The Housing Supply Channel of Monetary Policy*

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We study the role of regional housing markets in the transmission of U.S. monetary policy. Using a FAVAR model over 1999:Q1–2019:Q4, we find that differences in housing supply constraints explain part of the regional heterogeneity in the responses of U.S. states to a contractionary monetary policy shock. Specifically, house prices and consumption respond more in supply-constrained states. Financial stability risks also increase more sharply in these areas as mortgage delinquencies and foreclosures surge, worsening banks' balance sheets. Our findings stress the importance of regional housing supply conditions in assessing the macrofinancial effects of rising interest rates.

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1. Introduction

Housing plays a central role for macroeconomic fluctuations: two-thirds of U.S. households own a home, housing consumption accounts for around one-third of total private consumption expenditures,[1] and mortgagors display a higher marginal propensity to consume (MPC) compared with renters or outright owners (Cloyne, Ferreira, and Surico 2020). In addition, housing is highly sensitive to interest rate changes, with an extensive literature indicating that monetary policy affects housing demand.[2] Recent studies have begun to explore how differences in housing supply elasticities—the supply response to demand-driven house price changes—affect the monetary policy transmission (Fischer et al. 2021; Aastveit and Anundsen 2022; Cooper, Luengo-Prado, and Olivei 2022; Aastveit, Albuquerque, and Anundsen 2023).[3] We extend this emerging literature by highlighting the prominent role of housing supply in the transmission of monetary policy to the real economy.

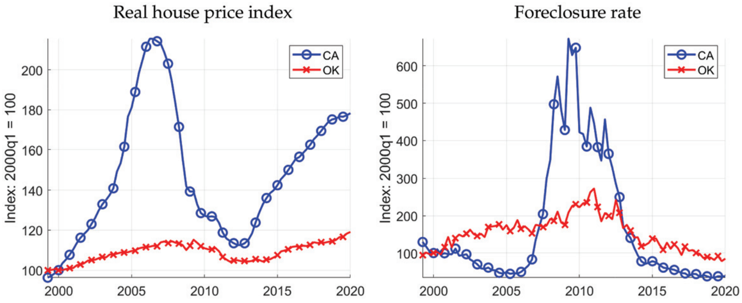
Understanding how housing supply affects the transmission of monetary policy shocks is particularly important in a context of rapidly rising interest rates. Higher interest rates may lead to a sharper decline in house prices in inelastic markets, resulting in greater consumption cuts and overall reduced economic activity. In addition, the decline in mortgagors' housing equity could heighten

[1] According to the 2022 Survey of Consumer Finances and the 2023 Bureau of Labor Statistics (BLS) Consumer Expenditures Survey.

[2] First, monetary policy stimulates borrowing and consumption through the credit supply channel, where lower borrowing costs and higher inflation reduce the real value of debt (Jordà, Schularick, and Taylor 2015; Bhutta and Ringo 2021; Wong 2021). Second, the household balance sheet channel, or home equity loan/collateral channel, posits that monetary policy has important housing wealth effects, encouraging mortgagors to extract equity for consumption and investment (Iacoviello 2005; Del Negro and Otrok 2007; Jarociński and Smets 2008; Bhutta and Keys 2016; Aladangady 2017; Beraja et al. 2019; Cloyne, Ferreira, and Surico 2020; Garriga and Hedlund 2020; Andersen and Leth-Petersen 2021). Third, changes in mortgage-related costs can influence demand for real estate services, affecting economic activity (Best and Kleven 2018; Bhutta and Ringo 2021; Anenberg and Ringo 2022; Benmelech, Guren, and Melzer 2023).

[3] Other structural features of the housing market, such as the share of adjustable-rate mortgages (ARMs) and the homeownership rate, may also influence the regional effects of monetary policy on house prices (Calza, Monacelli, and Stracca 2013; Corsetti, Duarte, and Mann 2022; Pica 2023).

Figure 1. Real House Prices and Foreclosure Rate in California and Oklahoma



Note: Real house prices and the foreclosure rate are rescaled to an index equal to 100 in 2000:Q1.

financial stability risks in these low-supply-elasticity areas due to increased mortgage delinquencies and foreclosures.

Figure 1 illustrates this point. California—an area with inelastic housing supply—has experienced more pronounced boom-bust housing cycles over the last two decades compared with Oklahoma, where housing supply is more elastic. House prices in California surged in the run-up to the Global Financial Crisis (GFC), coinciding with a fast rise in mortgage debt. This was followed by a sharper decline as the credit crunch intensified, leading to a notable increase in foreclosure rates that exacerbated the initial drop in house prices (Huang and Tang 2012; Anundsen and Heebøll 2016; Chodorow-Reich, Guren, and McQuade 2024).

Against this background, we examine the regional heterogeneity in the transmission of contractionary monetary policy to the real economy, focusing on differences in housing markets across U.S. states, particularly housing supply elasticities—the *housing supply channel of monetary policy*. Our main contributions are threefold. First, we trace out the effects of monetary policy not only on regional house prices—as explored in several studies (Fratantoni and Schuh 2003; Fischer et al. 2021; Aastveit and Anundsen 2022; Cooper, Luengo-Prado, and Olivei 2022; Aastveit, Albuquerque, and Anundsen 2023)—but also on the real economy and on financial variables. Second, we focus on how housing supply constraints across states influence the impact of contractionary monetary policy, allowing us to assess regional macrofinancial effects based on housing supply differences. Third, we incorporate a rich set of housing market variables, including both owner-occupied and rental segments. In contrast to most of the related literature, this allows us to study how monetary policy affects households' housing tenure decisions, which may amplify or dampen the effects of monetary policy (Dias and Duarte 2019, 2022; Koeniger, Lennartz, and Ramelet 2022).

We estimate a factor-augmented vector autoregression (FAVAR) model (Bernanke, Boivin, and Eliasz 2005), using a comprehensive quarterly data set covering the 50 U.S. states over 1999:Q1–2019:Q4. The model captures dynamic relationships in the economy and includes several state-level, and U.S. aggregate, indicators related to the real economy, labor market, financial sector, public finances, and housing market. The housing market block has information on prices and quantities, including rental and house prices, building permits, housing starts, homeownership rates, and vacancy rates. We identify monetary policy shocks using high-frequency changes in the Federal Reserve's policy rate around Federal Open Market Committee (FOMC) announcements (Gürkaynak, Sack, and Swanson 2005; Gertler and Karadi 2015; Nakamura and Steinsson 2018). We then apply the exogenous variable approach (Paul 2020) to assess the effects of monetary policy shocks within the FAVAR model.

Our main findings are as follows. First, we find significant heterogeneity in the transmission of an aggregate U.S. contractionary monetary policy shock to the U.S. states. The heterogeneity is particularly pronounced among housing market variables, which aligns with recent findings in the literature (Fischer et al. 2021; Aastveit and Anundsen 2022; Cooper, Luengo-Prado, and Olivei 2022; Corsetti, Duarte, and Mann 2022; Koeniger, Lennartz, and Ramelet 2022; Aastveit, Albuquerque, and Anundsen 2023). As homeownership costs rise due to tighter monetary policy, house prices fall while rent prices increase in most states, indicating a shift in demand from the owner-occupied market to renting (Dias and Duarte 2019, 2022). Our contribution is to show that monetary policy can differentially affect housing tenure choices across states. For instance, declines in the house price-to-rent ratio vary widely, and some states experience minimal changes in homeownership rates while others see sharper declines. The response of housing supply may help explain the differences across states in the shift from the owner-occupied to the rental market: home vacancy rates decline and rental vacancy rates increase in some states, diverging from aggregate U.S. trends.

Second, we find that differences in housing supply restrictions across states help explain the heterogeneity in responses to monetary policy. Using the state-level land-use restriction index (LRI) from Herkenhoff, Ohanian, and Prescott (2018) as our baseline measure of housing supply constraints, we compare how high- and low-regulation states respond to monetary policy. We find that house prices are more responsive in areas with tighter housing supply constraints, in line with recent evidence (Gyourko, Saiz, and Summers 2008; Saiz 2010; Glaeser et al. 2014; Herkenhoff, Ohanian, and Prescott 2018; Aastveit and Anundsen 2022; Cooper, Luengo-Prado, and Olivei 2022; Aastveit, Albuquerque, and Anundsen 2023; Albuquerque et al. 2026). Our contribution is to show that tighter housing supply constraints, which imply lower supply elasticities, not only affect house price responses to monetary policy but also have wider macrofinancial consequences. Specifically, states with more inelastic housing supply experience sharper declines in private consumption following a contractionary monetary policy shock, driven by a larger drop in housing wealth. In addition, financial stability risks rise more sharply in these areas, with higher rates of mortgage delinquencies, foreclosures, and a broader deterioration of the banking sector's health. Overall, our results suggest that the greater decline in consumption in states with restricted housing supply stems from collateral, credit supply, and local general equilibrium effects. This aligns with the transmission channels explaining the decline in U.S. household consumption due to falling house prices during the GFC (Aruoba, Elul, and Kalemli-Özcan 2026). Relatedly, our findings are consistent with those of Albuquerque et al. (2026), who show that countries with more restrictive housing supply constraints tend to experience stronger economic adjustments during housing contractions.

Third, household debt overhang also influences the heterogeneous effects of monetary policy: states with greater household debt imbalances are more sensitive to contractionary monetary policy shocks. Debt overhang can thus amplify business cycles (Schularick and Taylor 2012; Jordà, Schularick, and Taylor 2013, 2015; Dell'Ariccia et al. 2016; Mian, Sufi, and Verner 2017; Albuquerque and Krustev 2018; Albuquerque 2019; Greenwood et al. 2022; Jordà et al. 2022). States with greater debt gaps often have less elastic housing supply, which may explain why our results depart from the conventional view that the response of house prices to contractionary demand shocks is independent of supply restrictions (Glaeser and Gyourko 2005; Glaeser, Gyourko, and Saiz 2008; Aastveit and Anundsen 2022). In fact, areas experiencing stronger credit booms during economic expansions and credit busts during downturns also tend to have lower supply elasticities. This makes house prices more responsive to changes in housing demand, both increases and decreases. Our finding is in line with recent research showing that financial-accelerator effects (Huang and Tang 2012; Anundsen and Heebøll 2016), households' overoptimism during housing booms (Chodorow-Reich, Guren, and McQuade 2024), and a price-foreclosure spiral during housing busts (Guren and McQuade 2020; Chodorow-Reich, Guren, and McQuade 2024) help explain why supply-inelastic U.S. areas had more pronounced housing cycles around the GFC. Our findings highlight how household debt overhang and housing supply constraints amplify the macrofinancial impact of contractionary monetary policy, suggesting that house prices are not independent of supply constraints amid negative demand shocks, financial-accelerator effects, and misaligned household expectations.

