income (DTI) ratio within a given range and the frequency of loans in a given comparison year with a demand-adjusted counterfactual DTI ratio (omitting adjustments for income and house prices) in that range as a percentage of the total number of loans in the latter. The demand-adjusted counterfactual DTI distribution is based on the DTI that a loan would have had if it was originated in the same month of 2022 and then adjusting for demand on the intensive and extensive margin, similar to the description in Section 2.4.1 but omitting the adjustments for income and house prices. Standard errors computed via bootstrap with 100 replications with replacement and clustered by MSA are reported in parentheses. Source: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties in metropolitan statistical areas.

Figure A.10: Demand-adjusted counterfactual distribution placebo

Note: This table shows frequencies of the following for loans originated in 2020: the counterfactual debt-to-income (DTI) ratio relative to 2021 ("Counterfactual"), the counterfactual DTI ratio after adjusting the intensive margin of demand ("+ Intensive"), and the final demand-adjusted counterfactual DTI after adjusting both the intensive and extensive margins of demand ("+ Intensive & extensive"). It also shows frequencies of the observed DTI ratio for loans originated in 2021 ("Observed"). See Section 2.4.1 for further details on the construction of the demand-adjusted counterfactual DTI ratio, except in this case it is relative to 2021. The distributions are trimmed at a DTI of 80%. Dashed lines indicate the DTI ratios of 45% and 50%. Source: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties in metropolitan statistical areas.

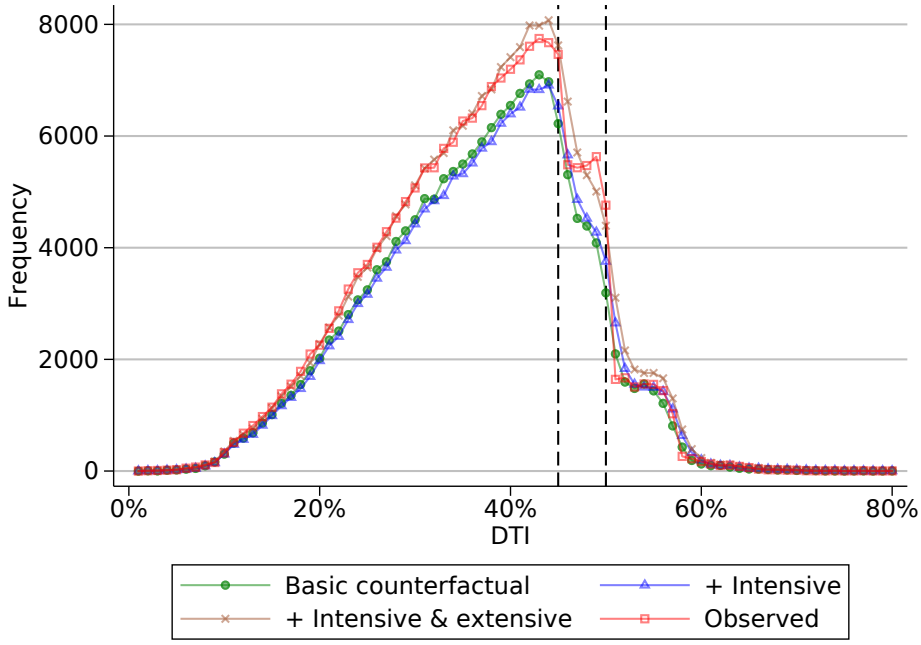


Table A.8: Demand-adjusted counterfactual distribution placebo: comparison with observed

	(1)	(2)	(3)
DTI $\leq$ 40	0	0	0
41 $\leq$ DTI $\leq$ 45	–0.706	0.125	1.582
	(0.187)	(0.245)	(0.203)
46 $\leq$ DTI $\leq$ 50	–0.121	1.036	0.877
	(0.251)	(0.263)	(0.174)
50 $<$ DTI	–2.058	–0.719	0.386
	(0.223)	(0.190)	(0.118)
41 $\leq$ DTI	–2.885	0.443	2.845
	(0.537)	(0.608)	(0.346)
Observations	361,682	353,143	331,365
Bootstrap reps.	100	100	100
Observed year	2021	2021	2020
Comparison year	2020	2019	2019

Note: This table shows the difference between the frequency of loans in a given "observed year" with an observed debt-to-income (DTI) ratio within a given range and the frequency of loans in a given "comparison year" with a demand-adjusted counterfactual DTI ratio (relative to the observed year) in that range as a percentage of the total number of loans in the counterfactual distribution. The demand-adjusted counterfactual DTI distribution is based on the DTI that a loan would have had if it was originated in the same month of the "observed year" and then adjusting for demand on the intensive and extensive margin, similar to the description in Section 2.4.1 except modifying the observed year. Standard errors computed via bootstrap with 100 replications with replacement and clustered by MSA are reported in parentheses. Source: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties in metropolitan statistical areas.

Figure A.11: Interest rates for VA and non-VA loans

Note: This figure shows the estimated interest rate for originations with a loan-to-value ratio of 75% and credit score of 760, estimated separately for VA loans and non-VA loans. Specifically, each point is the estimated value of a regression of the interest rate on a dummy for each year, the LTV ratio (minus 75%), and the minimum credit score among the borrowers (minus 760). We omit the constant term. Source: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties in metropolitan statistical areas.

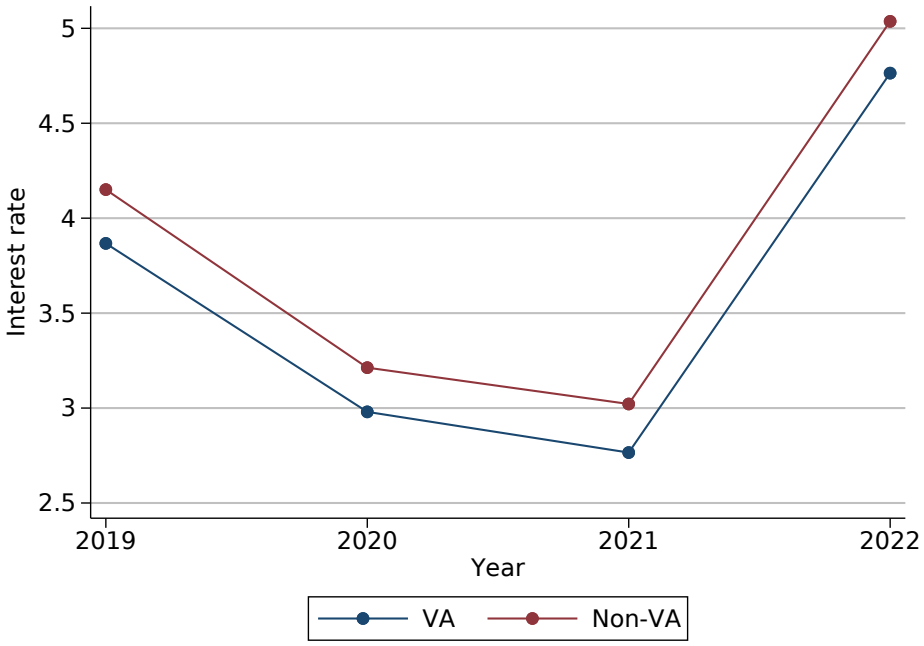


Table A.9: Comparison of VA and non-VA loans

(a) VA loans

	N	Mean	SD	P25	P50	P75
Interest rate (%)	16,818	2.84	0.43	2.50	2.75	3.00
Debt-to-income (%)	16,818	40.65	10.23	33.00	41.00	48.00
Loan-to-value (%)	16,818	97.46	9.54	98.00	100.00	102.00
Credit score	16,818	717.10	63.59	667.00	723.00	768.00
Loan amount ($1000s)	16,818	365.59	183.36	245.00	325.30	441.75
House value ($1000s)	16,818	379.59	200.83	250.00	335.00	454.50
Non-mortgage debts (%)	16,807	15.12	9.65	8.00	14.00	22.00
Age	16,818	40.57	13.42	30.00	37.00	49.00
Income ($1000s)	16,818	97.93	51.72	63.00	85.00	119.00

(b) Non-VA loans

	N	Mean	SD	P25	P50	P75
Interest rate (%)	174,912	3.07	0.53	2.75	3.00	3.25
Debt-to-income (%)	174,912	36.28	10.03	29.00	37.00	44.00
Loan-to-value (%)	174,912	82.35	17.23	78.00	88.00	95.00
Credit score	174,912	732.82	61.28	691.00	743.00	781.00
Loan amount ($1000s)	174,912	339.90	236.68	191.47	285.00	419.94
House value ($1000s)	174,912	428.37	325.87	228.00	340.00	515.00
Non-mortgage debts (%)	174,685	12.88	8.87	6.00	12.00	19.00
Age	174,912	40.74	12.54	31.00	38.00	48.50
Income ($1000s)	174,912	113.81	80.60	61.00	90.00	138.00

Note: These tables present summary statistics for Veterans Affairs (VA) loans and non-VA loans in 2021. *Interest rate* is the annualized interest rate at origination. *Debt-to-income* (DTI) is the ratio of all debt payments to household income. *Loan-to-value* (LTV) is the ratio of the loan amount to the lesser of the appraised value and the sale price. *Credit score* is the minimum credit score among the borrowers on a loan. *Loan amount* is self-explanatory. *House value* is the minimum of the sale price and appraised value. *Non-mortgage debts* is the back-end debt-to-income ratio minus the front-end payment-to-income ratio. *Age* is the mean age among the borrowers on a loan. *Income* is the annual household income. *VA* indicates whether a loan insured by the U.S. Department of Veterans Affairs. Continuous variables are winsorized at 1% in each year. Source: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties in metropolitan statistical areas.

Table A.10: VA-adjusted counterfactual DTI distribution for different comparison years

	(1)	(2)	(3)
DTI $\leq$ 40	0	0	0
41 $\leq$ DTI $\leq$ 45	–1.601	–1.632	–1.260
	(0.237)	(0.215)	(0.165)
46 $\leq$ DTI $\leq$ 50	–1.318	–0.828	–1.383
	(0.197)	(0.188)	(0.205)
50 $<$ DTI	–13.978	–16.166	–13.035
	(0.717)	(0.839)	(0.717)
All DTI	–16.898	–18.626	–15.678
	(0.941)	(0.998)	(0.910)
Observations	6,957,063	6,720,799	6,384,867
Bootstrap replications	100	100	100
Policy year	2022	2022	2022
Comparison year	2021	2020	2019

Note: This table shows the difference between the frequency of loans in 2022 with an observed debt-to-income (DTI) ratio within a given range and the frequency of loans in a given comparison year with a VA-adjusted counterfactual DTI ratio (relative to the observed year) in that range as a percentage of the total number of loans in the counterfactual distribution. The VA-adjusted counterfactual DTI distribution is based on the growth in the number of Veterans Affairs (VA) loans, as described in further detail in Section 2.5.1. Standard errors computed via bootstrap with 100 replications with replacement and clustered by MSA are reported in parentheses. Source: Home Mortgage Disclosure Act, restricting to purchase loans originated in 2019-2021 for one-unit, owner-occupied, site-built properties in metropolitan statistical areas.

