Distribution Agreement

Jihan Lee March 28, 2025

Quantitative Easing Transmission to Mortgage Market During COVID-19: Evidence from the Conforming Loan Segment

By

Jihan Lee

Esfandiar Maasoumi

Advisor

Department of Economics

Esfandiar Maasoumi

Advisor

Christopher Hansman

Committee Member

Nosayba El-Sayed

Committee Member

2025

Quantitative Easing Transmission to Mortgage Market During COVID-19: Evidence from the Conforming Loan Segment

By

Jihan Lee

Esfandiar Maasoumi

Advisor

An abstract of
a thesis submitted to the Faculty of Emory College of Arts and Sciences
of Emory University in partial fulfillment
of the requirements of the degree of
Bachelor of Arts with Honors

Department of Economics

2025

Abstract

Quantitative Easing Transmission to Mortgage Market During COVID-19: Evidence from the Conforming Loan Segment

By Jihan Lee

This paper examines the effectiveness of the Federal Reserve's unprecedented large-scale asset purchases (LSAP) program, or quantitative easing (QE), during the COVID-19 pandemic through the mortgage refinancing channel. Exploiting the institutional feature that the Fed can only purchase agency mortgage-backed securities backed by conforming loans, I employ a difference-in-differences approach to identify the effect of QE on mortgage market outcomes. Using Home Mortgage Disclosure Act (HMDA) data from 2017-2023, I find that the Fed's COVID-era asset purchases led to a 32-42 basis point larger reduction in interest rates for conforming loans relative to nonconforming loans. This differential effect translates into substantially higher refinancing activity, with conforming loan origination volumes increasing by 63-68 log points (approximately 88-97%) more than nonconforming loans during the QE period. Event study analysis indicates these effects materialized rapidly in 2020, then tapered off as the Federal Reserve scaled down and eventually stopped its asset purchases. The results remain robust to extensive loan-level controls and to exclusion of loans near the conforming loan limit threshold. Furthermore, metropolitan areas experiencing net in-migration showed somewhat stronger policy transmission, illustrating how demographic shifts can amplify QE's impact on local housing markets. This study contributes to our understanding of unconventional monetary policy transmission during exogenous economic crises and provides insights into the distributional consequences of central bank interventions across mortgage market segments.

Keywords: Quantitative Easing, Mortgage Refinancing, COVID-19, Monetary Policy Transmission, Agency MBS

Quantitative Easing Transmission to Mortgage Market During COVID-19: Evidence from the Conforming Loan Segment

By

Jihan Lee

Esfandiar Maasoumi

Advisor

A thesis submitted to the Faculty of Emory College of Arts and Sciences
of Emory University in partial fulfillment
of the requirements of the degree of
Bachelor of Arts with Honors

Department of Economics

2025

Acknowledgements

First and foremost, I would like to express my sincere gratitude to all of my thesis committee members for their guidance and support throughout this academic journey. It would not have been possible to finish this thesis without their help.

I am deeply indebted to Professor Maasoumi, whose Microeconometrics course provided me with my first truly intellectually challenging and stimulating learning experience. It was in his class that I began to think like an economist and problem solver. I am grateful for his consistent support, welcoming nature, wise advice, thought-provoking questions, and the perspectives he shared that have shaped my academic thinking.

I extend my appreciation to Professor Hansman for giving me my first opportunity to engage in research. I am thankful that he accepted me into the SIRE program, provided interesting ideas and helpful literature, and despite his busy schedule, was always willing and open to discussion. His guidance has been a source of tremendous inspiration throughout this process.

I would also like to express my gratitude to Professor El-Sayed for accepting my request to join the committee and welcoming me warmly, even though my research falls outside her immediate area of expertise. What I learned in her Database Systems course about handling data and maintaining their integrity has been very helpful in working with data for this thesis. I am also thankful for the interesting and engaging courses she taught, which have encouraged me to continue pursuing computer science.

And special thanks to Nicole for her constant mental and emotional support and help in editing and revising my thesis, despite it not being her area of interest and her own busy schedule.

Finally and most importantly, I wish to acknowledge my parents and family for their unwavering support and creating an environment that allowed me to focus solely on my intellectual development, providing both the resources and inspiration that made this academic journey possible. Their encouragement for the pursuit of my interests has been the very foundation upon which this work stands.

I dedicate this work to my late grandpa who showed me the importance of lifelong learning.

Contents

Quantitative Easing Transmission to Mortgage Market During COVID-19: Evidence from the Conforming Loan Segment

Jihan Lee

April 2025

1 Introduction

The global COVID-19 pandemic represented an unprecedented economic and public health crisis that required swift and decisive policy intervention. Unlike the Great Recession that stemmed from structural issues within the financial system, the COVID-19 downturn was triggered by an external shock that necessitated widespread lockdowns, resulting in rapid economic contraction. In response to this emergency situation, the Federal Reserve deployed large-scale asset purchases (LSAPs) with extraordinary speed and magnitude. This paper investigates how these unconventional monetary policy measures affected the mortgage market during this unique crisis period, and how the transmissions of monetary policy through the refinancing channel varied across different market segments.

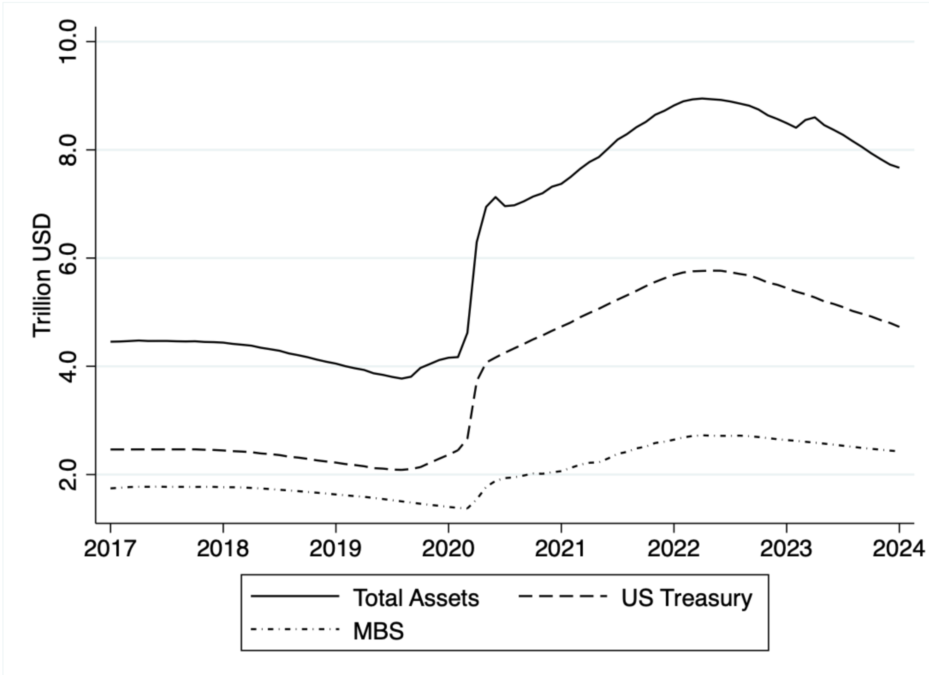


Figure 1: Federal Reserve Balance Sheet

Mortgage refinancing represents one of the most important channels through which monetary policy transmits to consumer welfare and broader economic activity. When homeowners refinance at lower interest rates, they reduce their monthly payments, potentially increase their disposable income (Di Maggio et al., 2017; Keys et al., 2014), and often extract equity from their homes—all of which can stimulate consumption and economic growth. Understanding the effectiveness of the Fed's unprecedented COVID-era QE program in facilitating mortgage refinancing is therefore crucial for evaluating monetary policy transmission during crisis periods.

The Federal Reserve's response to the COVID-19 crisis was both rapid and substantial. On March 15, 2020, in an unscheduled emergency meeting, the Federal Open Market Committee (FOMC) announced that "over coming months the Committee will increase its holdings of Treasury securities by at least \$500 billion and its holdings of agency mortgage-backed securities by at least \$200 billion."[1] Only eight days later, on March 23, 2020, the Fed

[1] See Board of Governors of the Federal Reserve System (2020a)

expanded this program to include agency commercial mortgage-backed securities[2], signaling an even more aggressive intervention. This emergency intervention continued until November 2021, when the Fed announced the beginning of tapering its asset purchases.[3] By May 2022, when the FOMC announced plans for reducing its balance sheet[4], the Fed had more than doubled its holdings compared to pre-pandemic levels (see Figure 1)—a dramatic acceleration compared to the five-year expansion following the Great Recession.

A key institutional feature of the U.S. mortgage market provides an opportunity to identify the effects of the Fed's asset purchases. By Federal Reserve Act Section 14(b)[5], the Fed can only purchase "any obligation which is a direct obligation of, or fully guaranteed as to principal and interest by, any agency of the United States." Subsequently, as a policy action, they purchase agency mortgage-backed securities (MBS), which are guaranteed by Government-Sponsored Enterprises (GSEs) such as Fannie Mae and Freddie Mac. For mortgages to qualify for GSE backing, they must fall below the conforming loan limit (CLL) established by federal regulatory agency. This regulatory framework creates a natural segmentation in the mortgage market between conforming loans (eligible to be included in agency MBS for Fed purchases) and nonconforming loans (ineligible to be in agency MBS for Fed purchases). When the Federal Reserve engages in MBS purchases, the differential impact across these market segments can be measured to isolate the policy's effect from other macroeconomic factors.

The theoretical mechanisms linking Fed MBS purchases to refinancing activity are straightforward. When the Fed purchases agency MBS, yields on these securities decrease. Since primary mortgage rates are closely tied to MBS yields, mortgage interest rates decline in tandem. This reduction in rates incentivizes homeowners to refinance their existing mortgages to secure lower monthly payments or to extract home equity for consumption or investment purposes. However, the extent to which these benefits materialize—and how they are

[2]See Board of Governors of the Federal Reserve System (2020b)
[3]See Board of Governors of the Federal Reserve System (2021)
[4]See Board of Governors of the Federal Reserve System (2022)
[5]See Board of Governors of the Federal Reserve System (2017)

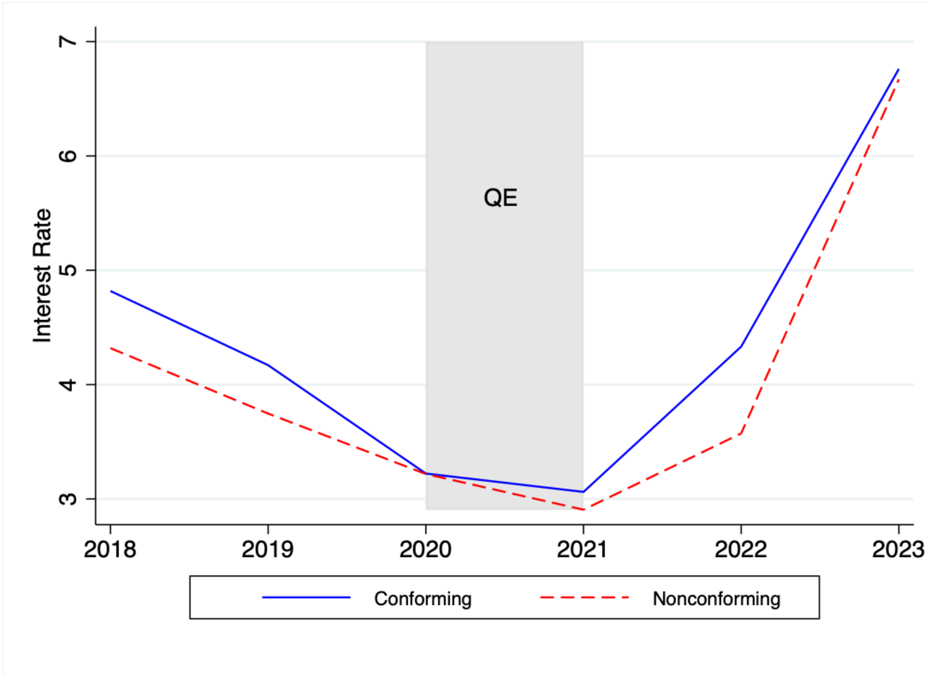


Figure 2: Interest Rates for Conforming and Nonconforming Refinance Loans

distributed across different borrower segments and geographic areas—remains an empirical question that this paper seeks to address.