Fourth, differences in housing wealth across states—both in the level and volatility—may partly explain the heterogeneity in the transmission of monetary policy to the housing market. While prior studies have documented the impact of housing wealth and the ability of homeowners to tap into home equity for consumption (e.g., Bhutta and Keys 2016; Aladangady 2017; Beraja et al. 2019; Andersen and Leth-Petersen 2021), the role of housing wealth volatility is less understood. Presumably, higher volatility could lead households to reduce demand for real estate services, such as realtors, loan officers, and mortgage brokers, lowering economic activity (Best and Kleven 2018; Bhutta and Ringo 2021; Anenberg and Ringo 2022; Benmelech, Guran, and Melzer 2023). Furthermore, uncertainty about future house prices can influence household tenure choices (Henderson and Ioannides 1983; Rosen, Rosen, and Holtz-Eakin 1984; Fu 1995). We find that differences in housing wealth (and its volatility) partially account for states' differential responses to monetary policy shocks.

Finally, we find that monetary policy may have a stronger influence on housing tenure decisions in low-supply-elasticity areas. Differences in market segmentation between states, such as the costs of converting owner-occupied housing to rental units, may help explain this (Greenwald and Guren 2025). In inelastic states, house prices and homeownership rates decline more sharply, indicating a greater contraction in demand for owner-occupied housing. At the same time, the rental vacancy rate remains stable, and rent prices increase less compared with more elastic areas, which challenges the assumption that housing demand shifts to rentals. However, we interpret the modest rise in rent prices as evidence that the rental market in inelastic areas can absorb demand more readily, likely due to lower adjustment costs. In addition, strict regulations on new housing construction may incentivize homeowners or investors to lower adjustment costs of converting owner-occupied units to rental units in response to declining demand.

Our main finding—states with more inelastic housing supply are more adversely affected by contractionary monetary policy shocks—does not imply that housing supply constraints are the only factor contributing to this heterogeneity, nor does it establish a causal link. We acknowledge that other factors, such as state-level differences in industry composition, demographics, income levels, and institutional quality, may also influence regional responses to monetary policy. While establishing causality is arguably challenging, we conduct cross-sectional regressions to control for several state-specific characteristics that might explain these differences. Even in this setting, housing supply restrictions are important in explaining the regional heterogeneity in the transmission of monetary policy.

We check the robustness of our results along several dimensions, including (i) using alternative monetary policy surprises (forward guidance) that affect the long end of the yield curve (Swanson 2021); (ii) controlling for central bank information effects in monetary policy (Jarociński and Karadi 2020); (iii) considering alternative measures of state-specific housing supply restrictions (Saiz 2010; Aastveit, Albuquerque, and Anundsen 2023); and (iv) using an alternative measure of state-level inflation (Hazell et al. 2022). Our main findings are overall robust.

In summary, our paper contributes to the growing literature on how housing supply constraints affect the transmission of demand shocks—such as monetary policy shocks—to housing markets (Gyourko, Saiz, and Summers 2008; Saiz 2010; Glaeser et al. 2014; Herkenhoff, Ohanian, and Prescott 2018; Albuquerque, Iseringhausen, and Opitz 2020; Fischer et al. 2021; Aastveit and Anundsen 2022; Cooper, Luengo-Prado, and Olivei 2022; Aastveit, Albuquerque, and Anundsen 2023). We add to this research by examining the differential macrofinancial effects of monetary policy across U.S. states, going beyond only analyzing house price dynamics. Our paper also relates to recent studies on how monetary policy affects households' housing tenure decisions, particularly showing that contractionary policy may disadvantage renters and mortgagors (Dias and Duarte 2019, 2022; Koeniger, Lennartz, and Ramelet 2022). We empirically document that monetary policy may influence housing tenure decisions differently across states, depending on differences in supply constraints, housing market segmentation, and household debt imbalances. Finally, our paper can be placed within the broader literature on regional and cross-country differences in the responses of macroeconomic variables to monetary policy (Carlino and DeFina 1998, 1999; Fratantoni and Schuh 2003; Francis, Owyang, and Sekhposyan 2012; Calza, Monacelli, and Stracca 2013; Albuquerque 2019; Fischer et al. 2021; Aastveit and Anundsen 2022; Corsetti, Duarte, and Mann 2022; Aastveit, Albuquerque, and Anundsen 2023; Pica 2023).

2. Data

We use state-level data to explore the regional heterogeneity in the U.S. economy. Although we would prefer to use more granular data, such as metropolitan statistical areas (MSAs) or city-level data, in this case data availability issues on a set of economic and financial indicators become more severe. U.S. states are characterized by significant variation across key macroeconomic variables (Figure B.1 in Appendix B). In particular, the heterogeneity in the dynamics of housing market variables is consistent with the notion that housing markets are local and exhibit their own cyclical movements, possibly decoupled from the national cycle (Ghent and Owyang 2010; Ferreira and Gyourko 2012; Hernandez-Murillo, Owyang, and Rubio 2017). We also note the substantial variation over time in house prices relative to rents, indicating that house prices may not move in line with rents over the long term—the no-arbitrage condition—as predicted by theory (Poterba 1984).[4]

For the FAVAR analysis, we use a quarterly data set of 26 state-specific series for 50 U.S. states over 1999:Q1–2019:Q4. We complement the data set with 47 aggregate national variables, including standard macroeconomic, financial, and housing market variables, to control for the state of the U.S. business cycle, for a total of over 1,200 time series. When extracting the factors, we exclude those U.S. variables that are already included at the state level (e.g., gross domestic product, GDP) or whose subcomponents are included, resulting in 1,221 series from which the factors are extracted (Table B.1 in Appendix B). At the state level, we include variables related to the real economy, the labor market, the financial sector, public finances, and the housing market. The rich information on state-specific housing market conditions includes house prices and rental prices, supply-side variables, such as permits and housing starts, and other important characteristics, e.g., the homeownership rate and vacancy rates. All nominal series are deflated using the U.S. consumer price index. If necessary, we take first (log-)differences of the variables to guarantee stationarity. Table B.1 in Appendix B contains detailed information on the variables' definitions, transformations, and data sources. Table B.2 provides summary statistics for the state-level variables.

To measure price developments in state-level rental markets, we use a new rent price index developed by Howard and Liebersohn (2021). The authors build annual real rent price indices for a large

[4]Standard theory predicts that the price of a house should be determined by the present value of cumulated future rents. The run-up to the GFC, however, showed that house prices can deviate from rents for an extended period of time. Glaeser and Gyourko (2007) show empirically that the no-arbitrage condition does not hold given the substantial differences between owning and renting, while renters and owners also differ dramatically from each other. More recently, Amaral et al. (2024) find that house prices inequality has increased more than rent prices inequality across (U.S. and other international) cities, as house prices rose more than rents, especially in areas with high house price-to-rent ratios.

panel of U.S. MSAs by resorting to data on rental incomes of multi-family residential properties taken from mortgage-backed securities data from Trepp. Their repeat-rent index (quality-adjusted) is conceptually similar to the consumer price index (CPI), which makes it comparable to the rent series in the CPI, but with the advantage of a much wider geographical coverage. We aggregate the original MSA rent index at the state level using population weights for each MSA.[5]

Our measure of monetary policy surprises follows the recent literature relying on high-frequency identification (Gürkaynak, Sack, and Swanson 2005; Gertler and Karadi 2015; Nakamura and Steinsson 2018). Specifically, we take the surprises in interest rates for three-month-ahead contracts on federal funds futures in a 30-minute window surrounding FOMC meetings. We then sum up all daily surprises within the respective quarter. Since the surprises may not capture the "true" structural monetary policy shock—for instance, due to monetary policy relevant news outside the FOMC announcement window—we use the one-year Treasury rate as the monetary policy indicator, which also captures forward-guidance effects about the future path of interest rates (Gertler and Karadi 2015). Several recent papers have emphasized the importance of further purging the high-frequency surprises from the so-called central bank information effect (e.g., Jarociński and Karadi 2020; Miranda-Agrippino and Ricco 2021; Bauer and Swanson 2023). In Section 6 we test the robustness of our baseline results by controlling for possible information effects.

3. Factor-Augmented VAR(X) Model

The FAVAR has several advantages compared with alternative models. For instance, traditional small and medium-scale VAR models can suffer from the problem of information deficiency, while the

[5]We interpolate the annual series to obtain quarterly data with the Denton (1971) method, using the real rent of primary residence series from the U.S. CPI as the auxiliary indicator. We decided not to use rents data from Zillow given the shorter time dimension (data starting only in 2015). The real rent index from Howard and Liebersohn (2021) is available for 217 MSAs (not available for four states, namely Alaska, Hawaii, New Hampshire, and Vermont), which contrasts with only 25 MSAs published by the Bureau of Economic Analysis.

FAVAR processes a much larger information set, providing a more complete overview of the economy (Bernanke, Boivin, and Eliasz 2005). Specifically, the FAVAR extracts a small number of common factors from the full data set. Similarly, and in contrast to individual VARs estimated for each state, the FAVAR provides a parsimonious framework to jointly analyze heterogeneous responses to a common monetary policy shock. We also prefer the FAVAR model over a panel VAR due to the lower estimation costs and fewer required specification assumptions.