Figure A.12: VA-adjusted counterfactual DTI distribution

This figure shows the frequencies of the debt-to-income (DTI) ratio for the observed distribution in 2022 and VA-adjusted counterfactual DTI distributions in 2019, 2020, and 2021. The VA-adjusted counterfactual DTI distribution is based on the growth in the number of Veterans Affairs (VA) loans, as described in further detail in Section 2.5.1. Dashed lines indicate the DTI ratios of 45% and 50%. Source: Home Mortgage Disclosure Act, restricting to purchase loans originated in 2019-2021 for one-unit, owner-occupied, site-built properties in metropolitan statistical areas.

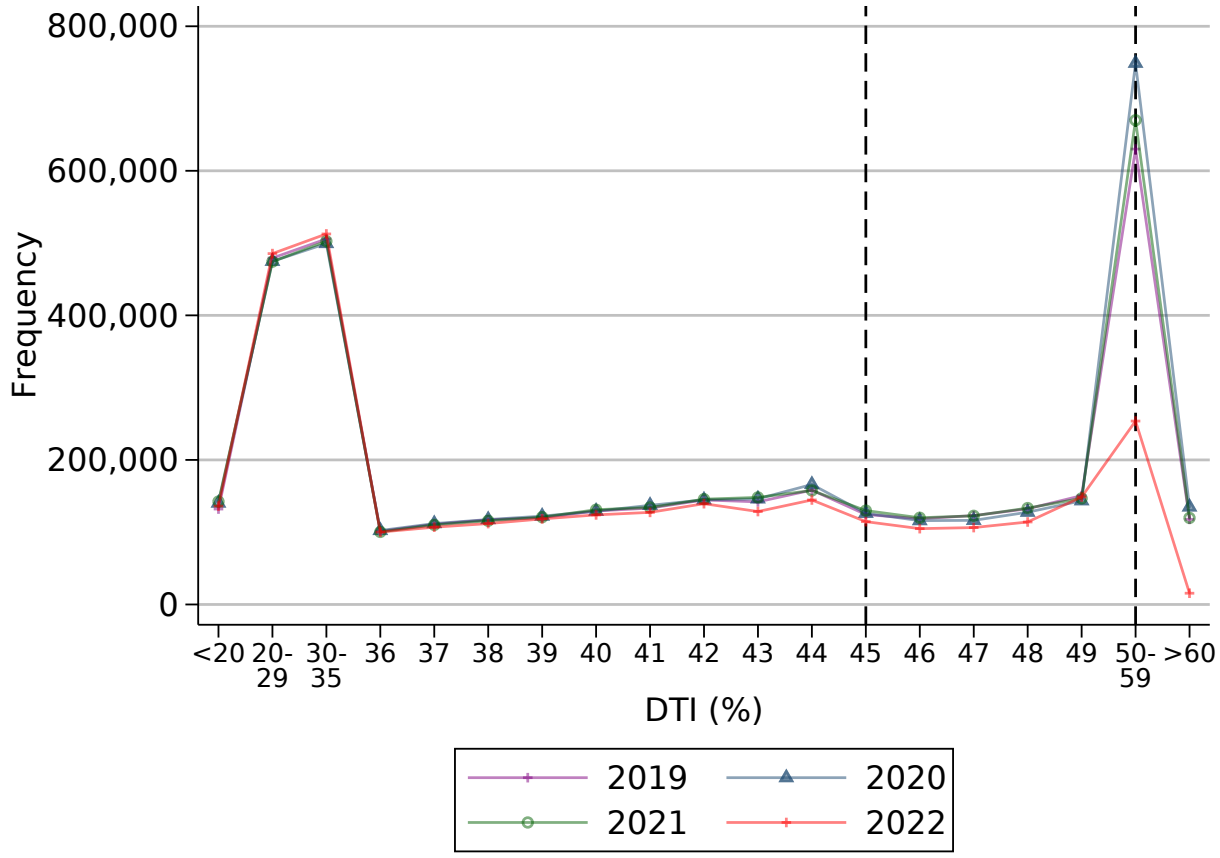


Table A.11: VA-adjusted counterfactual DTI distribution placebo

	(1)	(2)	(3)
DTI $\leq$ 40	0	0	0
41 $\leq$ DTI $\leq$ 45	–0.076	0.440	0.526
	(0.209)	(0.322)	(0.281)
46 $\leq$ DTI $\leq$ 50	0.657	–0.042	–0.759
	(0.169)	(0.215)	(0.187)
50 $<$ DTI	–3.488	1.599	5.134
	(0.380)	(0.450)	(0.518)
41 $\leq$ DTI	–2.907	1.997	4.900
	(0.523)	(0.824)	(0.676)
Observations	7,466,360	7,130,428	6,894,164
Bootstrap replications	100	100	100
Observed year	2021	2021	2020
Comparison year	2020	2019	2019

Note: This table shows the difference between the frequency of loans in a given "observed year" with an observed debt-to-income (DTI) ratio within a given range and the frequency of loans in a given "comparison year" with a VA-adjusted counterfactual DTI ratio (relative to the observed year) in that range as a percentage of the total number of loans in the counterfactual distribution. The VA-adjusted counterfactual DTI distribution is based on the growth in the number of Veterans Affairs (VA) loans, as described in further detail in Section 2.5.1 except modifying the observed year. Standard errors computed via bootstrap with 100 replications with replacement and clustered by MSA are reported in parentheses. Source: Home Mortgage Disclosure Act, restricting to purchase loans originated in 2019-2021 for one-unit, owner-occupied, site-built properties in metropolitan statistical areas.

B Additional material for Section 3

Figure B.1: High counterfactual DTI by race and ethnicity (using 50% threshold)

This figure shows the percentage of loans having a counterfactual DTI (CDTI) above 50%, when the policy year is either 2022 or 2023, for subsamples consisting of loans where all the borrowers are non-Hispanic black, Hispanic, or non-Hispanic white. The counterfactual DTI ratio is the DTI ratio a loan would have if it was originated in the same month in 2022, as described further in Section 2.3.1. Source: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties in metropolitan statistical areas.

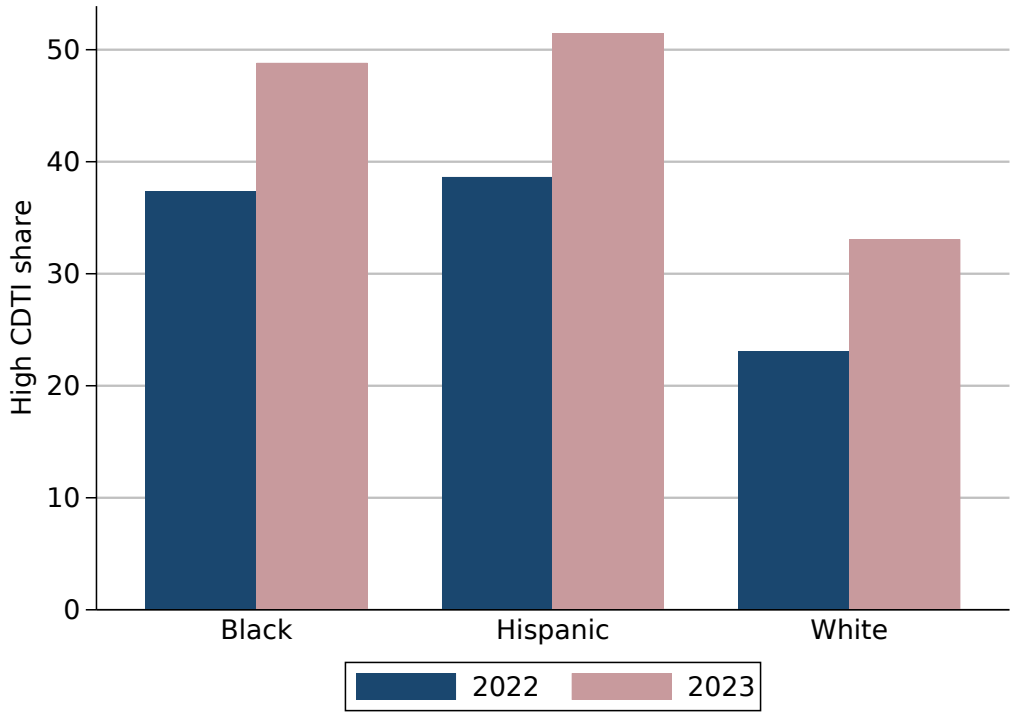
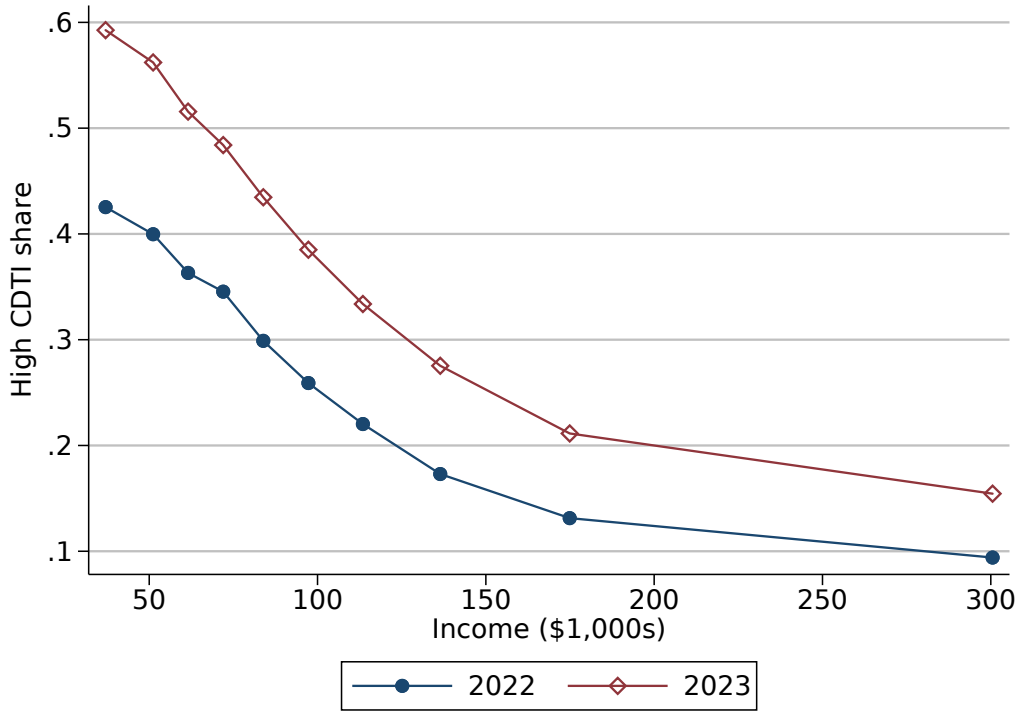


Figure B.2: High counterfactual DTI by income (using 50% threshold)

This figure shows a binned scatterplot of an indicator for a loan having a counterfactual DTI (CDTI) above 50%, when the policy year is either 2022 or 2023. The counterfactual DTI ratio is the DTI ratio a loan would have if it was originated in the same month in 2022, as described further in Section 2.3.1. Source: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties in metropolitan statistical areas.