This study largely builds upon the approach used by Di Maggio et al. (2019), where they examine the effects of QE programs following the Great Recession. However, I extend their analysis to the COVID-19 era, which presents a unique context characterized by a different type of crisis, an unprecedented pace of monetary intervention, and significant demographic shifts driven by the expansion of remote work. While Di Maggio et al. (2019) utilized proprietary loan-level data with high frequency and granularity, I employ the Home Mortgage Disclosure Act (HMDA) dataset, which is publicly available and provides near-universal coverage of mortgage applications and originations across the United States. Although this dataset offers annual rather than monthly observations, it allows for the classification of loans as conforming or nonconforming[6] and provides comprehensive geographic coverage.

[6] I address them as "nonconforming" loans as opposed to "jumbo" loans from Di Maggio et al. (2019), as loans other than jumbo loans might be classified as nonconforming. HMDA data does not provide further granular information on whether a loan is jumbo or other type of nonconforming loan.

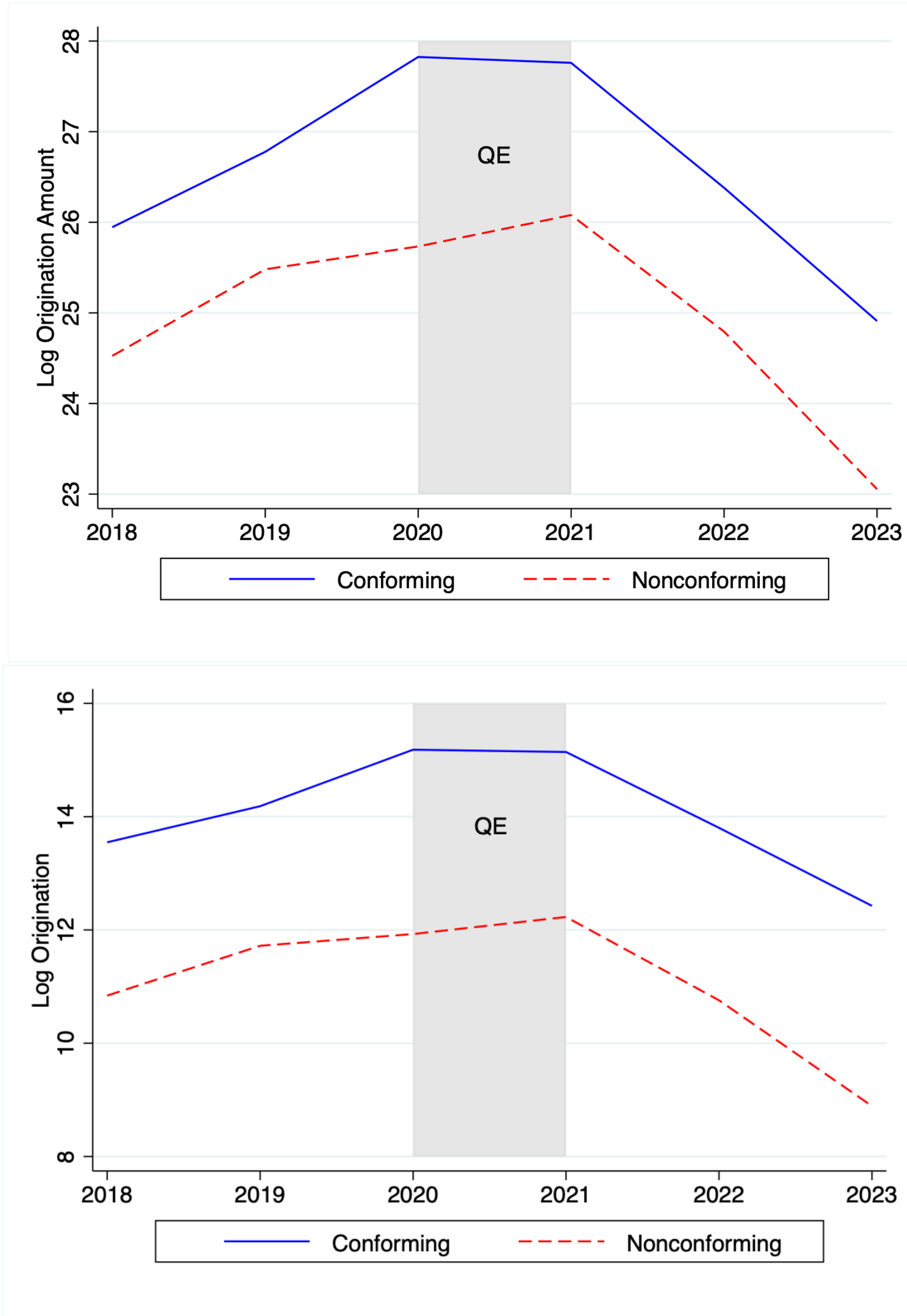


Figure 3: Log Refinance Origination Volume

Preliminary evidence suggests substantial changes in the refinancing market during the COVID-19 period. Figure 2 demonstrates a significant decline in refinance mortgage interest rates coinciding with the Fed's asset purchase program, with notably larger reductions for conforming loans compared to nonconforming loans. At the same time, Figure 3 shows marked increases in both the total dollar volume and the number of refinance originations, with conforming loan originations increasing at a higher rate than nonconforming loans. While these differential trends are suggestive of policy impact, attributing them solely to Fed interventions requires controlling for the multitude of concurrent economic changes during this period.

To address this identification challenge, I employ a difference-in-differences approach that exploits variation across loan segments (conforming versus nonconforming) before and after the implementation of the Fed's COVID-era QE program using loan-level data from the HMDA spanning 2017-2023 for conventional, first-lien 15/20/30-year term refinance mortgages for single-family homes. This methodology helps isolate the impact of the Fed's MBS purchases from other factors affecting the mortgage market during this period. My analysis reveals that the COVID-era QE program led to approximately 32-38 basis points larger reduction in interest rates and 88-97% higher origination volumes for conforming loans relative to nonconforming loans, with effects remaining robust to different specifications and further sample restrictions. The findings are the strongest immediately after implementation in 2020 and gradually diminishing as the Fed began tapering asset purchases in late 2021 and eventually started reducing their balance sheet in 2022.

A novel contribution of this study is the examination of heterogeneous policy effects across metropolitan areas experiencing different migration patterns during the pandemic. The COVID-19 crisis sparked mass internal migration within the United States, as remote work opportunities and lockdown measures prompted many households to relocate from dense urban centers to suburban and rural areas. This demographic shift potentially altered local housing markets and may have influenced the transmission of monetary policy through mortgage market. By examining differential effects on home purchase mortgage originations across areas with high net inflows versus outflows of residents, this study provides insights into how structural changes in residential preferences interact with monetary policy effectiveness.

This paper contributes to several strands of literature. First, it adds to the growing body of research on unconventional monetary policy by providing evidence on the transmission of QE during the COVID-19 crisis—a period that has received limited attention in the monetary policy literature thus far. Second, it extends beyond time-series approaches commonly used in monetary policy studies by employing cross-sectional variation for identification. Third, it connects monetary policy transmission to pandemic-induced migration patterns, bridging macroeconomic policy and spatial economics literature.

The remainder of this paper is organized as follows: Section 2 reviews the related literature and further contextualizes this research. Section 3 describes the HMDA dataset and other data used in the analysis. Section 4 outlines the empirical strategy and methodology. Section 5 presents the main results on the effects of COVID-era quantitative easing on mortgage refinancing with various robustness checks. Section 6 discusses heterogeneous effects across metropolitan areas with different migration patterns during the pandemic. Section 7 concludes with policy implications and directions for future research.

2 Related Literature

This paper draws on several strands of literature that examine monetary policy transmission, refinancing behavior, and the effects of unconventional monetary policy on households, with additional attention to the COVID-19 era.

My work builds on the seminal credit channel theory of monetary policy transmission developed by Bernanke and Gertler (1995), who established that informational frictions in credit markets worsen during contractionary periods, amplifying the effects of monetary policy on the real economy. I extend this framework by examining how quantitative easing operates through a refinancing channel, focusing specifically on how the composition of assets purchased by the central bank influences transmission effectiveness.

2.1 Conventional Monetary Policy and Refinancing Channel

Growing literature examines how mortgage refinancing serves as a key mechanism for transmitting monetary policy to households. Eichenbaum et al. (2022) demonstrate that monetary policy efficacy is state-dependent, varying with the pools of potential savings from refinancing. Wong (2019) finds that consumption responses to rate shocks are heterogeneous across age groups, with younger homeowners who refinance driving most of the aggregate response. Di Maggio et al. (2017) exploit variation in the timing of adjustable-rate mortgage resets to show that reduced mortgage payments lead to significant increases in car purchases, with lower-income and lower-housing-wealth borrowers exhibiting higher marginal propensity to consume.

The institutional structure of the mortgage market plays a critical role in policy transmission. Amromin et al. (2020) synthesize evidence on refinancing frictions that impede monetary policy transmission. Greenwald (2018) shows that payment-to-income constraints in mortgage markets amplify interest rate transmission into debt, house prices, and economic activity. Keys et al. (2016) document that a substantial proportion of households fail to refinance when it would be financially beneficial, suggesting significant frictions in the refinancing process.

2.2 Unconventional Monetary Policy Transmission

My methodological approach is most directly influenced by Di Maggio et al. (2019), who utilize the segmentation of the U.S. mortgage market to identify the impact of QE on refinancing activities. They find that QE1 MBS purchases led to substantially increased refinancing in the conforming segment compared to the jumbo segment, with conforming interest rates falling by 40-50 basis points more than jumbo rates. In contrast, subsequent QEs that did not involve MBS purchases had no significant effect. Their analysis demonstrates that households refinancing during QE1 increased durable consumption by approximately 12%, highlighting the real economic effects of central bank asset purchases.