The FAVAR model has a simple state-space representation. The observation equation reflects the assumption that the dynamics of a large set of N observed time series depend linearly on a smaller number of common (un)observed factors. In particular, the observation equation is given by

$$X_t = \Lambda H_t + \nu_t, \qquad \nu_t \sim \mathcal{N}(0, \Omega), \tag{1}$$

where $X_t = (X_{1t}, \ldots, X_{Nt})'$ is a vector of data observations, $H_t = (F_{1t}, \ldots, F_{qt}, R_{1t}, \ldots, R_{kt})'$ is a vector of q unobserved factors (F) and k observed factors (R), and Λ is a $N \times (q + k)$ matrix of factor loadings. In our case, there is only one observed factor ($k = 1$), which is the one-year Treasury rate used to scale the monetary policy shock. Finally, ν_t is a vector of normally distributed and uncorrelated error terms with diagonal covariance matrix Ω. The transition equation of the FAVAR model assumes that the factors follow a VAR(X) process given by

$$H_t = \Phi_1 H_{t-1} + ... + \Phi_p H_{t-p} + A z_t + u_t, \qquad u_t \sim \mathcal{N}(0, \Sigma), \tag{2}$$

where $\Phi = (\Phi_1, \ldots, \Phi_p)$ is the $(q + 1) \times p$ matrix containing the VAR coefficients and z_t is the "pre-identified" monetary policy surprise computed from intradaily financial market data. A is a vector of coefficients and u_t are the "non-monetary policy" disturbances assumed to be normally distributed with full covariance matrix Σ. We include $p = 2$ lags in the VAR, a fairly common choice for data at the quarterly frequency (see, for example, Baumeister, Liu, and Mumtaz 2013; Mumtaz and Theodoridis 2017).

To identify monetary policy shocks, we use the exogenous variable approach of Paul (2020). This identification strategy relies on including the set of "pre-identified" monetary policy surprises z_t (see Section 2) as an exogenous variable in the VAR Equation (2). Under the assumption that z_t is a noisy measure of the true monetary policy shock $\epsilon_{mp,t}$—i.e., $z_t = \alpha\epsilon_{mp,t} + \eta_t$, with η_t orthogonal to all other variables—Paul (2020) shows that this approach consistently estimates the relevant impulse response functions. Specifically, the contemporaneous reaction of factor j to a one-unit increase in the policy rate R_t is given by A_j/A_R. For the remaining horizons, the relative impulse responses are derived by tracing the shock in the policy rate through the system described by Equation (2). As the surprise series z_t is only identified up to sign and scale, we normalize the coefficient vector A such that a contractionary monetary policy shock corresponds to a median increase in the policy rate of 25 basis points (bps). On a methodological note, the *exogenous variable* approach of Paul (2020) shares similarities with the *external instrument* approach of Stock and Watson (2018). Paul (2020) shows analytically that the contemporaneous impulse responses obtained from both approaches are identical. For further details on the exogenous variable approach, we refer to Paul (2020).

As outlined in Bernanke, Boivin, and Eliasz (2005), the FAVAR model can be estimated in two ways: (i) using a fully likelihood-based (Bayesian) approach, in which the unobserved factors are sampled alongside the other model parameters; or (ii) by a two-step approach that first estimates the unobserved factors and then the remaining parameters conditional on these factors. In this paper, we follow Stock and Watson (2005), Korobilis (2013), and Corsetti, Duarte, and Mann (2022) and use the two-step approach that is based on principal component analysis, which is easier to implement and computationally less demanding.

In the first step, we extract, based on the Bayesian information criterion (BIC) of Bai and Ng (2002), five principal components from the set of state-level and aggregate U.S. variables.[6] Following common practice, the principal components are obtained from the standardized data after subtracting the mean of each series and dividing by the respective standard deviation. We address the issue that the principal component representation of the data is only identified up

[6] The maximum number of factors for the Bai and Ng (2002) test is set to $k_{max} = 10$.

to rotation by imposing the standard normalization $\Lambda_F' \Lambda_F = I_q$. The five factors explain around 56 percent of the variation in the data. In the second step, conditional on the estimated principal components to proxy F, the observation Equation (1) collapses to N univariate regressions (Korobilis 2013). Moreover, the transition Equation (2) constitutes a standard VAR(X) model. For the estimation of the model parameters and the impulse response functions, we use the demeaned, but not fully standardized, data. This allows us to interpret the impulse response functions directly and not just in relation to the variables' standard deviations. We estimate all parameters using Bayesian Markov chain Monte Carlo (MCMC) methods. In particular, we rely on an established Gibbs sampling algorithm, using a total of 10,000 draws and dropping the first 5,000 draws as "burn-in." We refer to Appendix A for details on the estimation procedure and prior choices, which are overall standard with the exception of a somewhat tighter prior for the covariance matrix of the VAR innovations, Σ, given the relatively short time dimension of our sample. The latter also contributes to the fairly wide posterior density intervals of many of the impulse response functions presented in the following sections. However, these intervals often still exclude the zero.

Figure C.1 in Appendix C shows the first five principal components together with the monetary policy indicator, which is the observed factor.[7] To better understand the explanatory power of the factors, we regress each variable in our data set on the six factors—both one factor at a time and all factors jointly—and report the respective R-squared values. Table C.1 lists the top five variables that are best explained by each factor. Although it is generally not possible to assign a structural interpretation to the unobserved factors, these results provide some evidence of what the factors may capture. While the first factor appears to relate closely to (mortgage) loan performance, the second, third, fourth, and fifth factors seem to contain information about the homeownership rate, rent

[7]While the second step of our model estimation does not account for uncertainty in the estimation of the factors, Figure C.1 also shows the (bootstrapped) confidence bands around the principal components (Gonçalves and Perron 2020). Estimation uncertainty of the factors appears overall limited, and virtually absent for the first factor.

developments, aggregate inflation and (state-level) personal expenditures, as well as (state-level) personal bankruptcies, respectively.

4. The Transmission of Monetary Policy to the Housing Market

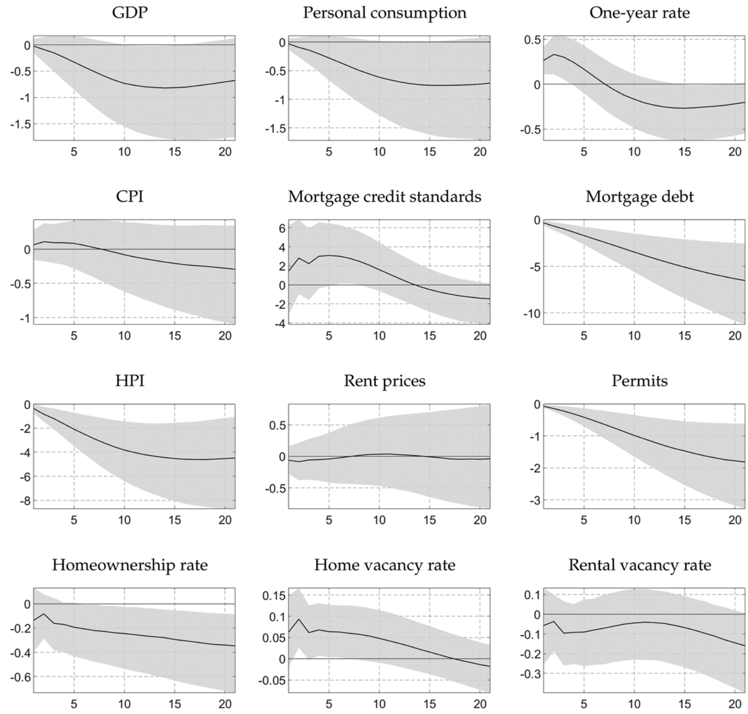
In this section we start by presenting the responses of aggregate U.S. variables to a monetary policy tightening with a particular focus on the housing market. We then move to the core of our analysis centered around the heterogeneity of the state-level responses.

4.1 U.S. Aggregate Evidence

The aggregate responses of U.S. variables allow us to check if our model is able to replicate a set of stylized facts on the effects of monetary policy. All variables are expressed in real terms, with the exception of permits, interest rates, and ratios. Figure 2 presents the cumulative impulse response functions (IRFs) of selected U.S. variables. Overall, we find that our results are in line with standard economic theory (Christiano, Eichenbaum, and Evans 1996, 1999). Following a monetary policy tightening calibrated to increase the one-year Treasury rate by 25 bps on impact, we find that economic activity falls quickly, with real GDP decreasing by around 0.6 percent after two years and reaching a trough of around 0.8 percent after three to four years. The temporary rise in the one-year Treasury rate—which lasts for about seven quarters—leads to a decline in inflation over the medium term, as measured by the consumer price index.

Turning to housing market variables, a tightening of monetary policy decreases both house prices and housing supply, measured by the number of building permit authorizations. Specifically, we find that house prices fall on impact, declining by roughly 3 percent after two years and 4.5 percent after five years, while building permits contract by almost 1 percent after two years and by 1.5–2 percent after five years. These relatively large estimates, including the impact on real activity, fall on the high side of those reported in a meta-analysis by Williams (2015), who reviews 11 papers on the effects of monetary policy shocks on house prices and activity. Williams (2015) finds that a 100

Figure 2. Impulse Response Functions of Selected U.S. Variables



Note: Cumulative IRFs of selected U.S. variables after a monetary policy tightening that increase the one-year Treasury rate by 25 bps. The solid black line is the median response (over all MCMC draws) and the gray shaded areas represent the 68 percent highest density interval (HDI).

bps monetary policy shock leads average house prices to decline between 1.7 percent and 10.8 percent after two years, which compares with 12 percent in our estimates. In turn, Williams (2015) finds that real activity falls between 0.3 percent and 9.3 percent after two years, which compares with 2.4 percent in our analysis.

The large drop of house prices is consistent with recent evidence that house prices may have become more responsive to monetary policy since the GFC due to a decline in housing supply elasticities (Albuquerque, Iseringhausen, and Opitz 2020; Aastveit, Albuquerque, and Anundsen 2023), a long-term increase in the investor share of home purchases, or a prolonged period of ultra-low interest rates (Chudik and Kumar 2023).[8]

We find suggestive evidence that monetary policy may affect both the intensive and extensive margins of housing. On the intensive margin, the literature has documented how homeowners' housing wealth effects may transmit to consumption (Iacoviello 2005; Bhutta and Keys 2016; Aladangady 2017; Beraja et al. 2019; Cloyne, Ferreira, and Surico 2020; Garriga and Hedlund 2020). In turn, the extensive margin can be seen in the fall in housing demand from prospective homeowners due to tighter credit conditions—measured with the net percentage share of banks reporting tightening standards for mortgage loans from the Senior Loan Officer Opinion Survey (SLOOS). As house purchases are typically debt-financed, tighter credit conditions lead to a decline in the homeownership rate (Bhutta and Ringo 2021). In this context, some housing demand presumably shifts to the rental market, as also evidenced by an increase in the home vacancy rate and a fall in the rental vacancy rate. We further explore this reallocation of housing demand in the following section.