C Additional material for Section 4

Table C.1: Summary statistics for the MSA-level analysis

	N	Mean	SD	P25	P75
High-DTI share (threshold: 50%)	381	0.261	0.082	0.201	0.317
High-DTI share (mod. for inc. and hp.)	381	0.299	0.094	0.232	0.361
High-DTI share (threshold: 45%)	381	0.290	0.061	0.249	0.325
Purchase loan amount gr. 2021-2023	381	-0.216	0.201	-0.336	-0.107
Purchase loan amount gr. 2020-2021	381	0.299	0.245	0.156	0.410
House price growth 2021Q4-2023Q4	381	0.184	0.064	0.145	0.227
House price growth 2020Q4-2021Q4	381	0.179	0.051	0.145	0.210
Cashout loan amount gr. 2021-2023	381	-0.728	0.201	-0.853	-0.670
Cashout loan amount gr. 2020-2021	381	0.449	0.403	0.205	0.641
Spending growth 2021-2023	342	0.105	0.067	0.066	0.136
Spending growth 2020-2021	354	0.165	0.053	0.137	0.192
Employees growth 2020-2021	381	-3.760	3.113	-5.691	-1.937
Log(per capita income)	381	10.434	0.184	10.309	10.547
WRLURI	302	-0.029	0.712	-0.482	0.365

Note: This table presents summary statistics for the MSA-level exercises. *High-DTI share (threshold: 50%)* is the fraction of originations in 2019-2021 having a counterfactual DTI (relative to 2023) greater than 50% but an observed DTI less than 50%. *High-DTI share (mod. for inc. and hp.)* is the fraction of originations in 2019-2021 having an observed DTI less than 50% but a counterfactual DTI (relative to 2023) greater than 50% after adjusting loan amounts in 2019 and 2020 to 2021 by multiplying the coefficients on house prices and income in Table 2 by the difference in the logarithm of the respective MSA-level median and adjusting for inflation. *High-DTI share (threshold: 45%)* is the fraction of originations in 2019-2021 having a counterfactual DTI (relative to 2023) greater than 45% but an observed DTI less than 45%. The counterfactual DTI ratio is the DTI ratio a loan would have if it was originated in the same month in 2023, as described further in Section 2.3.1. *Purchase loan amount gr. 2021-2023 (2020-2021)* is the growth in the dollar amount of purchase loans from 2021 to 2023 (or 2020 to 2021). *House price growth 2021Q4-2023Q4 (2020Q4-2021Q4)* is the growth of the FHFA all-transactions house price index from 2021Q4 to 2023Q4 (or 2020Q4 to 2021Q4). *Cashout loan amount gr. 2021-2023 (2020-2021)* is the growth in the dollar amount of cashout refinance loans from 2021 to 2022 (or 2020 to 2021). *Spending growth 2021-2023 (2020-2021)* is the change in debt and credit card spending (relative to January 6 to February 2nd, 2020) from 2021 to 2022 (or 2020 to 2021), based on data from the Economic Tracker associated with Chetty et al. (2022). *Employees growth 2020-2021* is the growth in the number of employees from 2020 to 2021 (using the County Business Pattern data provided by the US Census Bureau). *Log(per capita income)* is the logarithm of per capita income in the past 12 months (in 2021 inflation-adjusted dollars) as of 2021 (using the American Community Survey 1-year estimates). *WRLURI* is MSA-level mean of the Wharton Land Use Regulatory Index. Source for mortgage data: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties in metropolitan statistical areas.

Table C.2: Local impact of high-DTI share on purchase loans and house prices (2021 to 2022)

(a) High-DTI share and purchase loan growth

	(1)	(2)	(3)	(4)
High-DTI share	-0.945	-0.982	-1.131	-1.201
	(0.173)	(0.167)	(0.156)	(0.123)
Observations	381	381	302	302
R^2	0.087	0.190	0.198	0.290
DTI type	CDTI>50%	CDTI>50%	CDTI>50%	CDTI>50%
Base controls	No	Yes	Yes	Yes
Elasticity	No	No	WRLURI	WRLURI
Weighted	No	No	No	Yes

(b) High-DTI share and house price growth

	(1)	(2)	(3)	(4)
High-DTI share	-0.097	-0.239	-0.275	-0.212
	(0.045)	(0.052)	(0.053)	(0.088)
Observations	379	379	301	301
R^2	0.014	0.176	0.208	0.275
DTI type	CDTI>50%	CDTI>50%	CDTI>50%	CDTI>50%
Base controls	No	Yes	Yes	Yes
Elasticity	No	No	WRLURI	WRLURI
Weighted	No	No	No	Yes

Note: Column (1) regresses the MSA-level growth in the total dollar volume of purchase mortgage originations from 2021 to 2022 (Table C.2a) or the MSA-level growth of the FHFA all-transactions house price index from 2021Q4 to 2022Q4 (Table C.2b) on the high-DTI share, which is defined as the fraction of originations in 2019-2021 having a counterfactual DTI (CDTI) relative to 2022 greater than 50% and an observed DTI less than 50%. The counterfactual DTI ratio is the DTI ratio a loan would have if it was originated in the same month in 2022, as described further in Section 2.3.1. Column (2) adds the following control variables: the lagged dependent variable (growth of purchase loan volume from 2020 to 2021 or house price growth from 2020Q4 to 2021Q4), the growth in the number of employees from 2020 to 2021 (using the County Business Pattern data provided by the US Census Bureau), and per capita income in the past 12 months (in 2021 inflation-adjusted dollars) as of 2021 (using the American Community Survey 1-year estimates). Column (3) adds the CBSA-level mean of the Wharton Land Use Regulatory Index (WRLURI) from Gyourko, Hartley, and Krimmel (2021) to control for housing supply elasticity. Column (4) weights by population based on the 2020 census. Robust standard errors are reported in parentheses. Source for mortgage data: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties in metropolitan statistical areas.

Table C.3: Local impact of high-DTI share on cash-out refinance loans and spending (2021 to 2022)

(a) High-DTI share and cash-out refinance growth

	(1)	(2)	(3)	(4)
High-DTI share	-0.945	-0.725	-0.662	-1.019
	(0.167)	(0.172)	(0.181)	(0.148)
Observations	381	381	302	302
R^2	0.059	0.122	0.131	0.269
DTI type	CDTI>50%	CDTI>50%	CDTI>50%	CDTI>50%
Base controls	No	Yes	Yes	Yes
Elasticity	No	No	WRLURI	WRLURI
Weighted	No	No	No	Yes

(b) High-DTI share and spending growth

	(1)	(2)	(3)	(4)
High-DTI share	-0.247	-0.261	-0.261	-0.312
	(0.038)	(0.038)	(0.040)	(0.060)
Observations	342	342	275	275
R^2	0.092	0.148	0.167	0.336
DTI type	CDTI>50%	CDTI>50%	CDTI>50%	CDTI>50%
Base controls	No	Yes	Yes	Yes
Elasticity	No	No	WRLURI	WRLURI
Weighted	No	No	No	Yes

Note: Column (1) regresses the MSA-level growth in the total dollar volume of cash-out refinance originations from 2021 to 2022 (Table C.3a) or the MSA-level change in debt and credit card spending (relative to January 6 to February 2nd, 2020) from 2021 to 2022 (Table C.3b) on the high-DTI share, which is defined as the fraction of originations in 2019-2021 having a counterfactual DTI (CDTI) relative to 2022 greater than 50% and an observed DTI below 50%. The counterfactual DTI ratio is the DTI ratio a loan would have if it was originated in the same month in 2022, as described further in Section 2.3.1. Column (2) adds the following control variables: the lagged dependent variable (growth of cash-out refinance volume from 2020 to 2021 or change in spending from 2020 to 2021), the growth in the number of employees from 2020 to 2021 (using the County Business Pattern data provided by the US Census Bureau), and per capita income in the past 12 months (in 2021 inflation-adjusted dollars) as of 2021 (using the American Community Survey 1-year estimates). Column (3) adds the CBSA-level mean of the Wharton Land Use Regulatory Index (WRLURI) from Gyourko, Hartley, and Krimmel (2021) to control for housing supply elasticity. Column (4) weights by population based on the 2020 census. Robust standard errors are reported in parentheses. Source for mortgage data: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties in metropolitan statistical areas.

Table C.4: Local impact of high-DTI share on purchase loans and house prices (using the 45% DTI threshold)

(a) High-DTI share and purchase loan growth

	(1)	(2)	(3)	(4)
High-DTI share	-1.174	-1.117	-1.296	-1.809
	(0.173)	(0.164)	(0.193)	(0.202)
Observations	381	381	302	302
R^2	0.128	0.171	0.221	0.495
DTI type	CDTI>45%	CDTI>45%	CDTI>45%	CDTI>45%
Base controls	No	Yes	Yes	Yes
Elasticity	No	No	WRLURI	WRLURI
Weighted	No	No	No	Yes

(b) High-DTI share and house price growth

	(1)	(2)	(3)	(4)
High-DTI share	-0.348	-0.500	-0.553	-0.554
	(0.050)	(0.059)	(0.069)	(0.145)
Observations	381	381	302	302
R^2	0.113	0.191	0.228	0.242
DTI type	CDTI>45%	CDTI>45%	CDTI>45%	CDTI>45%
Base controls	No	Yes	Yes	Yes
Elasticity	No	No	WRLURI	WRLURI
Weighted	No	No	No	Yes

Note: Column (1) regresses the MSA-level growth in the total dollar volume of purchase mortgage originations from 2021 to 2023 (Table C.4a) or the MSA-level growth of the FHFA all-transactions house price index from 2021Q4 to 2023Q4 (Table C.4b) on the high-DTI share, which is defined as the fraction of originations in 2019-2021 having a counterfactual DTI (CDTI) greater than 45% and an observed DTI ratio below 45%. The counterfactual DTI ratio is the DTI ratio a loan would have if it was originated in the same month in 2023, as described further in Section 2.3.1. Column (2) adds the following control variables: the lagged dependent variable (growth of purchase loan volume from 2020 to 2021 or house price growth from 2020Q4 to 2021Q4), the growth in the number of employees from 2020 to 2021 (using the County Business Pattern data provided by the US Census Bureau), and per capita income in the past 12 months (in 2021 inflation-adjusted dollars) as of 2021 (using the American Community Survey 1-year estimates). Column (3) adds the CBSA-level mean of the Wharton Land Use Regulatory Index (WRLURI) from Gyourko, Hartley, and Krimmel (2021) to control for housing supply elasticity. Column (4) weights by population based on the 2020 census. Robust standard errors are reported in parentheses. Source for mortgage data: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties in metropolitan statistical areas.