Krishnamurthy and Vissing-Jorgensen (2011, 2013) evaluate the effects of Fed asset purchases on interest rates, finding that QE1's MBS purchases had larger effects on MBS yields than Treasury purchases, highlighting that the composition of assets purchased matters for transmission. Hancock and Passmore (2015) analyze LSAPs' effects on MBS yields and mortgage rates, finding that the Fed's accumulation of MBS and Treasury securities lowered rates beyond what market expectations alone would suggest.

Chakraborty et al. (2020) find that banks benefiting from MBS purchases increase mortgage origination while reducing commercial lending, suggesting potential unintended consequences of QE. Luck and Zimmermann (2020) show that QE3 had more significant spillovers from the mortgage segment to commercial lending than QE1, supporting the importance of banking sector health in policy transmission.

2.3 Regional Heterogeneity and Distributional Effects

My analysis of regional heterogeneity is largely informed by Beraja et al. (2018), who demonstrate that regions where households have higher housing equity show stronger refinancing and consumption responses to interest rate cuts. They find that during the 2008 recession, refinances were concentrated in relatively healthier markets, providing little relief to the hardest-hit regions. Their findings underscore how the distribution of home equity across regions shapes the effectiveness of monetary policy pass-through.

This regional dimension also connects to work by Hurst et al. (2016), who show that despite large regional variation in default risk, GSE mortgage rates for otherwise identical loans do not vary spatially, leading to cross-regional redistribution. My analysis complements this literature by examining how the composition of Fed asset purchases interacts with regional economic factors to influence the effectiveness of monetary stimulus.

2.4 COVID-19 Era QE and Migration Patterns

My paper extends the existing QE literature by analyzing the unprecedented monetary interventions during the COVID-19 pandemic. Rebucci et al. (2020) conduct an event study of QE announcements during March and April 2020, finding that QE maintained its effectiveness in advanced economies during the pandemic. Agarwal et al. (2024) document that during the first half of 2020, the difference in savings from mortgage refinancing between high- and low-income borrowers was 10 times higher than before, pointing to increased refinancing inequality during the pandemic.

The COVID-19 pandemic also triggered significant changes in migration patterns that may have implications for monetary policy transmission through mortgage market. Haslag and Weagley (2024) examine how broad changes in work arrangements and lifestyles brought on by the pandemic affected households' location decisions, finding that over 12% interstate moves were directly influenced by the pandemic, with remote work influencing more than 15% of these pandemic-related relocations. Ilham et al. (2024) find that the pandemic decreased the importance of transport and workplace accessibility in residential location choices as teleworking became more prevalent, potentially leading to migrations to areas of lower population density. These migration patterns could alter the regional housing market and, consequently, the effectiveness of monetary policy transmission through mortgage credit channel.

My paper makes several contributions to these literatures. First, while Di Maggio et al. (2019) and others have studies the effects of QE following the Great Recession, I provide evidence on how these policies operated during the COVID-19 pandemic, when both economic conditions and policy responses were unprecedented in scale and scope. This analysis is accompanied by further robustness check by including extensive loan-level controls and by excluding loans around the conforming loan limit to address potential endogenous selection around the threshold. Second, I analyze how pandemic-induced migration patterns interacted with monetary policy transmission, potentially altering the regional effectiveness of QE through changes in local housing market. By examining the transmission of QE to interest rates and origination volumes during the COVID-19 era, my paper provides a comprehensive assessment of unconventional monetary policy's effectiveness in stimulating economic activity through mortgage market during a unique period of economic disruption and adaptation.

3 Data

This study employs comprehensive loan-level data and supplemental data from multiple sources to examine the effects of monetary policy on mortgage refinancing activity across different market segments.

The primary data source is the Home Mortgage Disclosure Act (HMDA) dataset, which represents the most comprehensive publicly available information on the U.S. mortgage market. HMDA requires financial institutions to maintain, report, and publicly disclose loan-level information about mortgages. I use the loan-level Loan/Application Records (LAR) spanning from 2017 to 2023, retrieved from the Federal Financial Institutions Examination

Table 1: Summary Statistics

	Mean	Std. Dev.	10th	50th	90th
Panel I. Conforming Loans					
CLTV (%)	63.51	16.54	39.64	66.67	80
Interest Rate (%)	3.42	0.98	2.50	3.13	4.75
Amount ($)	272,718	145,669	115,000	245,000	475,000
Property Value ($)	465,132	791,383	185,000	385,000	815,000
Income ($)	125,581	1,022,788	47,000	100,000	210,000
Observations			16,905,826		
Panel II. Nonconforming Loans					
CLTV (%)	64.01	14.94	42.71	66.68	80
Interest Rate (%)	3.34	0.86	2.50	3.13	4.25
Amount ($)	1,095,717	884,719	595,000	905,000	1,705,000
Property Value ($)	1,927,877	2,796,462	825,000	1,475,000	3,275,000
Income ($)	506,227	4,194,045	171,000	319,000	815,000
Observations			741,525		

Notes: Panel I and Panel II report loan-level summary statistics on conforming and nonconforming loans from annual HMDA LAR datasets from 2018 to 2023. The sample includes conventional, first-lien, 15/20/30-year term, single family, refinancing or cash-out refinancing loans originated with observations without missing interest rate or loan amount data.

Council (FFIEC)[7].

To ensure the most accurate and comprehensive information within each year, I employ the most complete dataset available for each period: (1) Three Year datasets for 2017-2020, which include adjustments incorporated in the 34 months following the reporting deadline, (2) One Year datasets for 2021 and 2022, which include adjustments incorporated in the 12 months following the reporting deadline, and (3) Snapshot dataset for 2023, containing the national HMDA data as of May 1, 2024.

While the entire period spans 2017-2023, I primarily focus on 2018-2023 for the main analyses, as the 2017 data lacks interest rate and other important loan and demographic information. However, I retain 2017 data for event studies as it includes crucial information about loan amounts.

[7] Federal Financial Institutions Examination Council (2020, 2021, 2022, 2023a,b, 2024a,b)

The HMDA data provides extensive information on mortgage characteristics, including loan type, purpose, amount, interest rate, combined loan-to-value ratio, geographical information (state, county, census tract, metropolitan statistical area (MSA) code), borrower demographics (ethnicity, race, sex, age, income, debt-to-income ratio), property information (property value, number of units, construction methods), and various loan features, including but not limited to discount points, prepayment penalty, balloon payment. Despite its comprehensiveness, the public dataset does not include credit score information due to borrower privacy concerns, which is a limitation compared to the proprietary data used by Di Maggio et al. (2019).

For most analyses, I restrict the sample to conventional, first-lien, 15/20/30-year term, single-family homes with either refinancing or cash-out refinancing loans that are originated. I further restrict the sample to observations with non-missing values for interest rate, loan amount, and combined loan-to-value ratio, and trim extreme values above the 99.5th percentile and below the 0.5th percentile of main outcome variables to eliminate potential data entry errors and biases caused by skewness in the data. For analyses involving origination volumes, I aggregate the data over county-segment-time, as loan-level data cannot adequately capture these patterns.

Table 1 presents summary statistics for the resulting sample, separated by conforming and nonconforming loan segments. Panel I shows that conforming loans ($n = 16,905,826$) have an average combined loan-to-value (CLTV) ratio of 63.5%, with a mean interest rate of 3.42%. The average loan amount is approximately $273,000, with underlying property values averaging $465,000 and borrower incomes averaging about $126,000. Panel II reveals that nonconforming loans ($n = 741,525$) have a similar average CLTV ratio of 64.0% and a slightly lower average interest rate of 3.34%. However, as expected, nonconforming loans are substantially larger, with an average loan amount approximately $1.1 million and property values averaging $1.9 million. Borrowers in this segment have considerably higher incomes, averaging about $506,000. The distribution of each variable across different percentiles (10th, 50th, and 90th) shows considerable variation within each loan segment, providing substantial statistical power for the analyses.

For robustness check related to the conforming loan limit, I incorporate data from the Federal Housing Finance Agency (FHFA)[8] on annual conforming loan limit values, matched by county FIPS code.

The regional analysis leverages data derived from Brookings Institution research[9], which utilizes Internal Revenue Service (IRS) population migration data[10] at the county level. The derived data focuses on the 50 largest metropolitan areas rather than all counties, using net domestic migration changes in 2021 and 2022 as a percentage of 2020 population. Based on this data, I classify areas into net inflow and net outflow regions. For this analysis, I focus on home purchase loans rather than refinancing, as they are more appropriate for incorporating migration patterns. I additionally employ the Census Bureau's Core-Based Statistical Area (CBSA) to Federal Information Processing Series (FIPS) County Crosswalk[11] to match each MSA of interest with corresponding counties in the main HMDA dataset.

4 Empirical Strategy

In this section, I outline the empirical approach used to identify the effects of QE on refinancing interest rates and origination volumes. The identification challenge stems from the nonrandom nature of monetary policy interventions, which are typically implemented in response to economic conditions. To address this challenge, I employ several empirical strategies that exploit the segmentation in the U.S. mortgage market.

[8] Federal Housing Finance Agency (2024)
[9] See Appendix B of Berube (2024)
[10] See Internal Revenue Service
[11] See Census Bureau

4.1 Difference-in-Differences

I begin with a canonical difference-in-differences (DiD) approach to identify the effect of QE on mortgage market outcomes. This approach is necessary because we cannot randomly assign monetary policy shocks to different loans of the mortgage market. A simple Ordinary Least Squares (OLS) regression would likely yield biased estimates due to the endogeneity of monetary policy decisions.

My identification strategy exploits the institutional feature that the Fed can only purchase mortgages guaranteed by GSEs (*i.e.*, conforming mortgages). Mortgages exceeding the conforming loan limits (*i.e.*, nonconforming mortgages) are ineligible for Fed purchases. This creates a quasi-experiment setting where conforming mortgages constitute the treatment group and nonconforming loans serve as the control group.

For the analysis of refinance interest rates, I estimate the following equation:

$$r_{icst} = \theta_0 \text{QE}_t + \theta_1 \text{Conforming}_s + \theta_2 \text{QE}_t \cdot \text{Conforming}_s + X_i' \beta + \varphi_{cs} + \eta_{ct} + \varepsilon_{icst} \quad (1)$$

where r_{icst} represents the interest rate for loan i in county c, segment s (conforming or nonconforming), at time t. QE_t is a binary indicator equal to one for periods following QE implementation, which in this case, are 2020 and 2021. Conforming_s indicates whether the loan is in the conforming segment. X_i represents a vector of loan-level controls, and φ_{cs} and η_{ct} represent county-segment and county-time fixed effects, respectively. Loan-level controls and fixed effects are not included in 2×2 DiD analysis.

For refinance origination volumes, I estimate:

$$\log Q_{cst} = \psi_0 \text{QE}_t + \psi_1 \text{Conforming}_s + \psi_2 \text{QE}_t \cdot \text{Conforming}_s + X'_{cst}\beta + \delta_{cs} + \alpha_{ct} + u_{cst} \quad (2)$$

where $\log Q_{cst}$ is either the log dollar volume or quantity count of mortgage originations in county c, segment s, at time t. The remaining variables are defined similarly to the interest rate equation, except that X_{cst} is average CLTV over county-segment-time rather than individual loans.