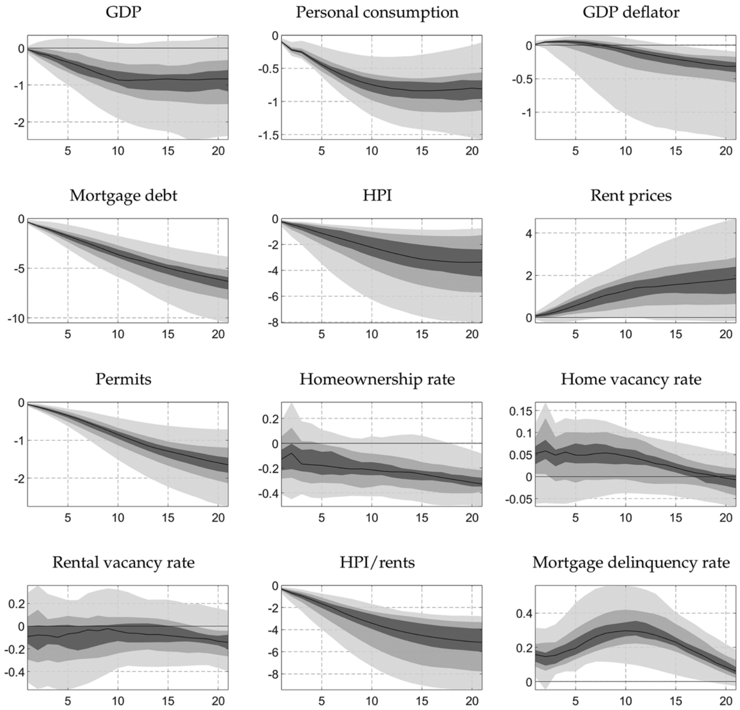
4.2 Transmission of Monetary Policy to State-Level Housing Markets

We take a closer look at the heterogeneity of housing market responses to a contractionary monetary policy shock across U.S. states.[9] Figure 3 summarizes the posterior median responses of

[8]Moreover, there is an ongoing debate about whether house prices may have become less responsive to contractionary monetary policy during the pandemic due to the increase in the share of fixed-rate mortgages. To be sure, the U.S. mortgage market is increasingly dominated by mortgagors locked in (fixed) low-interest-rate mortgages that originated before the 2022 tightening cycle started: the share of fixed-rate mortgages rose to 96.4 percent in 2023:Q2, up from 94.5 percent in 2019:Q4. Higher interest rates therefore only affect directly new mortgages. We remain silent on this issue since we are mostly interested in the cross-sectional variation of housing supply constraints. In addition, there is little variation in the share of fixed-rate mortgages across states.

[9]Our FAVAR model assumes symmetry regarding the monetary policy effects, i.e., contractionary and expansionary monetary policy shocks give rise to effects of the same magnitude, but with different signs. Recent literature, however, finds that there may be important asymmetries in the regional responses to monetary

Figure 3. Dispersion of State-Level Impulse Response Functions



Note: Distribution of the median (cumulative) IRFs across U.S. states after a monetary policy tightening that increase the one-year Treasury rate by 25 bps. The black line is the median response of all state-level (median) responses. The gray shaded areas include 30 percent (35–65 percentile), 60 percent (20–80 percentile), and 90 percent (5–95 percentile) of the median responses, respectively, going from dark to lighter gray.

all U.S. states. The solid black line is the response of the median state, while the gray areas refer to different percentiles of the states'

policy shocks: areas with more inelastic housing supply are more responsive to expansionary monetary policy shocks than to contractionary shocks (Aastveit and Anundsen 2022). These findings, however, are based on a sample that starts in the early 1980s and stops in 2007. During this period, real house prices were mostly on an upward trend. We leave the study of such asymmetric effects of shocks for future work.

median responses. Two main findings emerge. First, there is sizable heterogeneity across U.S. states in the responses to a contractionary monetary policy shock; while economic activity, house prices, housing supply, and the homeownership rate all fall across the board, the magnitude of those declines varies widely.[10] Differences in the housing market structure, which we explore later, may explain part of this heterogeneity. Overall, our results confirm a large degree of heterogeneity in the transmission of monetary policy or demand shocks to the housing market (Paciorek 2013; Fischer et al. 2021; Aastveit and Anundsen 2022; Corsetti, Duarte, and Mann 2022; Cooper, Luengo-Prado, and Olivei 2022; Koeniger, Lennartz, and Ramelet 2022; Aastveit, Albuquerque, and Anundsen 2023).

Second, we find that real rents increase over the horizon, which contrasts with the house price dynamics. This suggests that housing demand shifts from the owner-occupied segment to the rental market as the cost of homeownership goes up following a contractionary monetary policy shock. This is in line with recent research arguing that monetary policy influences the housing tenure decisions of households (Dias and Duarte 2019, 2022; Koeniger, Lennartz, and Ramelet 2022). We contribute to this literature by showing that, despite the synchronized fall in house prices and the increase in rent prices, monetary policy seems to exert a differential impact on households' housing tenure decisions across states. For instance, the magnitude of the fall in the house price-to-rent ratio (HPI/rents)—typically used to summarize how expensive the owner-occupied segment is relative to renting—varies markedly across states, presumably influencing differently households' decision to buy or rent.[11]

Other factors that should influence households' housing tenure decisions are the cost of debt or credit conditions more generally. We indeed find that the tightening in credit conditions leads to a contraction in mortgage debt and an increase in mortgage delinquencies. Consistent with this, the reallocation of demand from the

[10] Considerable dispersion is also present in the state-level responses for unemployment, employment, and nominal rents (Figure C.2 in Appendix C).

[11] We are simplifying the discussion, as regional heterogeneity in house price/rent ratios should reflect differences in housing risk, and in expectations on house and rent prices. But expectations about future house prices can be reasonably captured by current house prices in a context of extrapolative expectations (Glaeser, Gyourko, and Saiz 2008).

owner-occupied market to the rental market does not seem to evolve at the same pace across states. In fact, we find that the homeownership rate declines only marginally for some states, while falling more markedly for others. In addition, housing market differences across states can also be seen in the responses of housing supply: home (rental) vacancy rates actually decline (increase) for some states, which contrasts with the median state response and the U.S. aggregate evidence in Figure 2. The persistence in the decline of the rental vacancy rate indicates a high degree of segmentation in the U.S. housing market, as increasing demand for rental units may not be fully met by supply, thus explaining the increase in rent prices (Greenwald and Guren 2025).[12]

The shift from the owner-occupied to the rental market is consistent with recent evidence that contractionary monetary policy may disadvantage renters and homeowners with a mortgage (Dias and Duarte 2022). Our results indeed suggest that the combination of tighter credit conditions with lower house prices and higher rent prices could have disproportionate effects on these households. This questions the view that monetary policy may have little impact on renters (Aladangady 2017; Wong 2021) and bears relevance as mortgagors, and to a lesser extent renters, tend to be associated with the largest MPC (Cloyne, Ferreira, and Surico 2020). Moreover, by affecting house prices differently, and thus housing wealth and consumption, monetary policy may have important distributional effects (Coibion et al. 2017; Holm, Paul, and Tischbirek 2021; Amberg et al. 2022; Bonifacio et al. 2022; Amaral et al. 2024). Overall, our results suggest that the monetary policy transmission depends on state-specific characteristics. As we will see, differences in housing supply elasticities, and in credit and housing wealth conditions, may account for a portion of this regional variation.

[12]The theoretical and empirical predictions in Greenwald and Guren (2025) suggest that rental and owner-occupied housing in the U.S. are highly segmented. Their model generates house price dynamics that are close to those under perfectly segmented markets, reflecting large frictions in rental markets. The segmentation between owner-occupied and rental markets implies that credit supply shocks that shift the housing demand curve lead to higher house price-to-rent ratios, while the homeownership rate remains relatively unchanged.

5. Regional Characteristics and the Transmission of Monetary Policy

In this section we investigate the relevance of possible channels and state-specific characteristics in explaining the heterogeneous transmission of monetary policy. We follow the spirit of Corsetti, Duarte, and Mann (2022), who look at institutional characteristics of selected euro-area member states and their correlations with the strength of euro-area monetary policy transmission. Given our larger cross-section of U.S. states, we focus on the average responses of states, grouping them by state-specific characteristics. Specifically, we compare the posterior distributions of the average response between states belonging to the top and bottom deciles of selected characteristics (Figures 5–8). We also show in Appendix C the posterior distributions of the differences between the groups' average IRFs (Figures C.3–C.5), as well as the responses of the individual IRFs (Figures C.6–C.8) and the average quintiles (Figures C.9–C.11). We then complement this analysis with a conditional (regression-based) correlation analysis. Table B.3 in Appendix B contains the (average) values of selected characteristics for each state, highlighting those states that belong to the top/bottom deciles.

5.1 Transmission Channels

5.1.1 Housing Supply Channel

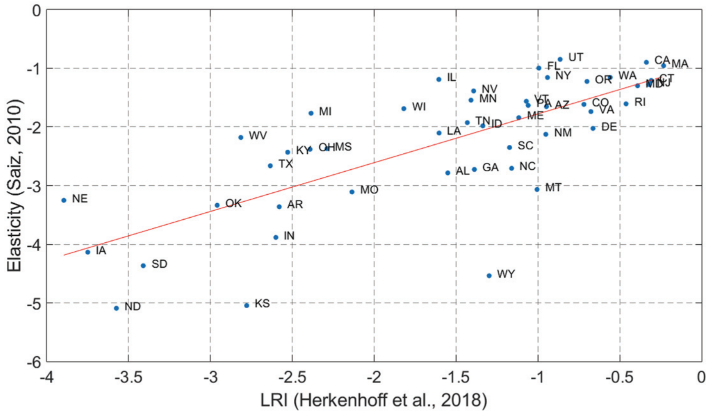
Recent research has shown that housing supply elasticities can play an important role in the transmission of demand shocks (e.g., from expansionary monetary policy) to the housing market (Gyourko, Saiz, and Summers 2008; Saiz 2010; Glaeser et al. 2014; Albuquerque, Iseringhausen, and Opitz 2020; Fischer et al. 2021; Aastveit and Anundsen 2022; Aastveit, Albuquerque, and Anundsen 2023). According to this strand of research, house prices in areas with lower housing supply elasticities are more responsive to an expansion in demand than those in high-supply elasticity areas. This finding is predicated on tighter land-use regulation and geographical restrictions that characterize a typical U.S. low-supply-elasticity area—found predominantly in coastal areas and in high-productivity and high-income places. These supply constraints make it more difficult and expensive to expand supply in the face of rising demand, resulting in a stronger increase of house prices to absorb demand.