Table C.5: Local impact of high-DTI share on cash-out refinance loans and spending (using the 45% DTI threshold)

(a) High-DTI share and cash-out refinance growth

	(1)	(2)	(3)	(4)
High-DTI share	-1.283	-1.084	-1.145	-1.189
	(0.127)	(0.130)	(0.180)	(0.123)
Observations	381	381	302	302
R^2	0.153	0.221	0.238	0.400
DTI type	CDTI>45%	CDTI>45%	CDTI>45%	CDTI>45%
Base controls	No	Yes	Yes	Yes
Elasticity	No	No	WRLURI	WRLURI
Weighted	No	No	No	Yes

(b) High-DTI share and spending growth

	(1)	(2)	(3)	(4)
High-DTI share	-0.341	-0.375	-0.384	-0.521
	(0.052)	(0.058)	(0.070)	(0.096)
Observations	342	340	273	273
R^2	0.105	0.127	0.129	0.261
DTI type	CDTI>45%	CDTI>45%	CDTI>45%	CDTI>45%
Base controls	No	Yes	Yes	Yes
Elasticity	No	No	WRLURI	WRLURI
Weighted	No	No	No	Yes

Note: Column (1) regresses the MSA-level growth in the total dollar volume of cash-out refinance originations from 2021 to 2023 (Table C.5a) or the MSA-level change in debt and credit card spending (relative to January 6 to February 2nd, 2020) from 2021 to 2023 (Table C.5b) on the high-DTI share, which is defined as the fraction of originations in 2019-2021 having a counterfactual DTI (CDTI) greater than 45% and an observed DTI below 45%. The counterfactual DTI ratio is the DTI ratio a loan would have if it was originated in the same month in 2023, as described further in Section 2.3.1. Column (2) adds the following control variables: the lagged dependent variable (growth of cash-out refinance volume from 2020 to 2021 or change in spending from 2020 to 2021), the growth in the number of employees from 2020 to 2021 (using the County Business Pattern data provided by the US Census Bureau), and per capita income in the past 12 months (in 2021 inflation-adjusted dollars) as of 2021 (using the American Community Survey 1-year estimates). Column (3) adds the CBSA-level mean of the Wharton Land Use Regulatory Index (WRLURI) from Gyourko, Hartley, and Krimmel (2021) to control for housing supply elasticity. Column (4) weights by population based on the 2020 census. Robust standard errors are reported in parentheses. Source for mortgage data: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties in metropolitan statistical areas.

Table C.6: Local impact of high-DTI share on purchase loans and house prices (adjusting 2019 and 2020 to 2021)

(a) High-DTI share and purchase loan growth

	(1)	(2)	(3)	(4)
High-DTI share	-0.680	-0.644	-0.687	-0.848
	(0.115)	(0.115)	(0.123)	(0.130)
Observations	381	381	302	302
R^2	0.101	0.148	0.180	0.406
DTI type	CDTI>50%	CDTI>50%	CDTI>50%	CDTI>50%
Base controls	No	Yes	Yes	Yes
Elasticity	No	No	WRLURI	WRLURI
Weighted	No	No	No	Yes

(b) High-DTI share and house price growth

	(1)	(2)	(3)	(4)
High-DTI share	-0.174	-0.346	-0.397	-0.285
	(0.035)	(0.044)	(0.048)	(0.092)
Observations	381	381	302	302
R^2	0.065	0.167	0.225	0.185
DTI type	CDTI>50%	CDTI>50%	CDTI>50%	CDTI>50%
Base controls	No	Yes	Yes	Yes
Elasticity	No	No	WRLURI	WRLURI
Weighted	No	No	No	Yes

Note: Column (1) regresses the MSA-level growth in the total dollar volume of purchase mortgage originations from 2021 to 2023 (Table C.6a) or the MSA-level growth of the FHFA all-transactions house price index from 2021Q4 to 2023Q4 (Table C.6b) on the high-DTI share, which is defined as the fraction of originations in 2019-2021 having a counterfactual DTI (CDTI) greater than 50% and an observed DTI less than 50%. The counterfactual DTI ratio is the DTI ratio a loan would have if it was originated in the same month in 2023, as described further in Section 2.3.1. When computing the counterfactual DTI ratio, we adjust loan amounts in 2019 and 2020 to 2021 by multiplying the coefficients on house prices and income in Table 2 by the difference in the logarithm of the respective MSA-level median and adjusting for inflation. Column (2) adds the following control variables: the lagged dependent variable (growth of purchase loan volume from 2020 to 2021 or house price growth from 2020Q4 to 2021Q4), the growth in the number of employees from 2020 to 2021 (using the County Business Pattern data provided by the US Census Bureau), and per capita income in the past 12 months (in 2021 inflation-adjusted dollars) as of 2021 (using the American Community Survey 1-year estimates). Column (3) adds the CBSA-level mean of the Wharton Land Use Regulatory Index (WRLURI) from Gyourko, Hartley, and Krimmel (2021) to control for housing supply elasticity. Column (4) weights by population based on the 2020 census. Robust standard errors are reported in parentheses. Source for mortgage data: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties in metropolitan statistical areas.

Table C.7: Local impact of high-DTI share on cash-out refinance loans and spending (adjusting 2019 and 2020 to 2021)

(a) High-DTI share and cash-out refinance growth

	(1)	(2)	(3)	(4)
High-DTI share	-0.744	-0.641	-0.672	-0.696
	(0.083)	(0.083)	(0.107)	(0.067)
Observations	381	381	302	302
R^2	0.120	0.203	0.222	0.396
DTI type	CDTI>50%	CDTI>50%	CDTI>50%	CDTI>50%
Base controls	No	Yes	Yes	Yes
Elasticity	No	No	WRLURI	WRLURI
Weighted	No	No	No	Yes

(b) High-DTI share and spending growth

	(1)	(2)	(3)	(4)
High-DTI share	-0.226	-0.246	-0.263	-0.315
	(0.036)	(0.038)	(0.045)	(0.053)
Observations	342	340	273	273
R^2	0.106	0.125	0.143	0.265
DTI type	CDTI>50%	CDTI>50%	CDTI>50%	CDTI>50%
Base controls	No	Yes	Yes	Yes
Elasticity	No	No	WRLURI	WRLURI
Weighted	No	No	No	Yes

Note: Column (1) regresses the MSA-level growth in the total dollar volume of cash-out refinance originations from 2021 to 2023 (Table C.7a) or the MSA-level change in debt and credit card spending (relative to January 6 to February 2nd, 2020) from 2021 to 2023 (Table C.7b) on the high-DTI share, which is defined as the fraction of originations in 2019-2021 having a counterfactual DTI (CDTI) greater than 45% and an observed DTI less than 45%. The counterfactual DTI ratio is the DTI ratio a loan would have if it was originated in the same month in 2023, as described further in Section 2.3.1. When computing the counterfactual DTI ratio, we adjust loan amounts in 2019 and 2020 to 2021 by multiplying the coefficients on house prices and income in Table 2 by the difference in the logarithm of the respective MSA-level median and adjusting for inflation. Column (2) adds the following control variables: the lagged dependent variable (growth of cash-out refinance volume from 2020 to 2021 or change in spending from 2020 to 2021), the growth in the number of employees from 2020 to 2021 (using the County Business Pattern data provided by the US Census Bureau), and per capita income in the past 12 months (in 2021 inflation-adjusted dollars) as of 2021 (using the American Community Survey 1-year estimates). Column (3) adds the CBSA-level mean of the Wharton Land Use Regulatory Index (WRLURI) from Gyourko, Hartley, and Krimmel (2021) to control for housing supply elasticity. Column (4) weights by population based on the 2020 census. Robust standard errors are reported in parentheses. Source for mortgage data: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties in metropolitan statistical areas.

Table C.8: Local impact of high-DTI share on purchase loans and house prices (additional controls)

(a) High-DTI share and purchase loan growth

	(1)	(2)	(3)	(4)
High-DTI share	-0.833	-0.627	-0.757	-0.947
	(0.128)	(0.141)	(0.159)	(0.167)
Observations	381	379	302	302
R^2	0.115	0.194	0.246	0.468
DTI type	CDTI>50%	CDTI>50%	CDTI>50%	CDTI>50%
Base controls	No	Yes	Yes	Yes
Elasticity	No	No	WRLURI	WRLURI
Weighted	No	No	No	Yes

(b) High-DTI share and house price growth

	(1)	(2)	(3)	(4)
High-DTI share	-0.246	-0.414	-0.460	-0.385
	(0.037)	(0.057)	(0.066)	(0.162)
Observations	381	379	302	302
R^2	0.100	0.216	0.252	0.236
DTI type	CDTI>50%	CDTI>50%	CDTI>50%	CDTI>50%
Base controls	No	Yes	Yes	Yes
Elasticity	No	No	WRLURI	WRLURI
Weighted	No	No	No	Yes

Note: Column (1) regresses the MSA-level growth in the total dollar volume of purchase mortgage originations from 2021 to 2023 (Table C.8a) or the MSA-level growth of the FHFA all-transactions house price index from 2021Q4 to 2023Q4 (Table C.8b) on the high-DTI share, which is defined as the fraction of originations in 2019-2021 having a counterfactual DTI (CDTI) greater than 50% and an observed DTI less than 50%. The counterfactual DTI ratio is the DTI ratio a loan would have if it was originated in the same month in 2023, as described further in Section 2.3.1. Column (2) adds the following control variables: the lagged dependent variable (growth of purchase loan volume from 2020 to 2021 or house price growth from 2020Q4 to 2021Q4), the growth in the number of employees from 2020 to 2021 (using the County Business Pattern data provided by the US Census Bureau), and per capita income in the past 12 months (in 2021 inflation-adjusted dollars) as of 2021 (using the American Community Survey 1-year estimates), the Black share of the population (using the ACS 1-year estimates), the Hispanic share of the population (using the ACS 1-year estimates), and the mean credit score (minimum credit score among the borrowers on a loan) in 2019 through 2021. Column (3) adds the CBSA-level mean of the Wharton Land Use Regulatory Index (WRLURI) from Gyourko, Hartley, and Krimmel (2021) to control for housing supply elasticity. Column (4) weights by population based on the 2020 census. Robust standard errors are reported in parentheses. Source for mortgage data: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties in metropolitan statistical areas.

Table C.9: Local impact of high-DTI share on cash-out refinance loans and spending (additional controls)

(a) High-DTI share and cash-out refinance growth

	(1)	(2)	(3)	(4)
High-DTI share	-0.903	-0.561	-0.671	-0.625
	(0.094)	(0.115)	(0.138)	(0.099)
Observations	381	379	302	302
R^2	0.134	0.242	0.275	0.439
DTI type	CDTI>50%	CDTI>50%	CDTI>50%	CDTI>50%
Base controls	No	Yes	Yes	Yes
Elasticity	No	No	WRLURI	WRLURI
Weighted	No	No	No	Yes

(b) High-DTI share and spending growth

	(1)	(2)	(3)	(4)
High-DTI share	-0.289	-0.260	-0.295	-0.312
	(0.039)	(0.050)	(0.058)	(0.083)
Observations	342	340	273	273
R^2	0.132	0.169	0.180	0.305
DTI type	CDTI>50%	CDTI>50%	CDTI>50%	CDTI>50%
Base controls	No	Yes	Yes	Yes
Elasticity	No	No	WRLURI	WRLURI
Weighted	No	No	No	Yes

Note: Column (1) regresses the MSA-level growth in the total dollar volume of cash-out refinance originations from 2021 to 2023 (Table C.9a) or the MSA-level change in debt and credit card spending (relative to January 6 to February 2nd, 2020) from 2021 to 2023 (Table C.9b) on the high-DTI share, which is defined as the fraction of originations in 2019-2021 having a counterfactual DTI (CDTI) greater than 45% and an observed DTI less than 45%. The counterfactual DTI ratio is the DTI ratio a loan would have if it was originated in the same month in 2023, as described further in Section 2.3.1. Column (2) adds the following control variables: the lagged dependent variable (growth of purchase loan volume from 2020 to 2021 or house price growth from 2020Q4 to 2021Q4), the growth in the number of employees from 2020 to 2021 (using the County Business Pattern data provided by the US Census Bureau), and per capita income in the past 12 months (in 2021 inflation-adjusted dollars) as of 2021 (using the American Community Survey 1-year estimates), the Black share of the population (using the ACS 1-year estimates), the Hispanic share of the population (using the ACS 1-year estimates), and the mean credit score (minimum credit score among the borrowers on a loan) in 2019 through 2021. Column (3) adds the CBSA-level mean of the Wharton Land Use Regulatory Index (WRLURI) from Gyourko, Hartley, and Krimmel (2021) to control for housing supply elasticity. Column (4) weights by population based on the 2020 census. Robust standard errors are reported in parentheses. Source for mortgage data: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties in metropolitan statistical areas.