The coefficients of interest are θ_2 and ψ_2, which measure the differential effect of QE on conforming versus nonconforming refinancing mortgages. A negative θ_2 would indicate that QE increased the conforming-nonconforming spread, as conforming rates decreased more, while a positive ψ_2 would indicate that QE increased origination volumes more in the conforming segment than in the nonconforming segment.

For these DiD estimates to have a causal interpretation, several key assumptions must hold. First, the outcome variables for conforming and nonconforming mortgages should have followed parallel trajectories in the absence of QE. While this counterfactual cannot be directly observed, I examine pre-treatment trends to assess the plausibility of this assumption. Visual inspection of interest rates and origination volumes prior to QE implementation in Figure 2 and Figure 3 provides initial evidence supporting this parallel trends assumption. Even if unconditional parallel trends do not hold perfectly, the inclusion of controls and fixed effects may allow for conditional parallel trends. By controlling for loan characteristics and county-segment and county-time fixed effects, I account for factors that might lead to differential trends across segments, such as local economic conditions or differences in borrower composition. Another key assumption is Stable Unit Treatment Value Assumption, or SUTVA. This assumption requires that the treatment of one unit does not affect outcomes for other units. In this context, SUTVA is likely violated because QE may indirectly affect the nonconforming segment through general equilibrium effects. For instance, improvements in overall economic conditions due to QE may increase demand for all types of mortgages, including non-conforming loans. This spillover implies that our DiD estimates likely understate the true effect of QE, as they only capture the differential impact between segments rather than the total effect.

4.2 Two-Way Fixed Effects

To account for time-invariant heterogeneity across county-segment pairs and time-varying factors affecting all counties, I enhance the baseline DiD by incorporating a two-way fixed effects (TWFE) structure. I use the same estimating equations as Equation 1 and Equation 2, but in these specifications, the county-segment fixed effects (φ_{cs} and δ_{cs}) absorb the main effect of the conforming indicator (*i.e.*, θ_1 and ψ_1), while the county-time fixed effects (η_{ct} and α_{ct}) absorb the main effect of the QE indicator (*i.e.*, θ_0 and ψ_0). This approach effectively compares conforming and nonconforming mortgages within the same county and time period, eliminating the influence of county-specific shocks that might otherwise bias the results.

The TWFE specification is more demanding than the baseline DiD as it removes both cross-sectional and temporal variation at the county level, isolating the differential effect of QE across mortgage segments. The coefficients θ_2 and ψ_2 maintain the same interpretation as in the baseline DiD, but with potentially greater credibility due to more exhaustive set of controls.

4.3 Dynamic Two-Way Fixed Effects (Event Studies)

To examine the dynamic effects of QE and formally test for pre-trends, I estimate an event study specification:

$$\log Q_{cst} = \sum_{k=-3}^{3} \delta_k \mathbb{1}\{t - t_0 = k\} + \mu_c + \alpha_t + u_{cst} \tag{3}$$

where t_0 represents the commencement date of QE (i.e., 2020), and k indexes years relative to this date. The coefficients δ_k for $k < 0$ capture any differential pre-trends between conforming and nonconforming refinance mortgages. Theoretically, if the parallel trends assumption holds, these coefficients should be statistically indistinguishable from zero. The coefficients for $k \geq 0$ trace out the dynamic response to QE, allowing us to assess whether the effects are immediate, delayed, or transitory. This event study approach serves both as a validation of the DiD identification strategy and as a way to characterize the temporal pattern of QE effects. It also helps distinguish between anticipation effects (if market participants react to announcements before implementation) and implementation effects (as the policy takes effect).

4.4 Robustness Check

To further assess the robustness of my results, I augment the TWFE model in Equation 1 with an extensive set of loan-level controls that might influence mortgage outcomes and potentially vary differentially across segments following QE. These include demographics, like income, age, race, and sex, and borrower characteristics like debt-to-income ratios, property characteristics, and census tract information. The specific list of controls used can be found in Appendix A. Including these controls helps address concerns that compositional changes in borrower or loan characteristics might drive the observed differential effects between conforming and nonconforming mortgages.

A potential threat to identification arises from borrowers' ability to strategically position their loans relative to the conforming loan limit (CLL). Specifically, borrowers near the threshold might reduce their loan amounts to qualify for conforming loans, especially when the benefits of doing so increase (*e.g.*, during QE). This endogenous selection could bias our estimates of QE effects.

To address this concern, I re-estimate the TWFE models in Equation 1 and Equation 2 after excluding loans with amounts between 90% and 140% of the CLL, focusing on loans that are clearly conforming or clearly non-conforming. This approach eliminates the subset of loans most susceptible to endogenous selection, providing a cleaner comparison between the two segments. If the results remain consistent after this exclusion, it suggests that endogenous selection around the threshold is not driving the observed effects.

By implementing these robustness checks alongside the main specifications, I aim to establish the credibility of the estimated QE effects against a range of potential confounding factors. The combination of baseline DiD, TWFE, event studies, and robustness tests provides a comprehensive assessment of how QE differentially affected conforming and non-conforming mortgages, shedding light on the transmission channels of unconventional monetary policy.

5 Results

This section presents the empirical results on the effects of the Federal Reserve's COVID-era QE program on mortgage refinancing outcomes. I examine how QE differently affected interest rates and origination volumes across conforming and nonconforming loan segments. Throughout this section, standard errors are clustered at the county level to account for potential correlation in the error terms within geographical areas.

5.1 Difference-in-Differences

Table 2 presents the effects of QE on refinance interest rates. Column (1) reports results from the baseline difference-in-differences (DiD) specification without fixed effects or controls. The

Table 2: Effect of QE on Refinance Interest Rates

	(1)	(2)	(3)	(4)
QE	-0.862***			
	(0.011)			
Conforming	0.432***			
	(0.021)			
QE × Conforming	-0.416***	-0.367***	-0.341***	-0.320***
	(0.011)	(0.006)	(0.005)	(0.006)
Basic Controls	No	No	Yes	Yes
County-Year FE	No	Yes	Yes	Yes
County-Segment FE	No	Yes	Yes	Yes
Extensive Controls	No	No	No	Yes
Include 2022 Data	No	No	No	No
Observations	15,758,569	15,758,076	15,758,076	15,143,826
R^2	0.467	0.527	0.614	0.688

Notes: The sample includes conventional, single-family, first-lien, 15/20/30-year term refinance mortgages with non-missing interest rate, loan amount, and CLTVs. The event window includes years from 2018 to 2021. Years 2022 and 2023 are excluded due to the change of Fed balance sheet policy. Specifications in columns (2)-(4) control for county-year fixed effects and county-segment fixed effects. Columns (3)-(4) control for 5-point CLTV bins and a categorical interaction of interest rate type, interest-only indicator, and loan term. Lastly, column (4) controls for extensive loan-level controls, which can be found in Appendix A. Standard errors are clustered at the county level. Asterisks denote significance levels ($^{***} = 1\%, ^{**} = 5\%, ^{*} = 10\%$)

coefficient on the QE indicator (-0.862) shows that, on average, refinance rates declined by approximately 86 basis points during the QE period, reflecting the overall monetary easing stance. The positive coefficient on the Conforming indicator (0.432) suggests that before QE implementation, conforming loans had interest rates that were about 43 basis points higher than nonconforming loans on average, which aligns with the expectation that jumbo loans typically serve higher-income, lower-risk borrowers.

The key coefficient of interest is on the interaction term QE × Conforming, which captures the differential effect of QE on conforming relative to nonconforming refinance rates. The estimated coefficient of -0.416 indicates that QE led to an additional 42 basis point reduction in interest rates for conforming loans relative to nonconforming loans. This effect is both

Table 3: Effect of QE on Log Refinance Origination Volume

	(1)	(2)	(3)	(4)
QE	0.792***	0.670***		
	(0.014)	(0.014)		
Conforming	2.141***	3.417***		
	(0.038)	(0.038)		
QE × Conforming	0.684***	0.659***	0.678***	0.656***
	(0.015)	(0.015)	(0.015)	(0.015)
Quantity Count	No	Yes	No	Yes
Controls	No	No	Yes	Yes
County-Year FE	No	No	Yes	Yes
County-Segment FE	No	No	Yes	Yes
Observations	5,848	5,848	5,848	5,848
R^2	0.401	0.602	0.994	0.996

Notes: The left-hand side variable is either the log dollar volume or the log quantity count of refinanced mortgages at the county-year-segment level as reported in the HMDA data. The sample includes conventional, single-family, first-lien, 15/20/30-year term refinance mortgages with non-missing interest rate, loan amount, and CLTVs. The event window includes years from 2018 to 2021. Years 2022 and 2023 are excluded due to the change of Fed balance sheet policy. Counties are included in the sample if they have a positive number of nonconforming originations in every sample year. Specifications in columns (3)-(4) control for average CLTV, county-year fixed effects and county-segment fixed effects. Standard errors are clustered at the county level. Asterisks denote significance levels ($^{***} = 1\%, ^{**} = 5\%, ^{*} = 10\%$)

economically substantial and statistically significant at the 1% level. This differential effect represents approximately half of the overall decline in the interest rates during the QE period, highlighting the importance of the MBS purchase channel in transmitting unconventional monetary policy to mortgage markets.

Similarly, Table 3 presents the effects of QE on refinance origination volumes. Columns (1) and (2) report results from the baseline DiD specification for log dollar volume and log quantity count, respectively. The coefficient on QE indicates that refinance volumes increased substantially during the QE period, with dollar volume increasing by 79.2 log points (approximately 121% in levels) and quantity count increasing by 67.0 log points (approximately 95% in levels). This broad-based increase in refinancing activity reflects the overall stimulative effect of monetary easing.

The positive coefficient on Conforming indicates that conforming loans had substantially higher origination volumes than nonconforming loans before QE, consistent with the much larger market segment represented by conforming loans. The interaction term QE $\times$ Conforming shows that conforming loan refinancing volumes increased by an additional 68.4 log points (approximately 98%) in dollar terms and 65.9 log points (approximately 93%) in quantity terms compared to nonconforming loans during the QE period. These estimates are statistically significant at the 1% level and economically substantial, indicating a strong differential response to Fed MBS purchases.

5.2 Two-Way Fixed Effects (TWFE)

To account for unobserved heterogeneity across counties and time periods, I employ a more demanding TWFE specification. In Table 2, columns (2)-(4) present these results for refinance interest rates. Column (2) includes county-year and county-segment fixed effects without loan-level controls. The coefficient on QE $\times$ Conforming (-0.367) remains negative and statistically significant, though slightly attenuated compared to the baseline DiD. This suggests that some of the differential effect in the baseline specification may be attributed to county-specific factors.