While there is growing evidence on the aforementioned link between monetary policy, supply elasticities, and house prices, the literature has not yet assessed, to the best of our knowledge, the wider macrofinancial implications of monetary policy conditional on regional differences in housing supply—the *housing supply channel* of monetary policy. This is particularly important given the recent rise of interest rates, where an expected larger fall in house prices in inelastic areas may amplify the contraction in economic activity, while raising financial stability risks.

We use the land-use restriction index (LRI) constructed by Herkenhoff, Ohanian, and Prescott (2018) as our measure of housing supply constraints. This indicator is based on a general equilibrium spatial model of the United States augmented with state-level data on employment, workers' output, house prices, and the amount of usable land. It is available for 48 states, excluding Alaska and Hawaii, and for each decade since 1950: 1950, 1960,. . . , 2000, and 2014. We split the states based on their indicator value in 2014, which should capture more accurately the prevailing stringency of land-use regulation during our estimation sample. Moreover, we divide the indicator by its standard deviation and change its sign so that higher values reflect states with tighter land-use regulation. There is a strong link between stringent land-use regulation and low housing supply elasticities, so we use these two terms interchangeably to refer to states with inelastic housing supply (Figure 4). We opted for the LRI of Herkenhoff, Ohanian, and Prescott (2018) as our baseline measure of supply constraints since the other measures available in the literature (Saiz 2010; Aastveit, Albuquerque, and Anundsen 2023) are computed at the MSA level, and thus need to be aggregated at the state level using population weights. The LRI is also available for an additional state (New Hampshire). In addition, the Saiz (2010) elasticities are estimated over 1970–2000, so they do not take into account the changes in supply elasticities over the last two decades.

We find evidence of an important role played by differences in housing supply restrictions in the transmission of monetary

Figure 4. Herkenhoff, Ohanian, and Prescott (2018) Land-Use Restrictions in 2014 vs. Saiz (2010) Housing Supply Elasticities



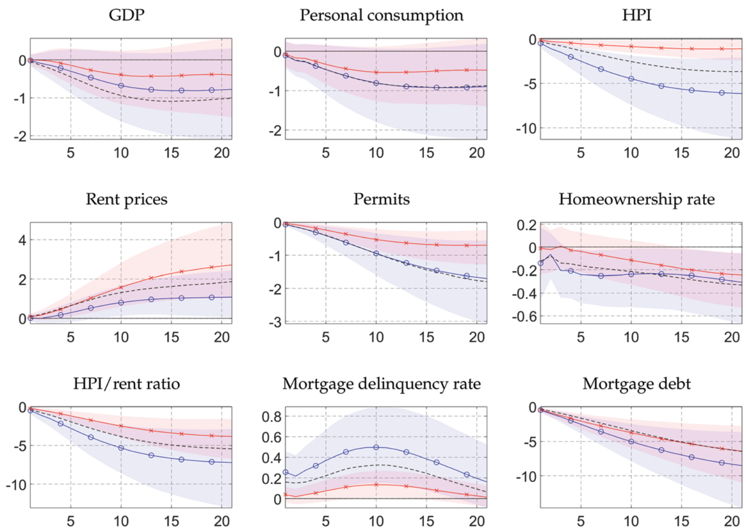
policy (Figure 5).[13] States with tighter land-use regulation (blue lines) experience a larger decline in house prices and permits after a contractionary monetary policy shock than states with less stringent regulation (red lines). The shaded areas represent the 68 percent highest density interval (HDI) of the average responses within the two groups across all MCMC draws. The HDI of the differences between the average IRFs across groups excludes zero for most variables (Figure C.3 in Appendix C).[14]

The estimated larger contraction in house prices leads to a greater fall in consumption for households in areas with more inelastic supply. While we cannot establish directly causality from the house-price-induced decline in consumption, we build on recent work by Aruoba, Elul, and Kalemli-Özcan (2026) who use rich information at the household level to identify several channels through which

[13]Our results remain robust to exploring the cross-sectional distribution of the LRI taking 2000, instead of 2014, as the reference year (Figure C.12 in Appendix C). Moreover, the same holds when exploring the cross-sectional distribution of house values and house price-to-rent ratios, as low-supply-elasticity states tend to have higher house prices (see Figures C.13 and C.14).

[14]Despite our relatively short sample that comes with sizable estimation uncertainty, this result reinforces our view that the differences we uncover between supply elasticity groups are an underlying characteristic of the economy.

Figure 5. Impulse Responses across Herkenhoff, Ohanian, and Prescott (2018) LRI (decile averages)



Note: Posterior distributions of the average (cumulative) IRFs across U.S. states after a monetary policy tightening that increases the one-year Treasury rate by 25 bps. The blue (red) line with circles (crosses) indicates the median (over all MCMC draws) of the average responses of the states belonging to the top (bottom) decile of the respective state characteristic. Shaded areas reflect the 68 percent HDI. The dashed black line is the median of the average IRFs across all the other states.

the collapse in house prices led to a large decline in U.S. household consumption between 2006 and 2009.[15] Aruoba, Elul, and Kalemli-Özcan (2026) find that the decline in U.S. consumption around the GFC was mostly driven by financial constraints (56 percent), followed by local general equilibrium effects (30 percent), and by credit supply effects (15 percent). Pure housing wealth effects did not seem

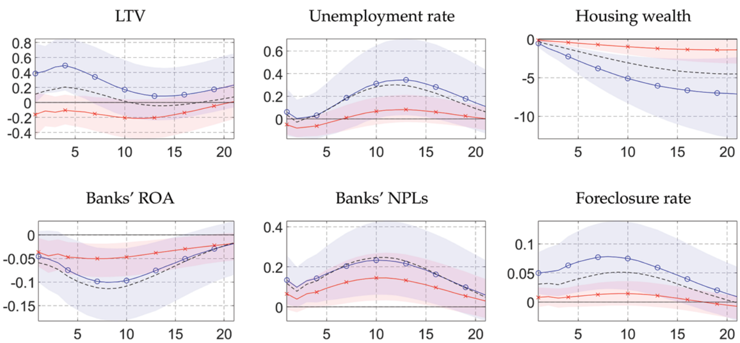
[15] Aruoba, Elul, and Kalemli-Özcan (2026) explore the following channels: (i) financial constraints, measured with the ex ante loan-to-value (LTV) ratio and with ex post delinquency rates; (ii) credit supply effects at the county level, computed as cumulative changes in credit supply driven by banks' fundamentals; (iii) pure housing wealth effects, measured with the change in consumption from prime mortgagors with very low LTVs; and (iv) local general equilibrium effects, measured with the change in the unemployment rate.

to explain the fall in consumption around the GFC. This is consistent with estimates in the literature showing that households with large mortgages or high LTVs are considerably more responsive to house price changes (Aladangady 2017; Garriga and Hedlund 2020; Guren et al. 2021).

These studies typically use rich granular data at the household level that allow for a better understanding of the channels through which house price changes may affect household consumption expenditures. In this context, our aggregated state-level data prevent us from properly investigating the contribution of each channel for the response of consumption to house price changes. Bearing in mind the data and model limitations of our setting, we further explore the role of some of these channels. In particular, we investigate the role of households' financial constraints in driving the regional heterogeneity in the consumption responses to monetary policy shocks. Financial constraints have been found to be the single most important driver in explaining the link between lower house prices and a greater fall in consumption. More specifically, we add the LTV ratio to our FAVAR model to understand whether there is any differential dynamics between inelastic and elastic areas. The assumption is that the fall we observe in house prices (the collateral) would tighten households' credit constraints: an increase in the LTV would thus make households more vulnerable to shocks, increasing the probability that high-LTV households would make a larger adjustment to their consumption. A scenario of a greater increase in the LTV could also translate into negative equity for some households—becoming "underwater"—encouraging further cuts in consumption. Figure 6 confirms our prior that the LTV ratio would increase by substantially more in inelastic states, while remaining unchanged (or even declining slightly) in more elastic states. This is consistent with the notion that the collateral channel or financial constraints channel plays an important role in driving the fall in private consumption in inelastic states in the face of contractionary monetary policy shocks. Our findings also align with Albuquerque et al. (2026), who document stronger economic adjustments in countries with tighter housing supply constraints during housing contractions.

At the same time, financial stability risks also seem to increase more sharply in inelastic states. Mortgage delinquencies rise more sharply, and foreclosures and other indicators proxying the health of

Figure 6. Impulse Responses across Herkenhoff, Ohanian, and Prescott (2018) LRI (decile averages)



Note: See Figure 5.

the banking sector also deteriorate more considerably (bottom panel of Figure 6). In addition, mortgage debt falls more strongly, arguably reflecting not only lower demand but also banks' tighter credit conditions. These results thus provide support for important credit supply effects driving down consumption in these inelastic areas. Finally, the decline in housing demand (collateral channel) coupled with the aforementioned tightening in credit conditions may feed to local general equilibrium effects—in the words of Aruoba, Elul, and Kalemli-Özcan (2026). This is reflected in a greater increase in the unemployment rate in inelastic states (Figure 6). Lower employment would exacerbate the decline in consumption.

Overall, our results suggest that the larger fall in consumption in states with tighter housing supply constraints seems to reflect the combination of collateral effects, local general equilibrium effects, and credit supply effects. Although we remain silent on pure housing wealth effects, we believe they should play a negligible role in explain the regional variation in consumption responses given that outright owners or borrowers with small mortgages are typically not responsive to house prices changes (Aruoba, Elul, and Kalemli-Özcan 2026).

Our results should not be driven by differences in the share of adjustable-rate mortgages across states. ARMs are fairly uncommon in the U.S. economy, which contrasts with Europe, where the share of ARMs varies considerably across countries, and therefore the pass-through of monetary policy to mortgage markets also varies widely (Calza, Monacelli, and Stracca 2013; Corsetti, Duarte, and Mann 2022; Pica 2023). In addition, according to data from the Federal Housing Finance Agency, there is very little variation in the ARM share across U.S. states: for instance, the ARM share stood at 5.5 percent of all outstanding mortgages nationally in 2019:Q4, with a standard deviation of 1.8 percentage points across all states.