Figure C.1: Heat map of high-DTI share

This figure shows a heat map of high-DTI share (based on the counterfactual DTI relative to 2023 and a threshold of 50%) across MSAs. Source: National Mortgage Database (2019-2021), restricting to purchase loans for one-unit, owner-occupied, site-built properties in metropolitan statistical areas.

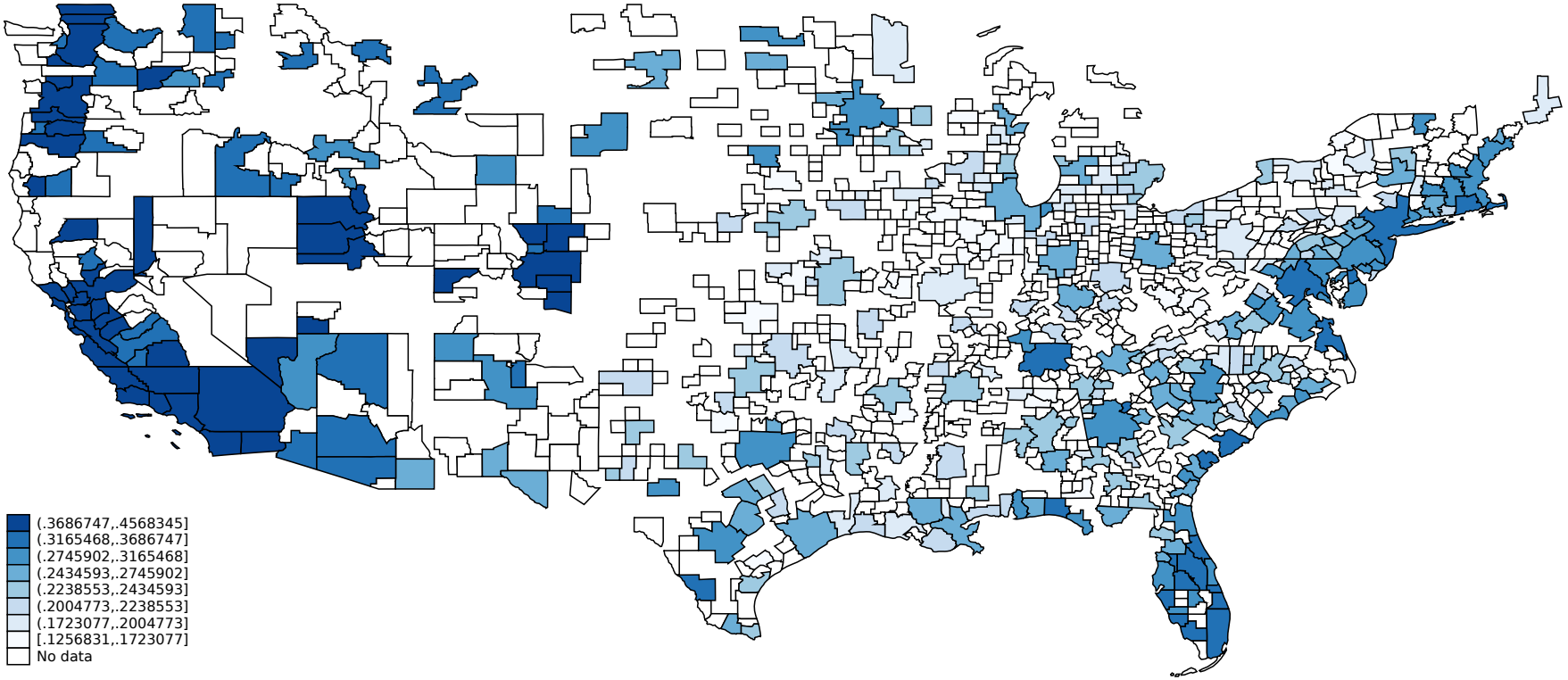


Table C.10: Variation in high-DTI share among large MSAs

MSA code	MSA name	High-DTI share
41180	St. Louis, MO-IL	0.198
28140	Kansas City, MO-KS	0.232
26900	Indianapolis-Carmel-Anderson, IN	0.243
19820	Detroit-Warren-Dearborn, MI	0.243
12420	Austin-Round Rock-Georgetown, TX	0.254
16980	Chicago-Naperville-Elgin, IL-IN-WI	0.269
26420	Houston-The Woodlands-Sugar Land, TX	0.269
16740	Charlotte-Concord-Gastonia, NC-SC	0.277
37980	Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	0.278
33460	Minneapolis-St. Paul-Bloomington, MN-WI	0.284
12060	Atlanta-Sandy Springs-Alpharetta, GA	0.285
19100	Dallas-Fort Worth-Arlington, TX	0.286
41700	San Antonio-New Braunfels, TX	0.294
12580	Baltimore-Columbia-Towson, MD	0.296
45300	Tampa-St. Petersburg-Clearwater, FL	0.307
14460	Boston-Cambridge-Newton, MA-NH	0.310
34980	Nashville-Davidson–Murfreesboro–Franklin, TN	0.317
35620	New York-Newark-Jersey City, NY-NJ-PA	0.330
47900	Washington-Arlington-Alexandria, DC-VA-MD-WV	0.334
36740	Orlando-Kissimmee-Sanford, FL	0.340
38060	Phoenix-Mesa-Chandler, AZ	0.358
33100	Miami-Fort Lauderdale-Pompano Beach, FL	0.366
38900	Portland-Vancouver-Hillsboro, OR-WA	0.378
19740	Denver-Aurora-Lakewood, CO	0.381
41860	San Francisco-Oakland-Berkeley, CA	0.382
42660	Seattle-Tacoma-Bellevue, WA	0.390
29820	Las Vegas-Henderson-Paradise, NV	0.396
41740	San Diego-Chula Vista-Carlsbad, CA	0.416
40140	Riverside-San Bernardino-Ontario, CA	0.440
31080	Los Angeles-Long Beach-Anaheim, CA	0.452

Note: This table shows high-DTI share (based on the counterfactual DTI relative to 2023 and a threshold of 50%) for the top 30 MSAs based on number of originations in 2019-2021. Source: National Mortgage Database (2019-2021), restricting to purchase loans for one-unit, owner-occupied, site-built properties.

Table C.11: Correlations with high-DTI share

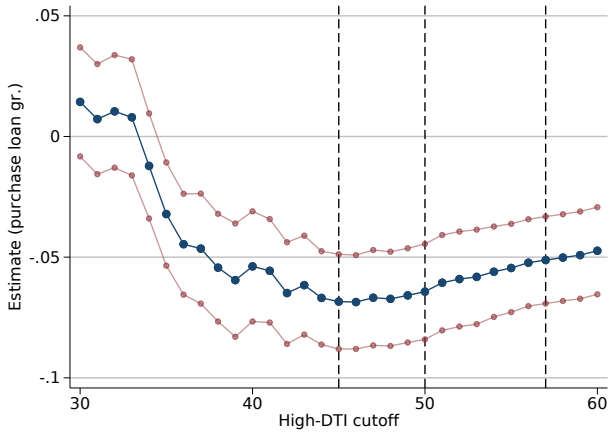
Variable	Coefficient	S.E.	T-stat
Employees growth 2020–2021	0.013	(0.022)	0.562
Log(per capita income) 2021	0.631	(0.111)	5.670
WRLURI 2018	3.684	(0.473)	7.782
Purchase loan amount gr. 2020–2021	–0.248	(0.145)	–1.706
House price growth 2020Q4–2021Q4	0.314	(0.028)	11.153
Cashout loan amount growth 2020–2021	0.287	(0.218)	1.318
Spending growth 2020–2021	–0.137	(0.029)	–4.738
Black share 2021	–0.264	(0.044)	–6.036
Hispanic share 2021	0.892	(0.091)	9.811
Mean credit score 2019–2021	55.993	(8.064)	6.944
Log(median loan amount) 2019–2021	3.562	(0.134)	26.671
Log(median house value) 2021	4.275	(0.167)	25.665

Note: This table shows the coefficient, robust standard error, and t-statistic associated with regressing the indicated variable on high-DTI share (based on the counterfactual DTI relative to 2023 and a threshold of 50%). Source: the growth in the number of employees from 2020 to 2021 comes from the County Business Pattern data provided by the US Census Bureau, the Wharton Land Use Regulatory Index (WRLURI) based on a 2018 survey comes from Gyourko, Hartley, and Krimmel (2021), house price growth from 2020Q4 to 2021Q4 comes from the FHFA all-transactions house price index, the change in debt and credit card spending (relative to January 6 to February 2nd, 2020) from 2021 to 2022 comes from the Economic Tracker associated with Chetty et al. (2022). The following variables are from the American Community Survey 1-year estimates: per capita income in the past 12 months (in 2021 inflation-adjusted dollars) in 2021 comes, the Black and Hispanic shares of the population, and the logarithm of median house values. The remaining variables (purchase loan growth from 2020 to 2021, cashout refinance loan growth from 2021 to 2021, the mean credit score (minimum credit score among the borrowers on a loan) in 2019 through 2021, and the median loan amount in 2019-2021 are computed using the National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties in metropolitan statistical areas.

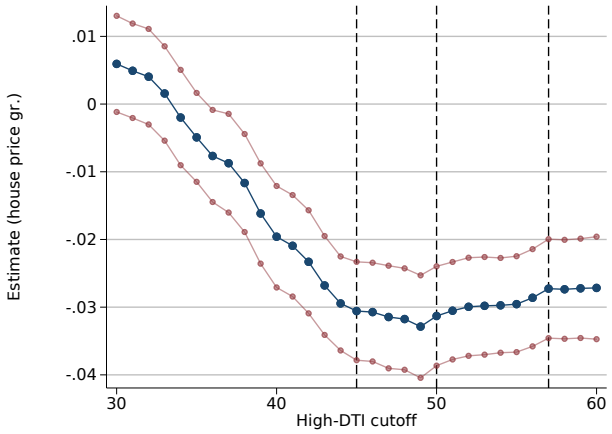
Figure C.2: Variation in the high-DTI share threshold

This figure shows the coefficients and 95% confidence interval derived from regressing the indicated variable on high-DTI share (based on the counterfactual DTI relative to 2023) defined using the threshold indicated on the x-axis and normalizing to have a standard deviation of 1. We include the following control variables: the lagged dependent variable, the growth in the number of employees from 2020 to 2021 (using the County Business Pattern data provided by the US Census Bureau), and per capita income in the past 12 months (in 2021 inflation-adjusted dollars) as of 2021 (using the American Community Survey 1-year estimates). Source for mortgage data: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties in metropolitan statistical areas.