Column (3) adds basic loan-level controls, including combine loan-to-value ratio bin and loan characteristics, which further attenuates the coefficient to -0.341. This indicates that changes in loan composition explain part of the differential effect, but the majority persists even after accounting for these factors. For robustness check, column (4) includes an extensive set of borrower and loan characteristics controls, which further reduced the coefficients to -0.320, but it remains robust and economically and statistically significant. This persistent differential effect after controlling for extensive loan characteristics suggests that the

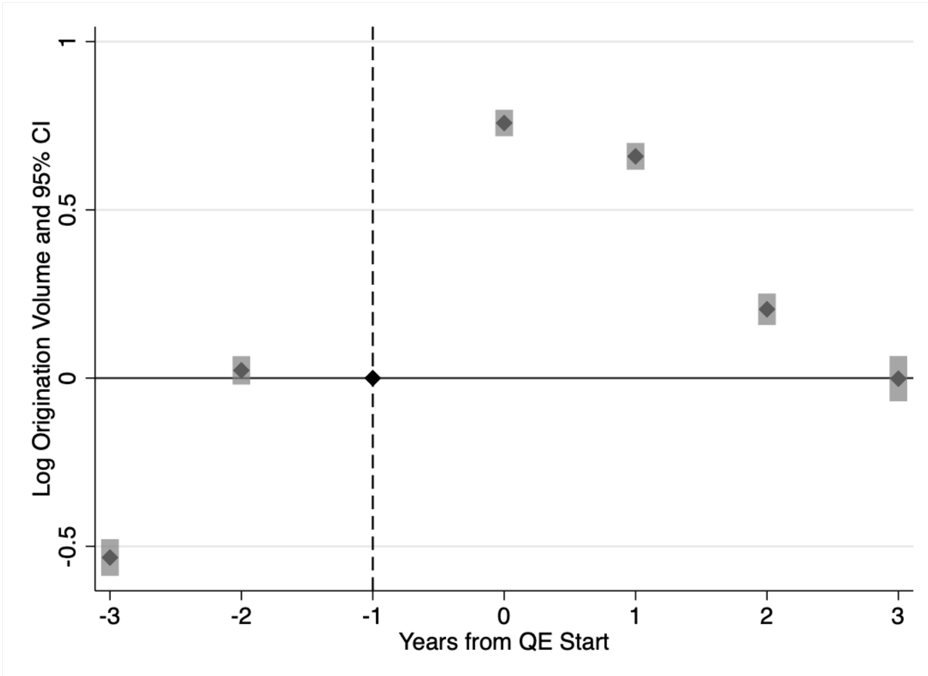
QE effect operates through a direct interest rate channel rather than through changes in borrower composition or credit risk.

In Table 3, columns (3) and (4) present the TWFE results for origination volumes in log dollar and quantity terms, respectively. The interaction term coefficients remain highly significant and positive: 67.8 log points for dollar volume and 65.6 log points for count. These estimates are remarkably consistent with the baseline DiD results, suggesting that county-specific factors play a minimal role in explaining the differential response in origination volumes. The persistence of these effects after including controls and fixed effects provides strong evidence that the Fed's MBS purchases had a causal impact on increasing refinancing activity in the conforming segment relative to the nonconforming segment.

The estimates from the TWFE models suggest that the Fed's COVID-era QE program led to approximately 32-37 basis points larger reduction in interest rates for conforming loans relative to nonconforming loans. This differential effect is approximately one-third of the overall interest rate decline during this period, highlighting the significant role of the MBS purchase channel. For origination volumes, the differential effect is approximately 65-68 log points, which translates to a 92-97% larger increase in refinancing activity for conforming loans compared to nonconforming loans.

5.3 Dynamic Two-Way Fixed Effects (Event Studies)

Figure 4 presents the event study results for log refinance origination dollar amount, showing the differential effect between conforming and nonconforming segments over time. It is important to note that 2019 (the first lag) is omitted as the reference period due to collinearity. The coefficients for 2018 (the second lag) is statistically indistinguishable from zero, which is a reassuring sign that there were no significant differential trends or anticipatory behaviors before the policy implementation. For 2017 (the third lag), we observe a negative effect, which is consistent with the Fed's contractionary policy stance during that period as they



Notes:

Figure 4: Log Refinance Amount Event Studies Plot

were normalizing monetary policy following earlier QE programs.

Following QE implementation in 2020, we observe a sharp and statistically significant increase in the differential effect, which is also consistent with TWFE results above. This indicates that conforming refinance volumes responded much more strongly to QE than nonconforming volumes. This finding remains relatively robust even after allowing for the parallel trends violation in the post-period up to the pre-period violation (see Figure A1 in Appendix B) using the "honest" approach developed by Rambachan and Roth (2023). The effect is strongest immediately in 2020, suggesting that the QE transmission to refinancing activity was rapid. The differential effect begins to attenuate in 2021 and continues to decline in 2022 and 2023, coinciding with the Fed's tapering of asset purchases announced in November 2021 and subsequent balance sheet reduction beginning in 2022. This temporal pattern aligns with the policy implementation timeline and demonstrates that the effects of QE on refinancing activity are closely tied to the Fed's balance sheet policies, with effects diminishing as monetary policy normalizes.

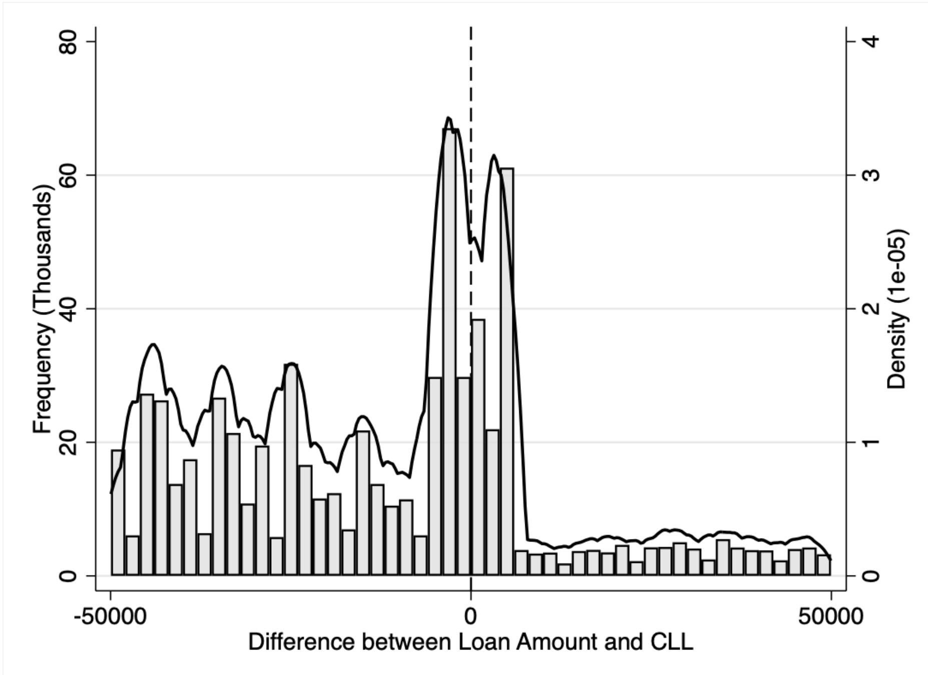


Figure 5: Histogram and Kernel Density of Loan Amount around CLL

The event study results provide important insights into the dynamics of QE effects. First, they support the validity of the DiD identification strategy by confirming the absence of anticipatory effect right before the policy was implemented. Second, they reveal the temporal pattern of QE effects, showing that they materialize quickly but are not permanent. Third, they demonstrate the sensitivity of refinancing activity to changes in the Fed's balance sheet policies, with effects dissipating as QE is reversed.

5.4 Robustness Check

Figure 5 illustrates the distribution of loan amounts around the conforming loan limit (CLL) threshold, showing evidence of significant bunching just below the threshold. This pattern is consistent with borrowers strategically positioning their loans to qualify for conforming status, particularly during the QE period when the benefits of doing so increased due to the larger spread between conforming and nonconforming rates. The histogram reveals a sharp discontinuity at the CLL, with substantially higher density just below the threshold compared to just above it. This bunching phenomenon raises concerns that strategic loan amount manipulation might confound our estimates of QE effects.

To address concerns about potential endogenous selection around the conforming loan limit (CLL), Table 4 presents results excluding loans with amounts between 90% and 140% of the CLL, following the criteria used by Di Maggio et al. (2019). This robustness check focuses on loans that are clearly conforming or clearly nonconforming, reducing concerns about strategic positioning of loan amounts to qualify for conforming status.

Column (1) reports the effect on interest rates, with a coefficient on QE $\times$ Conforming of -0.385, which is slightly larger in magnitude than the full-sample TWFE estimate in Table 2, column (3). This suggests that, if anything, including loans around the CLL threshold may understate rather than overstate the differential effect of QE. Columns (2) and (3) report the effects on origination volumes, with coefficients similar to the full-sample estimates (0.673 for log dollar amount and 0.629 for log count). The stability of these estimates when excluding loans around the CLL threshold suggests that strategic positioning of loan amounts is not driving our main results, despite the clear visual evidence of such behavior in Figure 5.

Overall, the robustness checks support the main findings: the Fed's COVID-era QE program had substantial differential effects on conforming versus nonconforming refinance mortgages, with larger interest rate reductions and origination volume increases in the conforming segment. These effects persist after accounting for loan characteristics and potential endogenous selection around the CLL threshold.

The magnitude of these effects is broadly consistent with, though slightly smaller than, previous research on QE programs following the Great Recession. Di Maggio et al. (2019) found that QE1 led to a 40-50 basis point larger reduction in conforming rates compared to jumbo rates, whereas my estimates show a 32-42 basis point differential effect. This modest attenuation in effectiveness may be attributed to several factors. First, the baseline

Table 4: Effect of QE Excluding Loans around CLL Cutoff

	(1) Interest Rate	(2) Log(Amount)	(3) Log(Count)
QE × Conforming	-0.385***	0.673***	0.629***
	(0.006)	(0.019)	(0.019)
Controls	Yes	Yes	Yes
County-Year FE	Yes	Yes	Yes
County-Segment FE	Yes	Yes	Yes
Observations	14,536,419	3,768	3,768
R^2	0.620	0.994	0.996

Notes: The left-hand side variable is nominal interest rate of refinanced mortgages for column (1) and the log dollar volume or the log quantity count at the county-year-segment level for columns (2) and (3). The sample includes conventional, single-family, single unit, first-lien, 15/20/30-year term with non-missing interest rate, loan amount, and CLTVs. The sample is further restricted by excluding loans with amounts between 90% and 140% of the conforming loan limit. The event window includes years from 2018 to 2021. Years 2022 and 2023 are excluded due to the change of Fed balance sheet policy. For columns (2) and (3), counties are included in the sample if they have a positive number of nonconforming originations in every sample year. Specification in column (1) control for 5-point CLTV bins and a categorical interaction of interest rate type, interest-only indicator, and loan term, while columns (2) and (3) control for average CLTV. All specifications include county-year fixed effects and county-segment fixed effects. Standard errors are clustered at the county level. Asterisks denote significance levels ($^{***} = 1\%, ^{**} = 5\%, ^{*} = 10\%$)

interest rate environment differed substantially: 30-year fixed-rate mortgages averaged approximately 3.45% in February 2020 before COVID-19 QE, compared to around 6.10% in October 2008 before QE1.[12] With mortgage rates already at historically low levels before the pandemic, there was potentially less room for QE to drive further reductions. Second, the nature of the crises differed markedly. While the Great Recession originated within the housing and mortgage markets, making direct interventions in these sectors particularly potent, the COVID-19 downturn was triggered by an external public health shock rather than underlying housing market weaknesses. Despite these differences, the COVID-era QE still generated substantial differential effects, highlighting the continued effectiveness of the MBS

[12] See Freddie Mac

purchase channel even in a low-interest-rate environment during a crisis of different origin.