Our finding that house prices decline more in inelastic states may, at face value, be surprising. Housing supply is rigid downwards, given the durability of housing, thus the house price response to negative demand shocks should be independent of supply restrictions (Glaeser and Gyourko 2005; Glaeser, Gyourko, and Saiz 2008; Aastveit and Anundsen 2022). We rationalize this result with findings on (i) the role of credit boom-busts in driving housing market cycles in more inelastic areas during the 2000s U.S. housing boom-bust (Huang and Tang 2012; Anundsen and Heebøll 2016), and on (ii) household overoptimism during the housing boom phase due to diagnostic expectations (Chodorow-Reich, Guren, and McQuade 2024). This strand of research shows that more inelastic U.S. areas had a stronger housing boom-bust during the 2000s, followed by a sharper post-GFC rebound (Chodorow-Reich, Guren, and McQuade 2024).

On (i) above, Huang and Tang (2012) find that households in cities with tighter supply constraints also relied more on credit, particularly subprime mortgages, which may explain why these cities recorded both a larger boom in house prices in the run-up to the GFC and a subsequent larger bust in house prices during the crisis as the credit crunch started to bite. Anundsen and Heebøll (2016) also document that both financial-accelerator effects and price-to-price feedback loops may explain why low-supply-elasticity areas recorded a stronger contraction in house prices in the aftermath of the GFC.

Finally, on (ii) above, Chodorow-Reich, Guren, and McQuade (2024) show empirically and theoretically that high-growth price areas (low-supply-elasticity areas) experienced a larger boom in house prices in the run-up to the GFC due to households' overoptimism, giving rise to a larger bust when beliefs started to correct. The fall in house prices in these low-supply-elasticity areas was also amplified by excessive borrowing and a price-foreclosure spiral as foreclosures increased the stock of housing available for sale, further depressing prices (also in line with the theoretical predictions in Guren and McQuade 2020). House prices may thus not be independent of the supply elasticity in the presence of negative demand shocks when important financial-accelerator effects and misaligned household expectations are at play. This can then rationalize our finding of a stronger credit crunch and rising financial stability risks in inelastic states, amplifying the house price responses after a tightening in monetary policy.[16]

Our findings also speak to research documenting the impact of monetary policy on households' housing tenure decisions (Dias and Duarte 2019, 2022; Koeniger, Lennartz, and Ramelet 2022). Our contribution is to show that monetary policy may have a stronger influence on housing tenure decisions in states where supply is more constrained. In particular, we draw this implication from the larger fall in house prices, coupled with signs of a larger decline in homeownership rates, and a stronger increase in home vacancy rates for inelastic states (Figure C.15 in Appendix C). These dynamics point to a larger contraction in housing demand for the owner-occupied segment in inelastic states.[17] But rent prices seem to increase by less in inelastic areas, which would, at face value, be at odds with the assumption of housing demand shifting to the rental market.

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[16] A complementary explanation relies on the relationship between house prices and minimum profitable construction costs (MPPC). Glaeser and Gyourko (2018) argue that the shape of the housing supply curve depends on house prices relative to MPPC. Building on this notion, Aastveit and Anundsen (2022) find that house prices are typically above the MPPC in supply-inelastic areas, which theoretically makes it possible for house prices to decline by more than in (elastic) areas where house prices are close to the MPCC. This is consistent with our results: low-supply-elasticity areas, typically found in coastal areas (e.g., California), characterized by high house prices relative to MPPC, experience a stronger fall in house prices after a contractionary monetary policy shock.

[17] Our results are not restricted to a few states with low or high supply constraints. Figure C.16 in Appendix C shows that U.S. states whose housing supply constraints are less severe (red lines) experience a smaller house price fall relative to states with low supply elasticities, or tight supply constraints (blue lines). Rent prices increase by more in most of elastic areas (with some exceptions), also validating our baseline results. Results for homeownership rates are more mixed, since they also seem to fall by less in some inelastic areas.

The smaller increase in rent prices in inelastic states, however, may be related to differences in market segmentation across states, i.e., the frictions and adjustment costs in converting owner-occupied housing units to rental properties (Greenwald and Guren 2024). While we cannot observe the degree of segmentation across markets, the rental market in these states seems to have more capacity to absorb demand than in elastic states, further illustrated by a relatively unchanged rental vacancy rate for inelastic states (Figure C.15). Overall, we speculate that more stringent regulation to build new housing units in some areas may indirectly create incentives for homeowners to reduce adjustment costs in converting owner-occupied units to rental units in the face of shocks. An alternative explanation for the weaker response of rent prices in inelastic areas could be the initially already high rent levels in these areas (according to Zillow data), which potentially limit the scope for further increases. Stringent rent controls in several cities in two inelastic states, California and Maryland (according to the National Multifamily Housing Council and RentPrep), may also explain the more muted response of rent prices. Overall, we acknowledge that our finding that monetary policy may have stronger effects on households' housing tenure decisions in areas with low supply elasticity is not conclusive.

Finally, the larger decline in house prices in low-supply-elasticity states, which leads to negative housing wealth effects and lower housing equity of existing homeowners, suggests important distributional effects *across* states. These are high-income states where households tend to have larger housing wealth and higher consumption/income per capita (Figures C.17–C.19). The larger decline in housing wealth in inelastic states can be mapped to a larger fall in overall consumption expenditures, and therefore in economic activity in these states. Although it is outside of the scope of our paper, we find that contractionary monetary policy shocks may have a non-negligible role in reducing regional consumption and housing wealth inequality. This chimes with Amaral et al. (2024), who suggest that higher interest rates can decrease the dispersion and thus inequality in house prices across U.S. cities.

Let us conclude this section by stressing that the presented exercise neither implies that housing supply constraints are the only driver of regional heterogeneity in the responses to monetary policy shocks nor proves a causal relationship. For instance, differences across states in the industry composition, demography, income levels, and in the quality of institutions may also explain the documented heterogeneity. Despite the limitations of our empirical approach that prevent us from fully exploring a causal link from housing supply constraints, we find reassurance in established literature highlighting the significant role these constraints play in shaping regional house price responses to demand shocks (Saks 2008; Saiz 2010; Aastveit and Anundsen 2022; Aastveit, Albuquerque, and Anundsen 2023). Moreover, Section 5.2 analyzes the combined effect of several state-specific characteristics, including housing supply constraints, on the differential responses to monetary policy shocks across states. Overall, we believe that the interaction of housing demand changes with housing supply frictions plays an important role in driving the differential behavior of the real economy across U.S. states.

5.1.2 Debt Overhang Channel

Another possible source of cross-sectional heterogeneity in the response to monetary policy shocks is differences in households' debt imbalances, or debt overhang in the spirit of (Eggertsson and Krugman 2012). In theory, as the cost of borrowing goes up, borrowing constraints become more binding for households with larger debt imbalances, i.e., whose debt deviates more from fundamentals, leading to a larger contraction in housing demand and house prices, consumption, and economic activity (Iacoviello 2005; Calza, Monacelli, and Stracca 2013; Hedlund, Karahan, and Ozkan 2016; Bhutta and Ringo 2021; Pica 2023; Bosshardt et al. 2024). We proxy household debt overhang for each state with the concept of a debt gap (Albuquerque 2019; Alpanda and Zubairy 2019). We compute the debt gap with the Hamilton (2018) filter on the state-level mortgage debt-to-income ratio, which involves regressing a given nonstationary variable at $t+h$ on a constant and on the four most recent values of the dependent variable available at time t. We set the forecast horizon to $h = 20$, the suggested horizon for financial variables at the quarterly frequency. Specifically, we compare states that fall in the top and bottom deciles of the debt gap distribution, using the maximum value of the debt gap over time for each state.[18]

We find that contractionary monetary policy shocks transmit more strongly to states with larger debt gaps: house prices, housing supply, mortgage debt, and consumption fall by considerably more than in states with smaller debt imbalances (Figure 7). Financial stability risk may also increase more prominently in areas with larger household debt imbalances (Figure C.21 in Appendix C). These findings are in line with research that finds that changes in interest rates affect more households and regions closer to the borrowing constraint (Hedlund, Karahan, and Ozkan 2016; Bhutta and Ringo 2021; Bosshardt et al. 2024). Furthermore, we find that the responses of states with high debt gaps are qualitatively similar to the previous results we saw for areas with low supply elasticity. This is not a surprise given the positive correlation between supply constraints and household debt gaps (Figure C.20 in Appendix C).[19] This reinforces the view that the interconnectedness between household debt overhang and housing supply constraints may amplify the macrofinancial effects of contractionary monetary policy shocks.

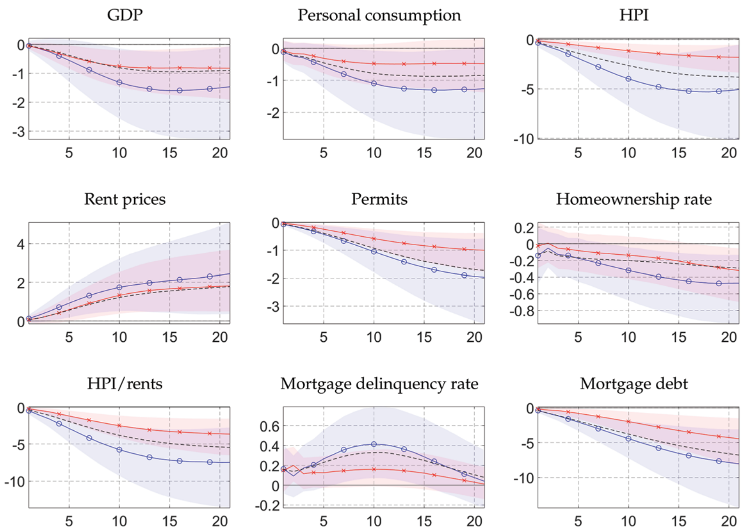
5.1.3 Housing Wealth Volatility and Household Balance Sheet Channel

The ability of mortgagors to extract home equity to finance consumption should also be relevant to explain the differential effects of monetary policy (Bhutta and Keys 2016; Aladangady 2017; Beraja et al. 2019; Andersen and Leth-Petersen 2021). According to this strand of the literature, the fall in house prices and in housing equity reduces housing equity extraction for existing homeowners, which leads to a contraction in housing demand that reinforces the decline in house prices and in economic activity. As a corollary, households

[18]Our results remain qualitatively similar when proxying debt imbalances with the state-level debt-to-income ratio.