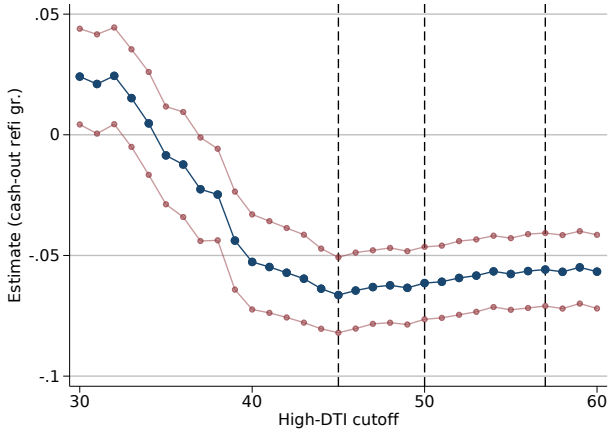
(a) Purchase loan growth



(b) House price growth



(c) Cash-out refinance growth



(d) Spending growth

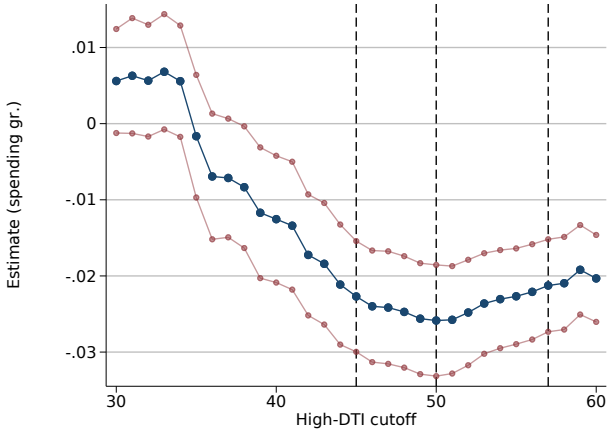
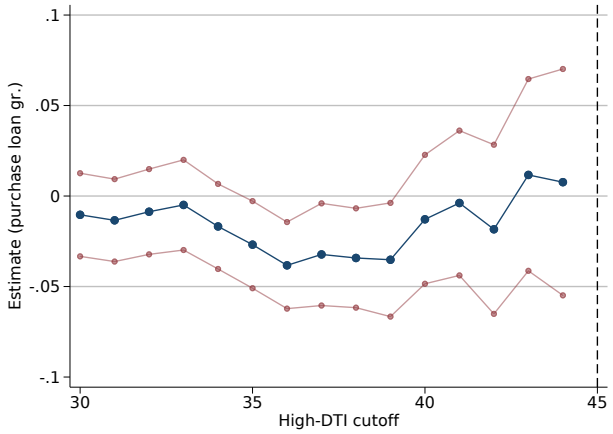


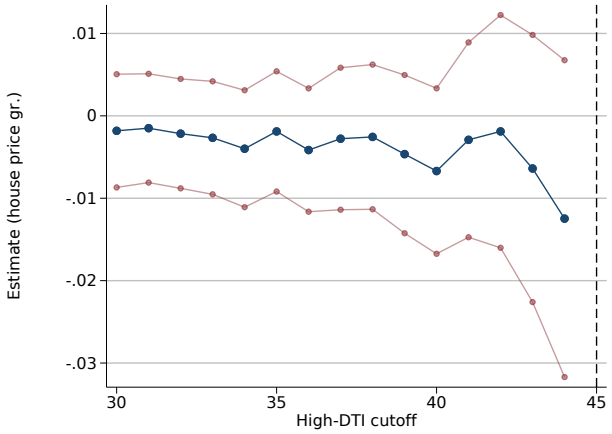
Figure C.3: Variation in the high-DTI share threshold when restricting to counterfactual DTI up to 45%

This figure shows the coefficients and 95% confidence interval derived from regressing the indicated variable on high-DTI share (based on the counterfactual DTI relative to 2023) defined using the threshold indicated on the x-axis and normalizing to have a standard deviation of 1. We include the following control variables: the lagged dependent variable, the growth in the number of employees from 2020 to 2021 (using the County Business Pattern data provided by the US Census Bureau), and per capita income in the past 12 months (in 2021 inflation-adjusted dollars) as of 2021 (using the American Community Survey 1-year estimates), and the original high-DTI share based on the 45% threshold using the full sample. We restrict to loans with a counterfactual DTI below 45%. Source for mortgage data: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties in metropolitan statistical areas.

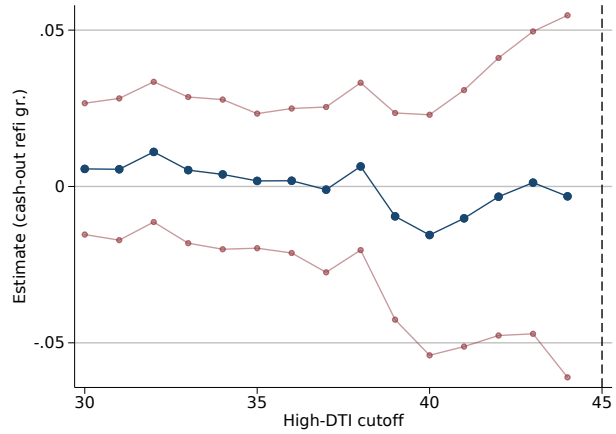
(a) Purchase loan growth



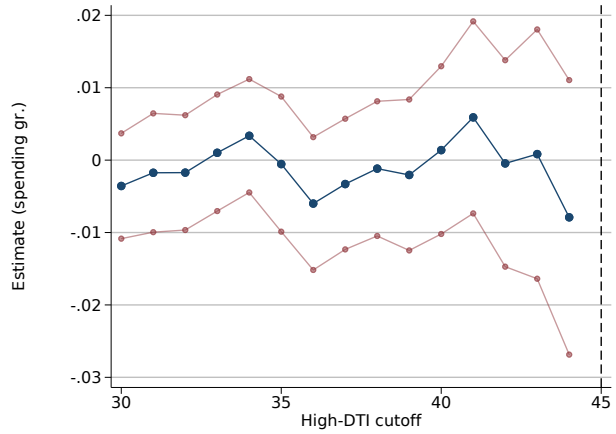
(b) House price growth



(c) Cash-out refinance growth



(d) Spending growth



D Persistence

This section shows that it would take the typical borrower with a counterfactual DTI ratio above one of the underwriting limits a median of more than five years to save enough to satisfy the limit. This finding suggests that our main results can persist for several years conditional on interest rates remaining high.

Consider a borrower with a counterfactual DTI above a given threshold, such as 50% or 45%. Denote the counterfactual DTI minus the threshold as ΔDTI. In order to decrease the DTI ratio by ΔDTI, the principal and interest rate payment must decrease by $\Delta DTI *$ monthly income. Recall that the principal and interest payment is determined by the amortization formula: $P = A\frac{(R/12)}{1-(1+R/12)^{-n}}$, where A is the amount of the loan, R is the counterfactual interest rate, and n is the contracted number of monthly payments. Therefore, we can compute the change in the loan amount as

$$\Delta A = \Delta DTI * \text{monthly income} * \frac{1-(1+R/12)^{-n}}{(R/12)} \tag{2}$$

Figure D.1 shows the mean and median change in the loan amount for each level of the counterfactual DTI. We focus on 2021 originations and restrict to borrowers with an observed DTI up to the threshold to exclude those that did not appear to be constrained by the limit. The median over all borrowers with a counterfactual DTI above 50% (45%) is \$45,000 (\$47,000).

We next determine how long it would take to reach a given threshold by saving. We divide ΔA by monthly income times an assumed savings rate s. We use the average savings rate in 2019 through 2021, which is 11.2%.[20] Note that this savings rate is unusually high due to the COVID-19 pandemic. By comparison, the average savings rate in 2015-2019 is only 6.2%. Therefore, using a savings rate of 11.2% will likely underestimate the time to save compared to more typical economic conditions.

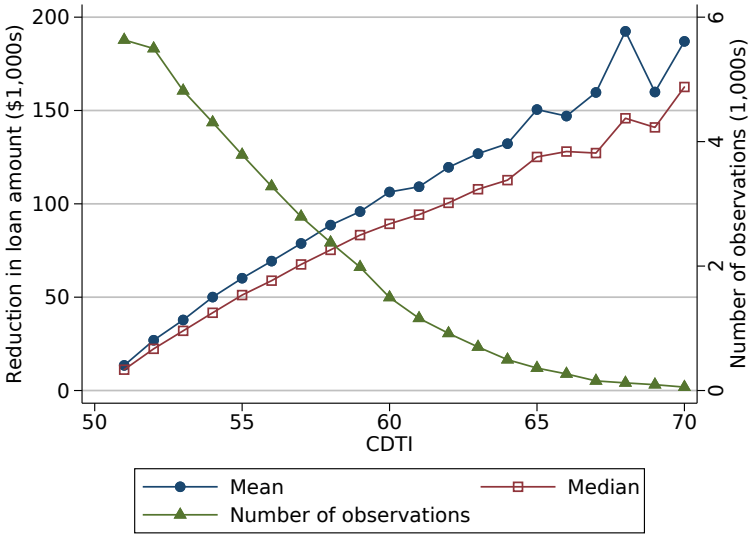
[20] See https://fred.stlouisfed.org/series/PSAVERT.

Figure D.2 shows the mean and median number of months to save for each level of ΔDTI. The median over all borrowers with a counterfactual DTI above 50% (45%) is 66 (65).

Figure D.1: Amount needed to save

Figure D.1a shows the mean and median amount that the loan amount must be decreased to achieve a DTI ratio of 50% as a function of the counterfactual DTI (CDTI) ratio. It also shows the number of loans for each counterfactual DTI ratio. Figure D.1b is analogous except with respect to the 45% threshold. Source: National Mortgage Database (2021 originations), restricting to purchase loans for one-unit, owner-occupied, site-built properties in metropolitan statistical areas. We also restrict to loans with an observed ratio up to the respective threshold.