6 Discussion: COVID-19 Migration-Induced Heterogeneity

The COVID-19 pandemic triggered substantial changes in residential preferences and migration patterns across the United States. As remote work became widespread and lockdown measures altered the value proposition of dense urban living, significant population shifts occurred from high-cost metropolitan areas toward more affordable locations with greater space and amenities (Haslag and Weagley, 2024). Major urban centers such as New York, San Francisco, and Los Angeles experienced substantial outflows, while cities like Dallas, Tampa, and Houston saw significant inflows of new residents (Berube, 2024). These demographic shifts potentially altered local housing markets and may have influenced the transmission of QE through the mortgage channel.

In this section, I investigate whether the effectiveness of QE varied systematically across areas experiencing different migration patterns. Unlike the previous sections, which focused on refinancing activity, this analysis examines home purchase mortgages, as they more directly reflect residential mobility decisions and housing demand in areas with population changes. The heterogeneous effects of QE on home purchase mortgages across different migration patterns provide insights into how structural changes in residential preferences interact with monetary policy effectiveness.

To analyze migration patterns, I utilize data from Brookings Institution research based on IRS population migration statistics. This data focuses on the 50 largest metropolitan statistical areas (MSAs) in the United States and measures net domestic migration changes in 2021 and 2022 as a percentage of 2020 population. I use the continuous measure of net migration rate for each MSA as my key variable of interest. For visual analysis and trend examination purposes, I also classify MSAs into "net in-migration" regions (*i.e.*, those experiencing positive net migration) and "net out-migration" regions (*i.e.*, those experiencing negative net migration).

Major MSAs in the net out-migration category include San Francisco, New York, Los Angeles, and Chicago, which collectively experienced substantial resident losses of about 2-4% of their population during the pandemic. The net in-migration category includes metro areas such as Jacksonville, Tampa, Austin, and Raleigh, which gained significant residents during the same period. By examining differential policy effects across these two groups, I can identify how pandemic-induced migration patterns potentially moderated the impact of the Fed's asset purchases on mortgage markets.

It is important to note that the migration data used in this analysis has certain limitations. First, while the pandemic likely influenced these migration patterns, the IRS data does not isolate purely pandemic-induced migration from other factors affecting residential mobility. Some of these migration trends may reflect longer-term demographic shifts that predated the pandemic but were potentially accelerated by it. Second, as Frey (2024) documents, many of these migration patterns proved temporary, as the pandemic impact subsided. This temporal aspect of migration patterns should be considered when interpreting the results.

Before implementing the formal empirical analysis, it is crucial to examine the trends in home purchase mortgage originations across different migration patterns. As shown in Figure A2 in Appendix C, both net in-migration and net out-migration metro areas exhibited similar trends in conforming and nonconforming purchase mortgage volumes during the pre-QE period (2018-2019), which supports the validity of my identification strategy.

Following the implementation of QE in 2020, conforming purchase mortgages increased steadily in both areas, with conforming loans initially growing slightly more rapidly than nonconforming loans. However, by 2021, nonconforming purchase mortgage volumes experienced substantial growth in both area types. Notably, nonconforming loan volumes are generally higher in net outflow areas compared to net inflow areas, consistent with higher average housing prices in metropolitan areas that experienced population outflows during the pandemic (such as New York, San Francisco, and Los Angeles).

To formally test for heterogeneous effects across migration patters, I employ a triple-difference (difference-in-difference-in-differences or DDD) estimator. This approach extends the previous DiD framework by adding a third dimension of variation: the continuous net migration rate of the metro area. The triple-difference specification is given by:

$$\begin{aligned}\log Q_{mst} = {} & \delta_0 \text{QE}_t + \delta_1 \text{Conforming}_s + \delta_2 \text{Migration}_m + \delta_3 \text{QE}_t \cdot \text{Conforming}_s \\ & + \delta_4 \text{QE}_t \cdot \text{Migration}_m + \delta_5 \text{Conforming}_s \cdot \text{Migration}_m \\ & + \delta_6 \text{QE}_t \cdot \text{Conforming}_s \cdot \text{Migration}_m + \eta_{mst}\end{aligned} \tag{4}$$

where $\log Q_{mst}$ is the log count of home purchase mortgage originations in metro area m, segment s (conforming or nonconforming), at time t. QE_t is a binary indicator for periods following QE implementation, and Conforming_s indicates whether the loan is in the conforming segment. Migration_m is the net migration rate for metropolitan area m, measured as the percentage change in population due to domestic migration.

The coefficient of primary interest is δ_6, which captures how the effect of QE on conforming versus nonconforming loans varies with the net migration rate of the area. A positive coefficient would indicate that the QE effect on conforming loans was stronger in areas with higher net migration rates compared to areas with lower or negative migration rates.

Table 5 presents the results from the triple-difference specification for home purchase mortgage originations. Column (1) shows the baseline DiD specification without the migration factor, while column (2) presents the full triple-difference specification.

Table 5: COVID-Induced Heterogeneity Analysis

	(1)	(2)
QE	0.212***	0.212***
	(0.014)	(0.012)
Conforming	2.764***	2.765***
	(0.128)	(0.121)
Migration		-0.152
		(0.091)
QE × Conforming	0.039***	0.040***
	(0.011)	(0.010)
QE × Migration		-0.026***
		(0.007)
Conforming × Migration		0.157*
		(0.085)
QE × Conforming × Migration		0.021***
		(0.005)
Triple Difference	No	Yes
Controls	No	No
Observations	588	588
R^2	0.653	0.668

Notes: The left-hand side variable is the log quantity count at the MSA-year-segment level. The sample includes conventional, single-family, single unit, first-lien, 15/20/30-year term home purchase mortgages with non-missing interest rate, loan amount, and CLTVs. Years 2022 and 2023 are excluded due to the change of Fed balance sheet policy. Standard errors are clustered at the MSA level. Asterisks denote significance levels ($^{***}=1\%$, $^{**}=5\%$, $^{*}=10\%$)

The coefficient on QE × Conforming indicates that QE led to approximately 4% higher origination volumes for conforming loans relative to nonconforming loans, a statistically significant but modest effect compared to the much larger differential effects observed for refinancing volumes in Table 3. The triple interaction term QE × Conforming × Migration has a coefficient of 0.021, which is positive and significant at the 1% level. This indicates that for each percentage point increase in net migration rate, the differential effect of QE on conforming versus nonconforming purchase mortgages was approximately 2.1 percentage points larger. For instance, comparing an MSA with a +2% migration rate to one with a -2%

migration rate, the conforming-segment policy boost would be approximately 8.4 percentage points ($4 \times 2.1\%$) stronger in the area with positive migration.

The coefficient on QE × Migration suggests that nonconforming purchase mortgages declined as the migration rate increased during the QE period. This could reflect compositional changes in borrower characteristics or shifting preferences for housing types across different migration patterns.

Several mechanisms might explain why QE had stronger effects on conforming purchase mortgages in areas experiencing population inflows. First, areas with net inflows experienced heightened demand for housing during the pandemic, amplifying the stimulative effect of QE on mortgage originations. This increased demand may have been particularly relevant for moderately priced homes in the conforming segment. Second, migration patterns during COVID-19 were not uniform across income groups (Haslag and Weagley, 2024). Higher-income households with greater ability to relocate may have disproportionately moved to net inflow areas, altering the pool of potential borrowers in ways that enhanced the transmission of monetary policy. Third, the pandemic may have affected local credit market conditions differently across regions. Areas experiencing population growth might have had more competitive mortgage markets, facilitating stronger transmission of QE effects.

It is important to acknowledge several limitations of this analysis. First, the sample includes only the 50 largest MSAs in the United States, which represent a small fraction of the 387 total MSAs and 538 micropolitan statistical areas (μSAs) nationwide. The relationship between QE, mortgage markets, and migration patterns in smaller metro areas, suburbs, and rural regions may differ substantially from what is observed in major urban areas. Consequently, the external validity of these findings beyond large metro areas is potentially limited. Second, as noted earlier, the migration data does not isolate purely pandemic-induced migration from other factors affecting residential mobility. A more thorough analysis would require more precise identification of migration drivers to distinguish pandemic effects from other concurrent trends.

Despite these limitations, the observed heterogeneity suggests several promising directions for future research. Using more granular migration data at the county or census tract level would allow for examination of heterogeneous effects within metro areas, potentially revealing how neighborhood-level demographic shifts interact with monetary policy transmission. Moreover, extending the analysis to include lagged or dynamic effects would help understand how the relationship between QE, mortgage markets, and migration patterns evolves over time, particularly as some pandemic-driven migration trends became moderated in subsequent years.

These results highlight the importance of considering spatial heterogeneity and demographic shifts when evaluating the effectiveness of monetary policy. The Fed's COVID-era QE program appears to have had heterogeneous effects across geographic areas, with stronger impacts in regions experiencing positive migration trends. This spatial dimension adds nuance to our understanding of unconventional monetary policy transmission during the pandemic period.

7 Conclusion

This study has investigated how the Federal Reserve's emergency monetary interventions during the COVID-19 crisis influenced mortgage markets through the refinancing channel. Taking advantage of the regulatory framework that restricts Fed purchases to agency MBS comprising only conforming loans, this research establishes a quasi-experiment to evaluate policy effectiveness. Through analysis of comprehensive HMDA data covering 2018-2023, I document significant differences in how QE affected segments of the mortgage market. The empirical evidence reveals that conforming loans experienced interest rate reductions 32-42 basis points larger than their nonconforming counterparts following implementation of the Fed's asset purchase program. This interest rate advantage corresponded with dramatically higher refinancing activity in the conforming segment, which saw loan origination volumes expand by approximately 88-97% more than in the nonconforming segment during the QE intervention period.

These findings have potentially significant real economic consequences. My conservative back-of-the-envelope calculation suggests that the 35 basis points larger decrease for conforming loans translated into approximately $1.3 billion ($270,000 $\times$ 1.4 million $\times$ 35 bps) in reduced annual interest payments, based on an average loan amount of $270,000 and using 2019-level origination volumes of 1.4 million loans. Applying a marginal propensity to consume (MPC) of 0.75 from Di Maggio et al. (2017), this reduction potentially generated about $1 billion in increased consumption. While these calculations should be interpreted cautiously—as they do not account for refinancing costs, the precise number of QE-induced loan originations, the interest rate effects fully attributable to QE MBS purchases, or potential variations in MPC values—they nonetheless highlight the substantial real economic impact of this policy intervention.

The results remain robust to extensive loan-level controls and to the exclusion of loans near the conforming loan limit threshold. Event study estimates confirm these findings while revealing that effects materialized rapidly after implementation but subsided as monetary policy normalized. Additionally, analysis of heterogeneous effects across metropolitan areas with different migration patterns during the pandemic indicates that the conforming-segment policy boost was approximately 52% stronger in areas experiencing net in-migration compared to areas with net out-migration.

The findings of this study have several important implications for monetary policy implementation, particularly during economic crises. First, they demonstrate that large-scale asset purchases can effectively lower borrowing costs and stimulate refinancing activity during exogenous economic downturns, providing a mechanism to support household financial positions during periods of stress. The rapid transmission observed—with effects materializing immediately following policy implementation—suggests that MBS purchases can be an effective tool for swift intervention when conventional interest rate policy is constrained.