[19]Despite the positive correlation (around 0.45), we generally capture different states in the high/low bins of the LRI and the debt gap. The only overlap refers to Iowa and North Dakota, which appear in both the bottom bins of the LRI and debt gap (see also Table B.3). This suggests that our results capture more the differential effects of groups of states with low/high supply elasticities and household debt imbalances, rather than being driven by particular states.

Figure 7. Impulse Responses across Debt Gap (decile averages)

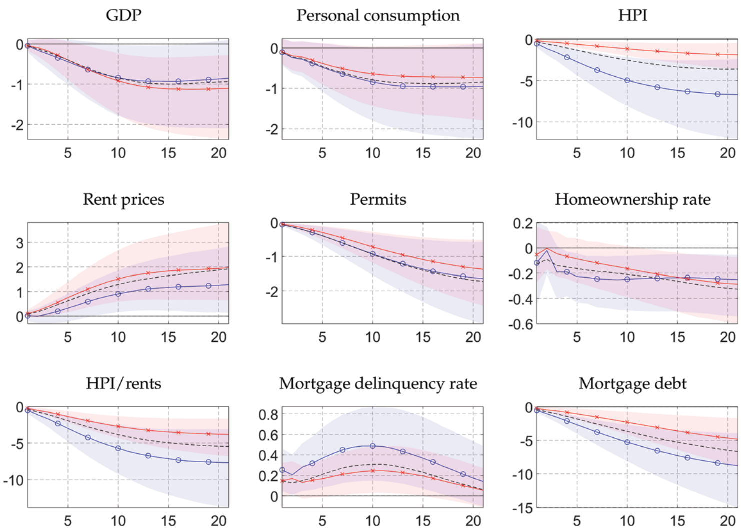


Note: See Figure 5.

with large housing wealth are in a better position to smooth their consumption expenditures in the face of interest rate shocks, as the probability of going *underwater*, i.e., the value of their houses falling below their mortgage commitments, is lower than for low-housing-wealth households. This is indeed what we see in Figure C.13 in Appendix C.

What is less studied is how the volatility of housing wealth—irrespective of its level—may affect households' housing demand and consumption decisions in the face of a monetary policy tightening. We posit that higher uncertainty or volatility of housing wealth may lead households to reduce more their demand for real estate services or postpone their house purchase, leading to an overall stronger reduction in economic activity. This conjecture relates to research that has found a link between uncertainty about future house prices and households' housing tenure decisions (Henderson and Ioannides 1983; Rosen, Rosen, and Holtz-Eakin 1984; Fu 1995). We use the standard deviation of housing wealth over the sample

Figure 8. Impulse Responses across Housing Wealth Volatility (decile averages)



Note: See Figure 5.

period as a proxy for housing wealth volatility. We follow Albuquerque and Krustev (2018) and compute housing wealth for each state j and quarter t as (homeownership rate$_{j,t}$ $\times$ total occupied housing units$_{j,t}$) $\times$ house price index$_{j,t}$ $\times$ median house price in 2000$_j$.

Figure 8 suggests that states with larger fluctuations in housing wealth may indeed react more strongly to monetary policy: house prices fall by more than in states with lower housing wealth volatility, which goes hand-in-hand with a larger fall in consumption expenditures. Interestingly, while we find a significant and positive correlation between housing wealth volatility and the consumption reaction, this is not the case when considering average housing wealth (see the unconditional pairwise correlations in Table C.2), despite the housing wealth level and its volatility being highly correlated (around 0.9). In addition, for most of the remaining variables, the correlation between the strength of the response and the volatility of housing wealth appears to be stronger compared with the housing wealth level. Overall, these findings suggest that larger uncertainty about housing wealth could strengthen the transmission of monetary policy.

5.2 Cross-Sectional Multivariate Analysis

In this section we use cross-sectional regressions to simultaneously analyze the drivers of heterogeneity in the responses of economic activity and housing markets to monetary policy. Specifically, we follow Mumtaz, Sunder-Plassmann, and Theophilopoulou (2018) and regress the IRFs of key variables on a set of state-level characteristics:

$$IRF^{y}_{h,i} = \alpha + X_i\beta + regions_i + \eta_i, \qquad \eta_i \sim \mathcal{N}(0, \sigma^2_\eta), \tag{3}$$

where $IRF^{y}_{h,i}$ denotes the cumulative response of variable y in state i after h quarters. The $1 \times K$ vector X_i includes state-specific variables that potentially explain the heterogeneity in the responses, β is a $K \times 1$ vector of regression coefficients, α is the regression constant, and $regions_i$ is a vector of dummies for the eight divisions defined by the Bureau of Economic Analysis. While this exercise allows us to jointly analyze the importance of several variables, we stress that the results should be taken with a pinch of salt given the relatively small cross-section of U.S. states. In addition, and differently from Section 5.1 that explored the differential responses between groups of states, the cross-sectional regressions focus on the *average* relationship between monetary policy and selected state characteristics.

On top of the variables discussed in Section 5.1, we also control for other state-level characteristics that may play a role in explaining the heterogeneity in the regional responses to a tightening in monetary policy. First, the so-called sand states (Arizona, California, Florida, and Nevada) are known to have a more sensitive housing cycle (Ben-David, Towbin, and Weber 2024). Second, we explore the role of *labor market rigidities.* A more rigid labor market may cushion the effects of an adverse monetary policy shock, leading to a smaller decline in income and potentially reducing the transmission to the housing market. We follow Mumtaz, Sunder-Plassmann, and Theophilopoulou (2018) and use the existence of the right-to-work legislation as a proxy for such rigidities. States which have implemented this legislation are considered to have a more flexible labor market. Third, we consider the share of manufacturing in state-level GDP and the share of small firms in total employment. States with more manufacturing-intensive sectors and areas with a larger share of small firms have been found to be more sensitive to interest rates (Carlino and DeFina 1998, 1999). Finally, we also control for the overall house price dynamics in a state by including the cumulative house price growth over the sample.

Table 1 presents our main results. While we focus on the variables' (medium-term) cumulative response after $h = 12$ quarters, our results remain qualitatively similar when using $h = 8$ and $h = 20$. We highlight several key results. For instance, the degree of land-use regulation in a state stands out as an important driver of the transmission of monetary policy to the housing market and the broader economy. A state in which land-use regulation is one standard deviation higher exhibits a 0.9 percentage point larger house price drop following a surprise tightening of 25 bps. Our results also indicate that this translates into lower consumption.

When inspecting the evidence of a potential debt overhang channel, measured by the debt gap, we do not find any of the coefficients to be significant. This suggests that household debt imbalances have little extra explanatory power for the differential effects of monetary policy on the housing market once we account for differences in housing supply constraints. Regarding a possible housing wealth channel, differences in the first moment of housing wealth over the sample can explain some degree of heterogeneity in the GDP and rents reactions, while a larger second moment, i.e., higher housing wealth volatility, is linked to a stronger drop in house prices.

For other state characteristics—whether a state is a so-called sand state or has the right-to-work legislation in place—the results are broadly consistent with our prior assumptions. The same holds for the small firms share, where the signs of the estimated coefficients, while not statistically different from zero, suggest that the larger the proportion of small firms in total employment, the stronger the fall in economic activity and house prices (Carlino and DeFina 1998; Furceri, Mazzola, and Pizzuto 2019). Regarding the role of a higher manufacturing share in an area, the results are somewhat mixed, with GDP reacting stronger but house prices weaker.

Table 1. Cross-Sectional Regression Results ($h = 12$)

Dependent Variables	(1) GDP	(2) PCE	(3) HPI	(4) Rents	(5) Permits	(6) HOR
LRI	–0.349	**–0.358*****	**–0.932****	**–0.918***	–0.010	–0.028
	(0.213)	(0.101)	(0.361)	(0.468)	(0.099)	(0.074)
Debt Gap	–0.012	–0.004	0.010	0.025	0.002	0.003
	(0.024)	(0.012)	(0.047)	(0.050)	(0.012)	(0.006)
HW (Avg.)	**0.012****	–0.000	0.021	**0.020****	0.001	0.001
	(0.006)	(0.003)	(0.013)	(0.009)	(0.003)	(0.002)
HW (Std.)	–0.006	0.001	**–0.018***	–0.001	–0.003	–0.001
	(0.004)	(0.002)	(0.009)	(0.007)	(0.003)	(0.001)
Sand State	**–1.419****	**–0.576****	**–3.048*****	–0.776	**–0.670*****	–0.083
	(0.541)	(0.254)	(0.862)	(0.896)	(0.228)	(0.079)
RTW	**–0.447****	**–0.625*****	**–0.890***	–0.614	**0.326****	–0.040
	(0.198)	(0.136)	(0.516)	(0.646)	(0.124)	(0.083)
Manufacturing	**–0.039***	0.018	**0.100****	0.073	0.002	0.004
	(0.022)	(0.011)	(0.041)	(0.045)	(0.012)	(0.007)
Small Firms	–0.029	–0.010	–0.043	–0.001	**0.024****	0.005
	(0.019)	(0.010)	(0.035)	(0.051)	(0.010)	(0.006)
HPI Growth	**0.073*****	**0.037*****	**0.066***	0.010	**0.024****	**0.011****
	(0.020)	(0.011)	(0.035)	(0.030)	(0.012)	(0.004)
Observations	**48**	**48**	**48**	**46**	**48**	**48**
Adjusted R^2	0.652	0.673	0.857	0.222	0.673	0.392

Note: The table shows the point estimates and standard errors for the regression shown in Equation (3). GDP = real GDP. PCE = real personal consumption expenditure. HPI = real house price index. HOR = homeownership rate. LRI = land-use restriction index of Herkenhoff, Ohanian, and Prescott (2018) for the year 2014. Debt gap = max. value of Hamilton-filtered mortgage debt-to-income ratio over 1999–2019. HW (Avg.) = 100*log(average housing wealth over 1999–2019). HW (Std.) = 100*log(standard deviation of housing wealth over 1999–2019). Sand state = dummy variable for Arizona, California, Florida, and Nevada. RTW = dummy variable for right-to-work states. Manufacturing = share of manufacturing in state-level GDP (average over 1999–2019). Small firms = share of small firms employment in total employment (average over 1999–2019). HPI growth = growth rate of house prices over 1999–2019. All regressions include regional dummies. Robust standard errors in parentheses. *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$.