(a) 50% threshold



(b) 45% threshold

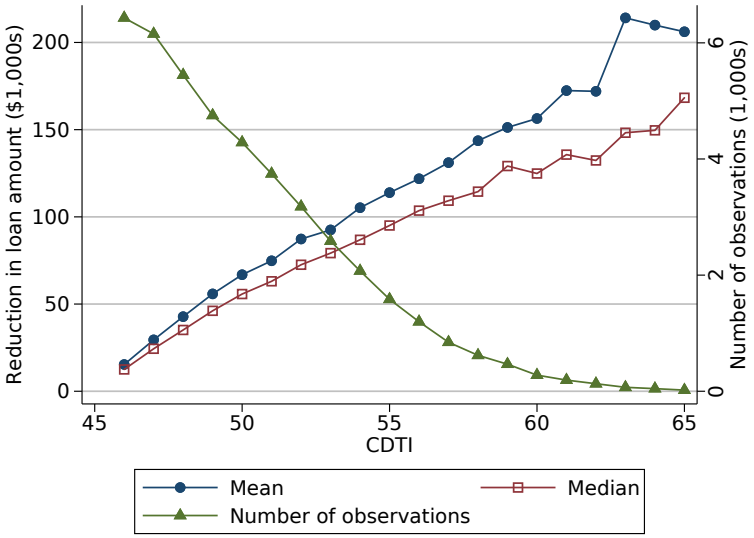
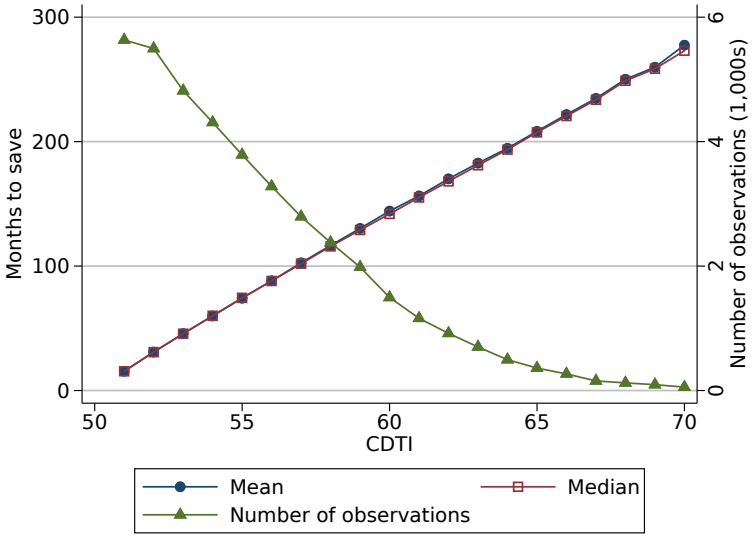


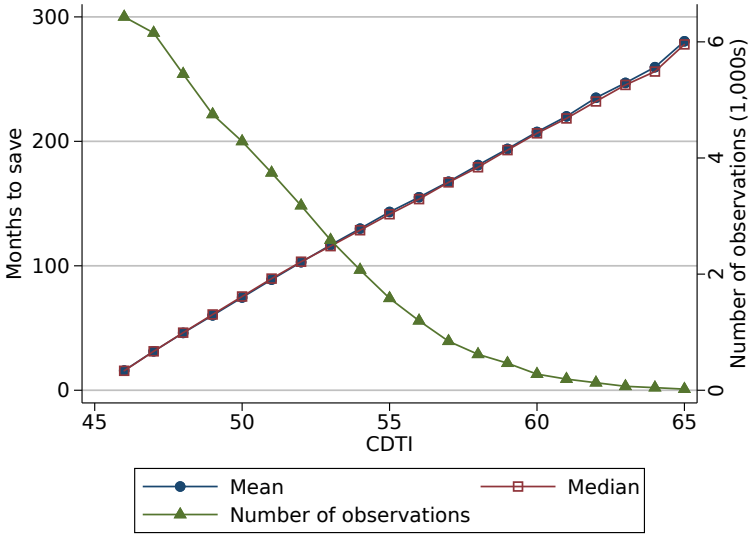
Figure D.2: Months to save

Figure D.2a shows the mean and median number of months a borrower must save to achieve a DTI ratio of 50% as a function of the counterfactual DTI (CDTI) ratio. It also shows the number of loans for each counterfactual DTI ratio. Figure D.2b is analogous except with respect to the 45% threshold. Source: National Mortgage Database (2021 originations), restricting to purchase loans for one-unit, owner-occupied, site-built properties in metropolitan statistical areas. We also restrict to loans with an observed ratio up to the respective threshold.

(a) 50% threshold



(b) 45% threshold



E The aggregate impact of the DTI constraints

This section develops a back-of-the-envelope quantification of the effect of the DTI constraints on mortgage-backed securities (MBS) issuances. Specifically, using a combination of our own estimate and estimates from the literature to think about the equilibrium for MBS, we determine that the DTI constraints resulted in at least twice as large a decline in mortgages compared to a counterfactual without them.

Our calculation is based on Figure E.1, which shows in reduced form the demand and supply for new MBS issuance and MBS interest rates.

In this figure, the "EIS+DTI" ("EIS") line depicts consumers' demand for mortgage borrowing (and therefore MBS issuance) in the presence (absence) of DTI constraints. An increase in MBS coupon rates (which affects mortgage interest rates) is associated with a decline in consumers' demand for two reasons: first, a positive elasticity of intertemporal substitution (EIS) means that an increase in interest rates is associated with decline in demand for borrowing. Second, in the presence of DTI constraints, an increase in interest rates is associated with a significantly larger decline in demand for borrowing, since borrowers with a counterfactual DTI above the threshold will be excluded.

The upward sloping curves represent lenders' supply of funds for new MBS. Point A in the figure represents the equilibrium before the monetary policy tightening. Both an increase in interest rates and quantitative tightening can result in upward shift (as well as change in the slope) of the relationship between interest rates and supply of funds to new MBS.[21] Point B (C) represents the equilibrium after the monetary policy tightening in the presence (absence) of DTI constraints. DTI constraints make total demand for borrowing more sensitive to interest rates. Therefore, the equilibrium with DTI constraints features

[21]The reduced demand for MBS by the Federal Reserve resulted in higher yields (or lower prices) in the secondary market, which is consistent with an increase of the spread between mortgage interest rates and the 10-year Treasury yield during 2022 (Figure E.2). There was also a reduction in MBS holdings by commercial banks, possibly due to their higher opportunity cost. Overall, these maneuvers resulted in an increase of mortgage interest rates and a reduction in originations, consistent with the observations in Section 2.1.

a greater decline in mortgage originations and less of an increase in mortgage rates. We next quantify the difference in MBS issuance and rates in the presence and absence of DTI constraints and as a function of the parameters of these curves. We use the estimates in this paper as well as estimates of the demand response to interest rates from DeFusco and Paciorek (2017) and Fuster and Zafar (2021).

We suppose that the flow of new mortgages is in logarithmic scale and take a first order approximation around the initial equilibrium at point A. The initial upward-sloping supply curve representing financial institution incentives can be written as

$$i = i_0 + \mu_s \left(\log(f) - \log(f_0)\right), \tag{3}$$

where i_0 and f_0 represent the interest rate and mortgage originations at point A.

The monetary policy tightening can be represented as a combination of a level shift by Δi_0 and a change in the slope by $\Delta\mu_s$, which we can write as

$$i = (i_0 + \Delta i_0) + (\mu_s + \Delta\mu_s)\left(\log(f) - \log(f_0)\right). \tag{4}$$

The downward-sloping curve can be represented as

$$i = i_0 - \gamma_d^{scenario}\left(\log(f) - \log(f_0)\right), \tag{5}$$

where *scenario* can be, for example, $EIS + DTI$, which represents the setting with DTI constraints, or EIS, which represents the setting without DTI constraints. To obtain the new equilibrium, we solve for the solution of (4) and (5), which yields

$$\log(f) - \log(f_0) = -\frac{\Delta i_0}{\gamma_d^{scenario} + \mu_s + \Delta\mu_s}. \tag{6}$$

Since our estimates focus on the effect of the DTI constraints, our parameter selection is based on a slightly different scenario in which the downward-sloping line is completely

determined by the DTI constraints.[22] Based on column (1) of Table 1, we observe that the DTI constraints were associated with a 16.1% reduction in mortgages.[23] Recall that the average increase from the observed interest rate to the counterfactual interest rate is 2.4 percentage points. Substituting the change in mortgages and interest rates into (5), we find that γ^{DTI} is about 14.9. Substituting the change in mortgages and γ^{DTI} into (6), we find that

$$\Delta i_0 = 2.4 + .161(\mu_s + \Delta\mu_s) \tag{7}$$

Then we can rewrite (6) as

$$\log(f) - \log(f_0) = -\frac{2.4 + .161(\mu_s + \Delta\mu_s)}{\gamma_d^{scenario} + (\mu_s + \Delta\mu_s)}. \tag{8}$$

To compute the counterfactual equilibrium in the case without DTI constraints, we determine γ^{EIS} and $\mu_s + \Delta\mu_s$ based on estimates from the literature. We choose γ^{EIS} based on the estimates in DeFusco and Paciorek (2017). They find a semi-elasticity of mortgage demand to the interest rate of -2 to -3 percent, which implies γ^{EIS} is in a range from $\frac{1}{.03} = 33$ to $\frac{1}{.02} = 50$.[24] We choose $\mu_s + \Delta\mu_s$ based on the shift of interest rates and MBS issuances around the introduction of the third round of quantitative easing (QE3) in September 2012. During QE3, the Federal Reserve reduced MBS yields by purchasing mortgage-backed securities (see, for example, Krishnamurthy and Vissing-Jorgensen (2013)). Since this change in mortgage interest rates was driven by the actions of the Federal Reserve, it can be used to trace out the supply curve of MBS investors. We focus on MBS issued

[22] Note that not taking into account reductions in mortgages via demand channels implies that our estimates of the effect of the DTI constraints will be a lower bound. We show this in Section E.1.

[23] Note that this is similar to the average across all columns in Table 1, which is 16.3%.

[24] Note that the estimates from DeFusco and Paciorek (2017) abstract away from the extensive margin. We are not aware of any estimates that directly show or include the extensive margin. However, our slope coefficient is similar if we use other estimates that could potentially affect both the intensive and extensive margins. In particular, Fuster and Zafar (2021) show that consumers' willingness to pay for a house decreases by 4 to 5 percent for a 2 percentage point increase in the interest rate. If this reduction in the willingness to pay results in a similarly sized total reduction in mortgage amounts, then it corresponds to a slope for γ^{EIS} of either $\frac{2}{.05} = 40$ or $\frac{2}{.04} = 50$.

by Fannie Mae since the data is easily available. Figure E.3 shows that net purchases of Fannie Mae MBS exhibited a discrete increase from August to September of 2012. During this time, the spread of the Fannie Mae 30-year MBS yield relative to the 10-year Treasury yield decreased by 34 basis points and Fannie Mae issuances decreased by 22%, which yields a slope for $\mu_s + \Delta\mu_s$ of around 1.55.

Based on these estimates, the decline of mortgages in the counterfactual ranges from 5.1% (using $\gamma^{EIS} = 50$) to 7.7% (using $\gamma^{EIS} = 33$). Therefore, in the absence of the DTI constraints, the reduction in MBS issuance would have been 52% to 68% lower compared to the estimated 16.1% decline.[25] Incidentally, the MBS-Treasury spread would have been higher by 13 to 17 basis points. If we instead apply a similar series of steps based on the 2023, we find that the decline of mortgages in the counterfactual ranges from 8.5% to 12.7%, which means that the reduction in MBS would have been 58% to 72% smaller in the absence of the DTI constraints.

E.1 Proof of estimate bound

This section shows that focusing only on the effect of the DTI constraints on mortgage originations in the transition from point A to point B in Figure E.1, i.e., not taking into account reductions in mortgages via demand channels, results in a lower bound for the estimate of the effect of the DTI constraints.

To see this, let the superscript $reference$ denote a given reference case, i.e., $reference = EIS + DTI$ when including the effects of both demand and DTI constraints and $reference = DTI$ when just including the effects of the DTI constraints. Note that (5) can be rearranged

[25] Note that DeFusco and Paciorek (2017) find a semi-elasticity of -2 to -3 for first mortgage demand and an elasticity of -1.5 to -2 for total mortgage debt. Based on the latter estimate, the corresponding γ^{EIS} could be as high as $\frac{1}{.015} = 67$, resulting in a reduction of mortgages by 3.9%. In that case, in the absence of the DTI constraints, the reduction in MBS would have been lower by 76%.