Second, the observed heterogeneity across loan segments reveals important distributional consequences of QE. The larger benefits accruing to conforming loans suggest that the Fed's asset purchases disproportionately benefit homeowners with moderate-value properties who qualify for conforming mortgages. While this supports middle-class homeowners, it may provide less relief to lower-income households, who are less likely to own homes. This segmentation in policy effects should be considered when evaluating the overall equity implications of monetary interventions. Finally, the spatial heterogeneity in QE effects across migration patterns underscores the interaction between demographic shifts and monetary policy transmission. The finding that QE had stronger effects in areas experiencing population inflows suggests that monetary policy may amplify rather than counteract demographic trends during crises. This observation is relevant for policymakers concerned with regional economic convergence and geographic inequality.

Despite the robust findings, several limitations warrant consideration when interpreting these results. First, the study period coincided with numerous other policy interventions, including unprecedented fiscal stimulus through the Coronavirus Aid, Relief, and Economic Security (CARES) Act, eviction moratoriums, and forbearance programs. These contemporaneous policies may have affected refinancing behavior and potentially interacted with monetary policy effects in ways that are difficult to isolate.

Second, the COVID-19 pandemic triggered severe supply chain disruptions and labor market dislocations that may have affected the mortgage origination process. Lender capacity constraints during the refinancing wave could have led to differential processing times or approval rates across loan segments, potentially confounding our estimates of QE effects. If lenders prioritized conforming loans due to their easier salability in secondary markets, this could amplify the observed differential effects beyond what is directly attributable to Fed purchases.

Third, an important methodological limitation is that the analysis only observes individuals who actually refinanced, creating a potential selection bias. The characteristics of borrowers who chose not to refinance—despite potentially favorable conditions—remain unobserved in the current dataset. With more comprehensive data on non-refinancers' characteristics, techniques such as Heckman correction or propensity score matching could be employed to account for this selection bias and provide more robust estimates of policy effects.

Fourth, while the difference-in-differences approach helps isolate the effect of QE from other macroeconomic factors, it cannot entirely eliminate potential bias from time-varying unobservable characteristics that differentially affect conforming and nonconforming borrowers. For example, if higher-income borrowers (who are more likely to have nonconforming loans) experienced different employment or income shocks during the pandemic, this could influence refinancing decisions independently of QE effects.

Lastly, the use of annual HMDA data limits the temporal precision of our estimates compared to the high-frequency proprietary data employed in some previous studies. This temporal aggregation may mask important dynamics in policy transmission and potentially attenuate estimated effects if they occurred unevenly within years.

Several promising avenues for future research emerge from this study. First, using more temporally granular data (quarterly or monthly) would enable more precise identification of QE effects and allow for more restricted estimation windows surrounding policy announcements and implementations. This approach would help isolate the impact of QE from other concurrent policies and economic developments, providing cleaner estimates of transmission mechanisms. Second, deeper investigation into the distributional consequences of QE across borrower demographics would enhance our understanding of monetary policy equity implications. Analyzing heterogeneous effects by income, race, gender, and age could reveal important variations in who benefits most from unconventional monetary policy. This analysis would be particularly valuable for policymakers concerned with widening economic inequalities from unconventional monetary policy.[13] Third, extending the analysis to examine the complete transmission mechanism from interest rate reductions to consumption

[13] See Lee (2024) for the relevant analysis.

or income effects would provide a more comprehensive picture of QE's macroeconomic impact. This could involve linking mortgage refinancing data with consumption expenditures, employment outcomes, or other indicators of household economic well-being. Such analysis would help quantify the real economic effects of the mortgage refinancing channel during the COVID-19 crisis. Fourth, incorporating these empirical findings into heterogeneous agent New Keynesian (HANK) models (Kaplan et al., 2018) would allow for simulation of general equilibrium effects beyond the partial equilibrium framework employed in this study. These models could account for spillovers between conforming and nonconforming markets, feedback effects through labor markets and consumption, and interactions with fiscal policy. Such an approach would provide a more holistic understanding of QE effectiveness during crisis periods.

In conclusion, this study contributes to our understanding of unconventional monetary policy transmission during exogenous economic crises and provides insights into the distributional consequences of central bank interventions across mortgage market segments. While the Federal Reserve's COVID-era asset purchases successfully lowered borrowing costs and stimulated refinancing activity, the benefits were unevenly distributed across loan segments and geographic areas. These findings highlight the importance of considering both segmentation in financial markets and spatial heterogeneity when evaluating monetary policy effectiveness.

8 Bibliography

Sumit Agarwal, Souphala Chomsisengphet, Hua Kiefer, Leonard C. Kiefer, and Paolina C. Medina. Refinancing inequality during the COVID-19 pandemic. *Journal of Financial and Quantitative Analysis*, 59(5):2133–2163, 2024. doi: 10.1017/S0022109023001059.

Gene Amromin, Neil Bhutta, and Benjamin J. Keys. Refinancing, monetary policy, and the credit cycle. *Annual Review of Financial Economics*, 12(1):67–93, December 2020. doi: 10.1146/annurev-financial. URL https://doi.org/10.1146/annurev-financial-012720-120430.

Martin Beraja, Andreas Fuster, Erik Hurst, and Joseph Vavra. Regional heterogeneity and the refinancing channel of monetary policy. *The Quarterly Journal of Economics*, 134(1): 109–183, 09 2018. ISSN 0033-5533. doi: 10.1093/qje/qjy021. URL https://doi.org/10.1093/qje/qjy021.

Ben S. Bernanke and Mark Gertler. Inside the black box: The credit channel of monetary policy transmission. *Journal of Economic Perspectives*, 9(4):27–48, December 1995. doi: 10.1257/jep.9.4.27. URL https://www.aeaweb.org/articles?id=10.1257/jep.9.4.27.

Alan Berube. How the pandemic changed – and didn't change – where americans are moving, Sep 2024. URL https://www.brookings.edu/articles/how-the-pandemic-changed-and-didnt-change-where-americans-are-moving/.

Board of Governors of the Federal Reserve System. Section 14. Open-Market Operations. *Federal Reserve Act*, Mar 2017. URL https://www.federalreserve.gov/aboutthefed/section14.htm.

Board of Governors of the Federal Reserve System. Federal Reserve issues FOMC statement, Mar 2020a. URL https://www.federalreserve.gov/newsevents/pressreleases/monetary20200315a.htm.

Board of Governors of the Federal Reserve System. Federal Reserve issues FOMC statement, Mar 2020b. URL https://www.federalreserve.gov/newsevents/pressreleases/monetary20200323a.htm.

Board of Governors of the Federal Reserve System. Federal Reserve issues FOMC statement, Nov 2021. URL https://www.federalreserve.gov/newsevents/pressreleases/monetary20211103a.htm.

Board of Governors of the Federal Reserve System. Plans for Reducing the Size of the Federal Reserve's Balance Sheet, May 2022. URL https://www.federalreserve.gov/newsevents/pressreleases/monetary20220504b.htm.

Census Bureau. Census Core-Based Statistical Area (CBSA) to Federal Information Processing Series (FIPS) County Crosswalk. URL https://data.nber.org/cbsa-csa-fips-county-crosswalk/cbsa2fipsxw.dta.

Indraneel Chakraborty, Itay Goldstein, and Andrew MacKinlay. Monetary stimulus and bank lending. *Journal of Financial Economics*, 136(1):189–218, 2020. ISSN 0304-405X. doi: https://doi.org/10.1016/j.jfineco.2019.09.007. URL https://www.sciencedirect.com/science/article/pii/S0304405X19302260.

Marco Di Maggio, Amir Kermani, Benjamin J. Keys, Tomasz Piskorski, Rodney Ramcharan, Amit Seru, and Vincent Yao. Interest rate pass-through: Mortgage rates, household consumption, and voluntary deleveraging. *American Economic Review*, 107(11):3550–88, November 2017. doi: 10.1257/aer.20141313. URL https://www.aeaweb.org/articles?id=10.1257/aer.20141313.

Marco Di Maggio, Amir Kermani, and Christopher J Palmer. How quantitative easing works: Evidence on the refinancing channel. *The Review of Economic Studies*, 87(3):1498–1528, Dec 2019. ISSN 0034-6527. doi: 10.1093/restud/rdz060. URL https://doi.org/10.1093/restud/rdz060.

Martin Eichenbaum, Sergio Rebelo, and Arlene Wong. State-dependent effects of monetary policy: The refinancing channel. *American Economic Review*, 112(3):721–61, March 2022. doi: 10.1257/aer.20191244. URL https://www.aeaweb.org/articles?id=10.1257/aer.20191244.

Federal Financial Institutions Examination Council. Loan/application records. *2017 Three Year National Loan Level Dataset*, Dec 2020. URL https://ffiec.cfpb.gov/data-publication/three-year-national-loan-level-dataset/2017.

Federal Financial Institutions Examination Council. Loan/application records. *2018 Three Year National Loan Level Dataset*, Dec 2021. URL https://ffiec.cfpb.gov/data-publication/three-year-national-loan-level-dataset/2018.

Federal Financial Institutions Examination Council. Loan/application records. *2019 Three Year National Loan Level Dataset*, Dec 2022. URL https://ffiec.cfpb.gov/data-publication/three-year-national-loan-level-dataset/2019.

Federal Financial Institutions Examination Council. Loan/application records. *2020 Three Year National Loan Level Dataset*, Dec 2023a. URL https://ffiec.cfpb.gov/data-publication/three-year-national-loan-level-dataset/2020.

Federal Financial Institutions Examination Council. Loan/application records. *2021 One Year National Loan Level Dataset*, May 2023b. URL https://ffiec.cfpb.gov/data-publication/one-year-national-loan-level-dataset/2021.

Federal Financial Institutions Examination Council. Loan/application records. *2022 One Year National Loan Level Dataset*, May 2024a. URL https://ffiec.cfpb.gov/data-publication/one-year-national-loan-level-dataset/2022.

Federal Financial Institutions Examination Council. Loan/application records. *2023 Snapshot National Loan Level Dataset*, May 2024b. URL https://ffiec.cfpb.gov/data-publication/snapshot-national-loan-level-dataset/2023.

Federal Housing Finance Agency. Conforming loan limit (CLL) values, Nov 2024. URL https://www.fhfa.gov/data/conforming-loan-limit.

Freddie Mac. Primary Mortgage Market Survey. URL https://www.freddiemac.com/pmms.

William H. Frey. New census data hints at an urban population revival, assisted by immigration, Apr 2024. URL https://www.brookings.edu/articles/new-census-data-hints-at-an-urban-population-revival-assisted-by-immigration/.

Daniel L. Greenwald. The mortgage credit channel of macroeconomic transmission. *SSRN Electronic Journal*, 2018. ISSN 1556-5068. doi: 10.2139/ssrn.2735491. URL http://www.ssrn.com/abstract=2735491.

Diana Hancock and Wayne Passmore. How does the Federal Reserve's large-scale asset purchases (LSAPs) influence mortgage-backed securities (MBS) yields and U.S. mortgage rates? *Real Estate Economics*, 43(4):855–890, 2015. doi: https://doi.org/10.1111/1540-6229.12109. URL https://onlinelibrary.wiley.com/doi/abs/10.1111/1540-6229.12109.