Figure E.1: Monetary policy tightening with and without DTI constraints

This figure shows a reduced form depiction of equilibrium in the mortgage market, with the mortgage interest rate on the y-axis and the flow of new mortgages on the x-axis. Point A represents the equilibrium before the monetary policy tightening, which occurs at the intersection of the lenders' supply of funds for new mortgages and the "EIS+DTI" curve representing the combined effect of consumer demand, as determined by the elasticity of intertemporal substitution (EIS) and the debt-to-income (DTI) constraints. Point B represents the equilibrium after the monetary policy tightening, including the increase in short-term interest rates (conventional monetary policy or "MP") and quantitative tightening ("QT"). The "EIS" line represents the negative relationship between mortgage originations and the mortgage interest rates for a counterfactual scenario in which there are no DTI constraints. In particular, the "EIS" line reflects only demand by consumers. Point C represents a counterfactual equilibrium after monetary policy tightening but without the DTI constraints.

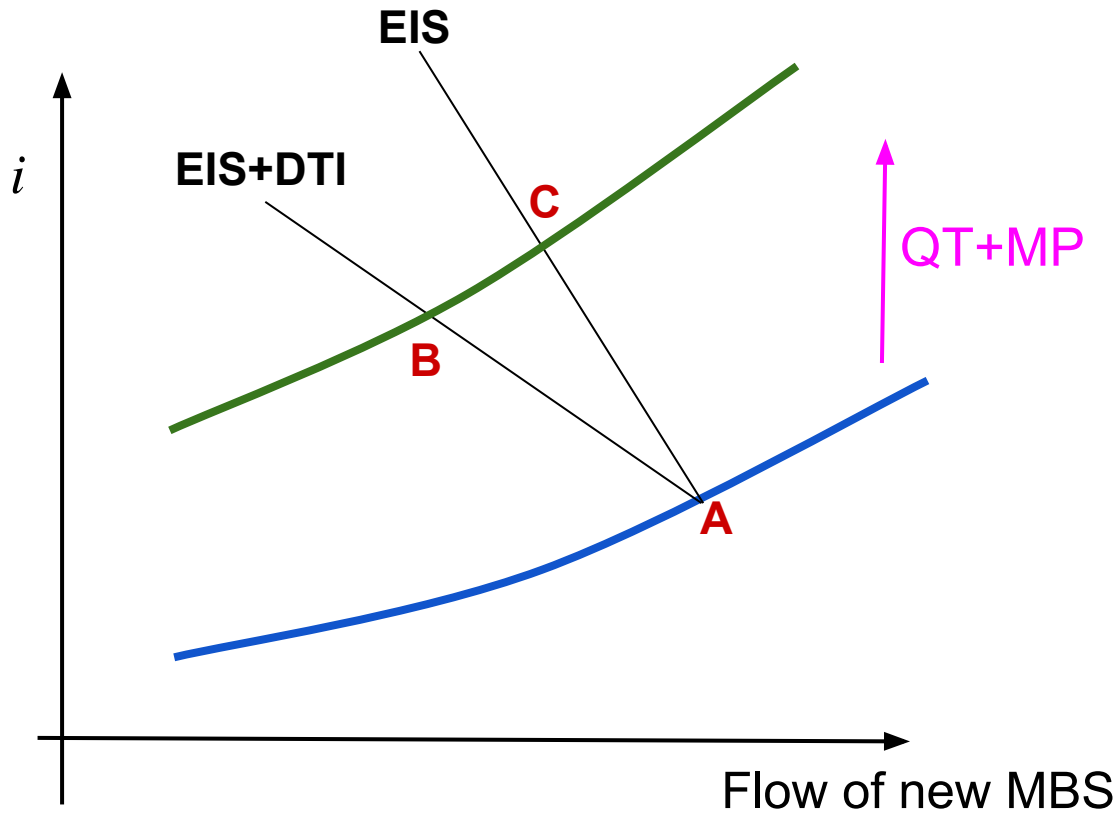


Figure E.2: Mortgage-backed securities holdings and interest rate spread

The left axis shows monthly average agency mortgage-backed securities by the Federal Reserve (obtained from FRED series WSHOMCB) and commercial banks (obtained from FRED series TMBACBM027SBOG). The right axis shows the average interest rate for 30-year fixed rate mortgages based on the Freddie Mac Primary Mortgage Market Survey (obtained from FRED series MORTGAGE30US) minus the yield on 10-year Treasury securities (obtained from FRED series DGS10). The dashed line indicates January 2022.

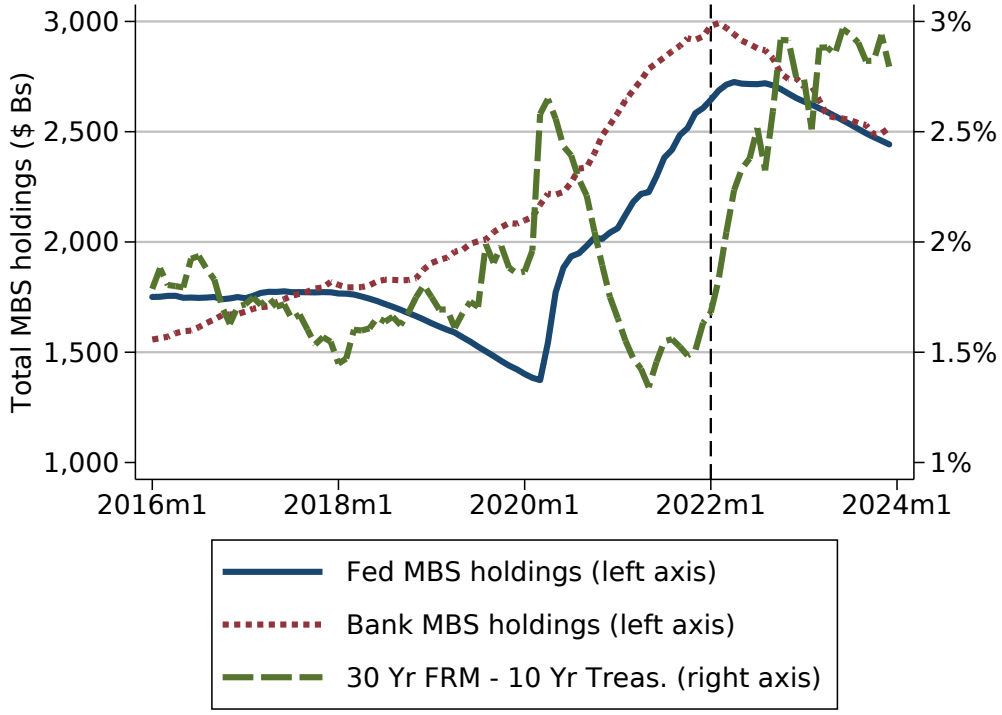
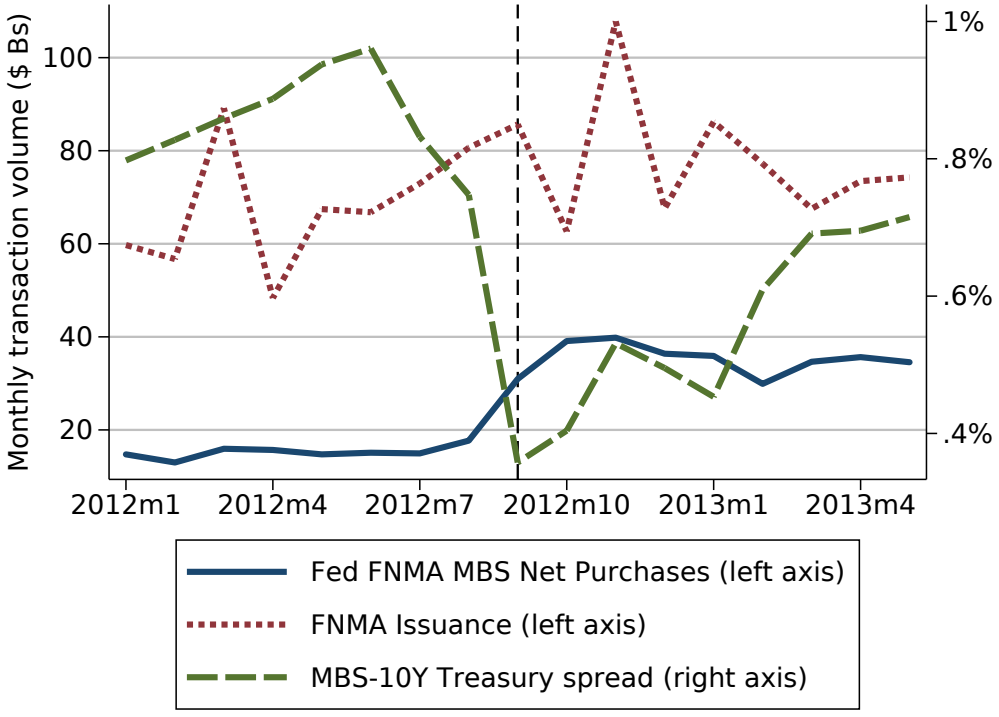


Figure E.3: MBS issuances and mortgage interest rates around QE3

This figure shows net purchases of Fannie Mae MBS by the Federal Reserve (obtained from the New York Fed Historical Transactions Data), issuances of Fannie Mae MBS (obtained from Fannie Mae), and the current coupon rate on 30-year Fannie Mae mortgage-backed securities (a measure of yield obtained from Bloomberg series MTGEFNCL) minus the yield on 10-year Treasury securities (retrieved from FRED series DGS10). The dashed line at September 2012 indicates the start of QE3.



as

$$\gamma_d^{reference} = -\frac{i - i_0}{\log(f^{reference}) - \log(f_0)} \tag{9}$$

Substituting $\gamma_d^{reference}$ into (6) obtains the perceived change in Δi_0 that is consistent with the given reference case:

$$\Delta i_0^{reference} = (i - i_0) - \Big(\log(f^{reference}) - \log(f_0)\Big)\,(\mu_s + \Delta\mu_s). \tag{10}$$

We can then obtain the counterfactual change in lending for the EIS scenario, based on calibrating the model with respect to the given reference case, by substituting $\Delta i_0^{reference}$ into (6):

$$\log(f^{EIS}) - \log(f_0) = -\frac{(i - i_0) - \big(\log(f^{reference}) - \log(f_0)\big)\,(\mu_s + \Delta\mu_s)}{\gamma_d^{EIS} + (\mu_s + \Delta\mu_s)}, \tag{11}$$

If we express this as a fraction of the reduction in the reference case, we obtain

$$\frac{\log(f^{EIS}) - \log(f_0)}{\log(f^{reference}) - \log(f_0)} = -\frac{\frac{(i-i_0)}{\log(f^{reference}) - \log(f_0)} + (\mu_s + \Delta\mu_s)}{\gamma_d^{EIS} + (\mu_s + \Delta\mu_s)}. \tag{12}$$

Therefore, as long as $\log(f^{EIS+DTI}) - \log(f_0)$ is larger in magnitude than $\log(f^{DTI}) - \log(f_0)$, the counterfactual change in mortgages will be a smaller fraction of the total change in mortgages in the reference case. Equivalently, the change in mortgages due to the DTI constraints will be a larger fraction of the total change.