Peter Haslag and Daniel Weagley. From L.A. to Boise: How migration has changed during the COVID-19 pandemic. *Journal of Financial and Quantitative Analysis*, 59(5):2068–2098, 2024. doi: 10.1017/S002210902300073X.

Erik Hurst, Benjamin J. Keys, Amit Seru, and Joseph Vavra. Regional redistribution through the us mortgage market. *American Economic Review*, 106(10):2982–3028, October 2016. doi: 10.1257/aer.20151052. URL https://www.aeaweb.org/articles?id=10.1257/aer.20151052.

Mostafa Ayman Ilham, Achille Fonzone, Grigorios Fountas, and Luca Mora. To move or not to move: A review of residential relocation trends after COVID-19. *Cities*, 151:105078, 2024. ISSN 0264-2751. doi: https://doi.org/10.1016/j.cities.2024.105078. URL https://www.sciencedirect.com/science/article/pii/S0264275124002920.

Internal Revenue Service. SOI tax stats - migration data. URL https://www.irs.gov/statistics/soi-tax-stats-migration-data.

Greg Kaplan, Benjamin Moll, and Giovanni L. Violante. Monetary policy according to hank. *American Economic Review*, 108(3):697–743, March 2018. doi: 10.1257/aer.20160042. URL https://www.aeaweb.org/articles?id=10.1257/aer.20160042.

Benjamin J Keys, Tomasz Piskorski, Amit Seru, and Vincent Yao. Mortgage rates, household balance sheets, and the real economy. Working Paper 20561, National Bureau of Economic Research, October 2014. URL http://www.nber.org/papers/w20561.

Benjamin J. Keys, Devin G. Pope, and Jaren C. Pope. Failure to refinance. *Journal of Financial Economics*, 122(3):482–499, 2016. ISSN 0304-405X. doi: https://doi.org/10.1016/j.jfineco.2016.01.031. URL https://www.sciencedirect.com/science/article/pii/S0304405X16301507.

Arvind Krishnamurthy and Annette Vissing-Jorgensen. The effects of quantitative easing on interest rates: Channels and implications for policy. Working Paper 17555, National Bureau of Economic Research, October 2011. URL http://www.nber.org/papers/w17555.

Arvind Krishnamurthy and Annette Vissing-Jorgensen. The ins and outs of LSAPs. *Proceedings - Economic Policy Symposium - Jackson Hole*, 2013. URL https://www.kansascityfed.org/documents/4563/2013Krishnamurthy.pdf.

Donggyu Lee. Quantitative easing and inequality. *Federal Reserve Bank of New York Staff Reports*, 2024. doi: 10.59576/sr.1108. URL https://doi.org/10.59576/sr.1108.

Stephan Luck and Tom Zimmermann. Employment effects of unconventional monetary policy: Evidence from QE. *Journal of Financial Economics*, 135(3):678–703, 2020. ISSN 0304-405X. doi: https://doi.org/10.1016/j.jfineco.2019.07.004. URL https://www.sciencedirect.com/science/article/pii/S0304405X19301771.

Ashesh Rambachan and Jonathan Roth. A more credible approach to parallel trends. *The Review of Economic Studies*, 90(5):2555–2591, 02 2023. ISSN 0034-6527. doi: 10.1093/restud/rdad018. URL https://doi.org/10.1093/restud/rdad018.

Alessandro Rebucci, Jonathan S Hartley, and Daniel Jiménez. An event study of COVID-19 central bank quantitative easing in advanced and emerging economies. Working Paper 27339, National Bureau of Economic Research, June 2020. URL http://www.nber.org/papers/w27339.

Arlene Wong. Refinancing and the transmission of monetary policy to consumption. *Unpublished Manuscript*, 2019.

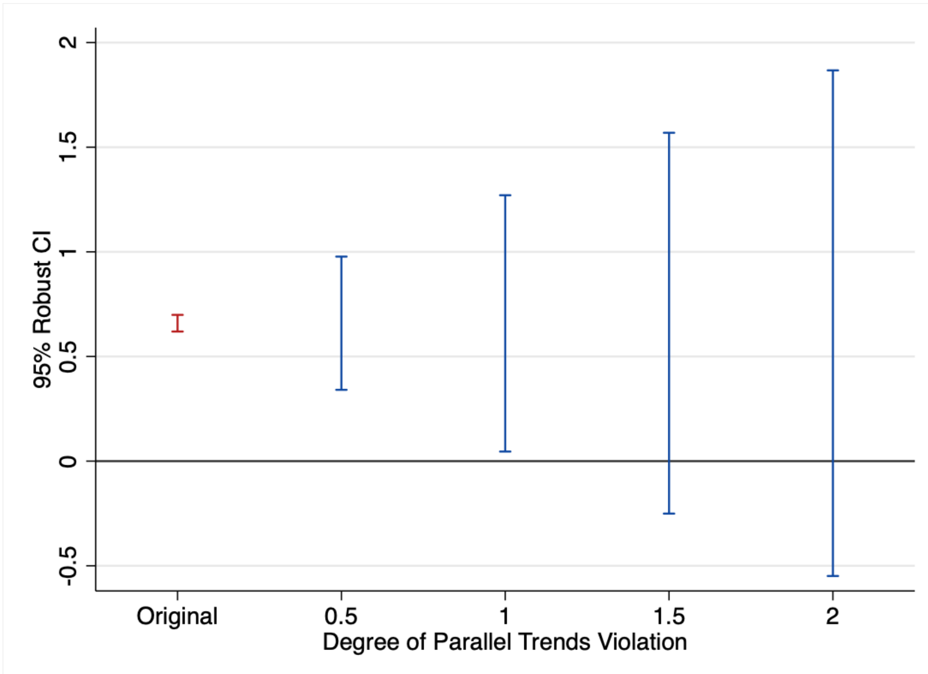
A List of Covariates

Table A1: List of Covariates and Definition

Variable	Definition
Basic Loan-Level Controls	
Combined Loan to Value Ratio	The ratio of the total amount of debt secured by the property to the value of the property
Balloon Payment	Whether the contractual terms include, or would have included, a balloon payment
Interest Only Payment	Whether the contractual terms include, or would have included, interest-only payments
Prepayment Penalty	Whether the contractual terms include, or would have included, any prepayment penalty
Loan Term	The number of months after which the legal obligation will mature or terminate, or would have matured or terminated
Extensive Controls	
Dwelling Category	Derived dwelling type from Construction Method and Total Units fields
Ethnicity	Single aggregated ethnicity categorization derived from applicant/borrower and co-applicant/co-borrower ethnicity fields
Race	Single aggregated race categorization derived from applicant/borrower and co-applicant/co-borrower race fields
Sex	Single aggregated sex categorization derived from applicant/borrower and co-applicant/co-borrower sex fields
Debt to Income Ratio	The ratio, as a percentage, of the applicant's or borrower's total monthly debt to the total monthly income
Age	The age of the applicant
Property Value	The value of the property securing the covered loan
Income	The gross annual income, in thousands of dollars
Total Loan Costs	The total points and fees, in dollars, charged in connection with the covered loan
Discount Points	Whether any points is paid to the creditor to reduce the interest rate
Loan Purpose	The purpose of covered loan or application (refinancing or cash-out refinancing)
Total Units	The number of individual dwelling units related to the property securing the covered loan
Open-end Line of Credit	Whether the covered loan or application is for an open-end line of credit
HOEPA Status	Whether the covered loan is a high-cost mortgage
Negative Amortization	Whether the contractual terms include a term that would cause the covered loan to be a negative amortization loan
Occupancy Type	Occupancy type for the dwelling
Tract Population	Total population in tract
Tract to MSA Income Percentage	Percentage of tract median family income compared to MSA/MD median family income
Tract Minority Population Percentage	Percentage of minority population to total population for tract, rounded to two decimal places
Tract Median Age of Housing Unit	Tract median age of homes
Tract 1-4 Family Homes	Dwellings that are built to houses with fewer than 5 families
Tract Owner Occupied Units	Number of dwellings, including individual condominiums, that are lived in by the owner

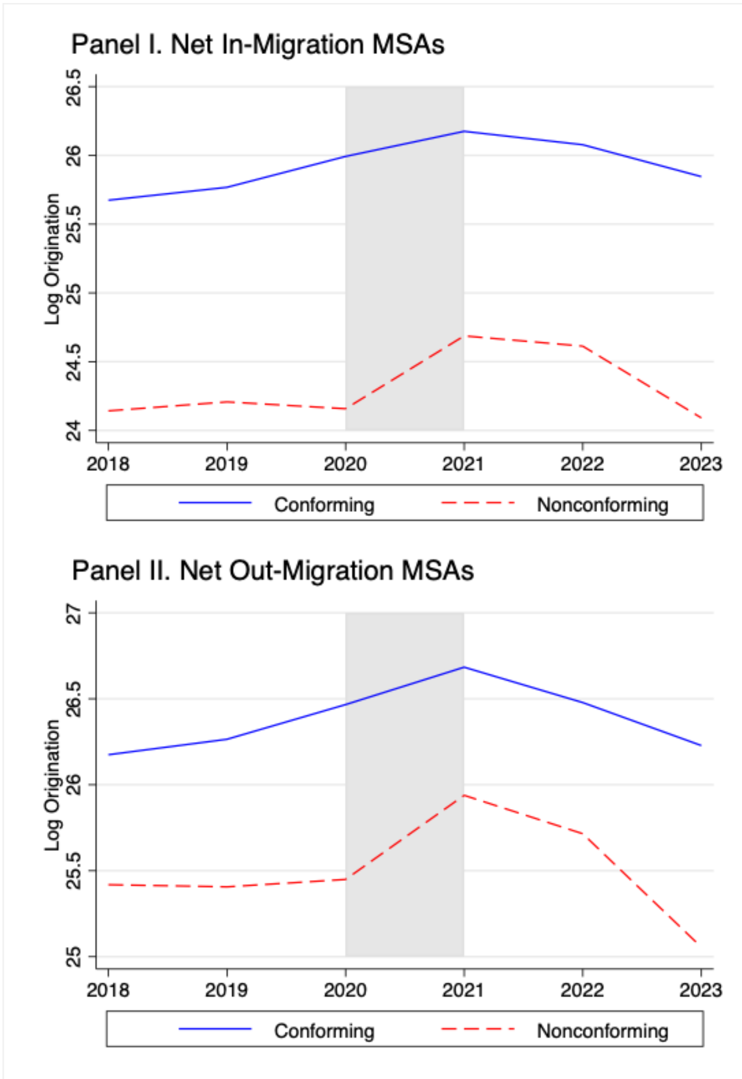
B Parallel Trends Sensitivity Test

Figure A1: Event Studies Parallel Trends Sensitivity Test



C Loan Origination Trends with Net Migration

Figure A2: Log Home Purchase Origination Volume



Notes: The sample includes conventional, single-family, single unit, first-lien, 15/20/30-year term home purchase mortgages with non-missing interest rate, loan amount, and CLTVs. The gray areas represent the Fed's QE implementation period.