6. Robustness Checks

In this section, we carry out three main exercises to check the robustness of our baseline results. First, we use alternative monetary policy surprise series from the literature. We first depart from the conventional monetary policy shocks by also using shocks that capture more the long end of the yield curve. Specifically, we use shocks on forward guidance (FG) from Swanson (2021). Inspecting the cross-state dispersion of the IRFs of consumption, house prices, and permits, as well as the reactions sorted by the land-use restriction index of Herkenhoff, Ohanian, and Prescott (2018), we find that the results remain qualitatively similar (Figure C.22 in Appendix C). We also replace our baseline series of monetary policy surprises with the one from Jarociński and Karadi (2020) that controls for central bank information effects. While the new results remain qualitatively similar for house prices and permits, in this case the differential effect of monetary policy on consumption across states, grouped by LRI, disappears (Figure C.23).

Second, we take alternative measures of the elasticity of housing supply from the existing literature. In particular, we replace the land-use restriction index of Herkenhoff, Ohanian, and Prescott (2018) with the housing supply elasticity series from Saiz (2010) and Aastveit, Albuquerque, and Anundsen (2023). These supply elasticity series are available for a large set of U.S. MSAs, so we aggregate them at the state level using population weights (results are very similar when using income weights). When using the housing supply elasticities computed by Aastveit, Albuquerque, and Anundsen (2023), available as average elasticities over 1996–2006 (Figure C.24) or over 2012–19 (Figure C.25), we find that—with some exceptions—the results remain broadly comparable to our baseline findings in Figure 5. The same holds true when using Saiz (2010) housing supply elasticities (Figure C.26).

Third, we replace the state-specific GDP deflator, used throughout the paper, with an alternative state-level inflation series computed by Hazell et al. (2022). We find that our results for the cross-state dispersion of the IRFs of consumption and house prices remain comparable, while the price reactions differ, showing an initial increase (Figure C.27). Nevertheless, the differences in the consumption and house price reactions across states, grouped by the

LRI, are very similar to the baseline results. While the state-level inflation data of Hazell et al. (2022) end in 2017:Q4, this series is smoother for a few states compared with the growth rate of the GDP deflator series.

7. Conclusion

We use a FAVAR model and a large set of state-level (and aggregate U.S.) variables over 1999:Q1–2019:Q4 to trace out the role of regional housing markets in the transmission of monetary policy. Our main findings point to significant heterogeneity in the transmission of an aggregate contractionary monetary policy shock to the U.S. states. We find that the regional variation in responses to monetary policy can be partly accounted for by state-specific characteristics, most prominently by differences in housing supply elasticities, but also household debt overhang and housing wealth (volatility). In particular, we show that low-supply-elasticity areas, where land-use regulation is more stringent, record a larger fall in house prices and in economic activity more generally. In addition, financial stability risks appear to increase more sharply in these areas, as evidenced by a surge in mortgage delinquencies and foreclosures, while indicators proxying bank health also deteriorate faster. We find similar results for areas with higher imbalances in household debt—presumably where household borrowing constraints become more binding. Our findings thus show that the interaction between household debt overhang and housing supply constraints can amplify the macrofinancial effects of monetary policy.

Our results shed more light on the possible macrofinancial effects of monetary policy in the context of recently rapidly rising interest rates to tame inflationary pressures. It is well-established that housing is highly sensitive to interest rates, but we have shown that its sensitivity varies across U.S. states, particularly resulting from differences in supply conditions in the housing market, and in household indebtedness. Although the Federal Reserve conducts monetary policy with a dual mandate of price stability and full employment for the U.S. economy as a whole, our paper shows that monetary policy can nonetheless have differential macrofinancial effects across states within the country.

Our results have policy implications. If housing markets, and the wider macroeconomy, are more sensitive to monetary policy in areas with more inelastic housing supply, it could be advisable for financial supervision to tighten more in these areas to limit excessive house price volatility (Glaeser 2019). Since house purchases are mostly financed by mortgage debt, there is a case for strengthening macroprudential measures aimed at taming borrowing, such as limits on loan-to-income and/or debt-service ratios, before debt imbalances start to emerge. In addition, the relaxation of land-use restrictions should make an area less prone to boom-bust cycles in house prices, as builders are less constrained to expand supply during an expansion. By smoothing the cycle during an expansion, less stringent regulation should help an economy be more resilient to contractionary demand shocks.

Although we have carried out a battery of tests to validate our main findings, our results on the regional heterogeneity in the responses to monetary policy cannot necessarily be interpreted as causal: the identification of the effect of monetary policy on economic activity through housing supply constraints is not fully immune to endogeneity issues. For instance, we acknowledge that other state characteristics beyond housing supply constraints may also play an important role in explaining the regional heterogeneity we find in the responses to monetary policy. Against this background, our work opens up new research avenues. Further research can build on our work by extending the analysis to more granular data, and to a longer time series. For example, focusing on city-level data over a long period could help identify the response of macroeconomic variables, including house prices, to monetary policy shocks around changes in land-use regulation. A difference-in-differences framework, where land-use regulation changes in one city but not in another with similar levels of housing supply constraints, provides an ideal setting to study the role of housing supply constraints on economic activity after contractionary monetary shocks.

Appendix A. Estimation Procedure

This appendix contains details on the MCMC algorithm used to estimate the FAVAR model.

Block 1: Sample the factor loadings Λ from $p(\Lambda|X, H, \Omega)$ and the error covariance matrix Ω from $p(\Omega|X, H, \Lambda)$.

Conditional on the estimated factors (principal components), sampling the elements of the matrix of factor loadings in Equation (1) and the error covariance matrix Ω reduces to N standard linear Bayesian regression problems (see, e.g., Koop 2003). The conditional posterior of the loadings in each of the N rows of Λ, denoted by $\Lambda_i = (\lambda_{1i}^F, \ldots, \lambda_{qi}^F, \lambda_i^R)$ for $i = 1, \ldots, N$, under the normal prior $\Lambda_i \sim \mathcal{N}(\Lambda_{i,0}, \Sigma_{\Lambda_i,0})$, is

$$\Lambda_i|X_i, H, \omega_i^2 \sim \mathcal{N}(\widehat{\Lambda}_i, \Sigma_{\Lambda_i}), \quad \text{with} \tag{A.1}$$

$$\widehat{\Lambda}_i = \left(\Sigma_{\Lambda_i,0}^{-1} + \frac{1}{\omega_i^2} H'H\right)^{-1} \left(\Sigma_{\Lambda_i,0}^{-1}\Lambda_{i,0} + \frac{1}{\omega_i^2} H'H\right)^{-1}, \tag{A.2}$$

$$\Sigma_{\Lambda_i} = \left(\Sigma_{\Lambda_i,0}^{-1} + \frac{1}{\omega_i^2} H'X_i\right)^{-1}, \tag{A.3}$$

where $H = (F_1, \ldots, F_q, R)$, $X_i = (X_{i1}, \ldots, X_{iT})'$, and ω_i^2 is the ith diagonal element of Ω. After sampling Λ_i, the corresponding element of Ω, ω_i^2, can be sampled, under the inverse-gamma prior $\omega_i^2 \sim \mathcal{IG}(c_0, C_0)$, from

$$\omega_i^2|X_i, H, \Lambda_i \sim \mathcal{IG}(c_0 + (T-1)/2, C), \tag{A.4}$$

where notation follows Chan and Hsiao (2014) and where C is defined as

$$C = C_0 + \left[\sum_{t=1}^{T} (X_{it} - \Lambda_i H_t')^2\right] /2. \tag{A.5}$$

Finally, the prior values are set to $\Lambda_{i,0} = 0_{(q+1)\times 1}$, $\Sigma_{\Lambda_i,0} = 4 \times I_{(q+1)}$, $c_0 = 0.2$, and $C_0 = 0.2$.

Block 2: Sample the VAR(X) coefficients Φ and A from $p(\Phi, A|H, z, \Sigma)$.

The VAR(X) coefficients $\theta = vec((\Phi, A))$, assuming a normal prior distribution $\theta \sim \mathcal{N}(\theta_0, V_{\theta,0})$, have the following conditional posterior distribution (see, for example, Blake and Mumtaz 2012):

$$\theta \sim \mathcal{N}(\bar{\theta}, V_\theta), \quad \text{with} \tag{A.6}$$

$$\bar{\theta} = (V_{\theta,0}^{-1} + \Sigma^{-1} \otimes \widetilde{H}'\widetilde{H})^{-1}(V_{\theta,0}^{-1}\theta_0 + \Sigma^{-1} \otimes \widetilde{H}'\widetilde{H}\bar{\theta}_{\text{OLS}}), \tag{A.7}$$

$$\Sigma_\theta = (V_{\theta,0}^{-1} + \Sigma^{-1} \otimes \widetilde{H}'\widetilde{H})^{-1}, \tag{A.8}$$

and where $\widetilde{H} = (H_{t-1}, \ldots, H_{t-p}, z)$ and $\bar{\theta}_{\text{OLS}}$ is the ordinary least squares (OLS) estimate of the VAR(X) coefficients. The prior configuration is relatively uninformative, i.e., $\theta_0 = 0_{[(q+1)\times(1+p\times(q+1))]\times 1}$ and $V_{\theta,0} = I_{(q+1)\times(1+p\times(q+1))}$.

Block 3: Sample the VAR(X) innovation covariance matrix Σ from $p(\Sigma|H, z, \Phi, A)$.

The covariance matrix of the VAR innovations, assuming an inverse-Wishart prior distribution $\Sigma \sim \mathcal{IW}(\Sigma_0, \nu_\Sigma)$, has the following conditional posterior distribution (see, for example, Blake and Mumtaz 2012):

$$\Sigma \sim \mathcal{IW}(\Sigma_0 + u'u, \nu_\Sigma + T - p), \tag{A.9}$$

where $u = (u_1, \ldots, u_T)'$ are the "non-monetary policy" VAR residuals with each $u_t = H_t - \Phi_1 H_{t-1} - \ldots - \Phi_p H_{t-p} - Az_t$, and the prior scale matrix and prior degrees of freedom are set to $\Sigma_0 = \lambda_0 I_{q+1}$ (with $\lambda_0 = 3^{-1}$) and $\nu_\Sigma = q + 1$, respectively.

Appendix B. Data Description

We use seasonally adjusted quarterly data from 1999:Q1 to 2019:Q4 and deflate all nominal data using the U.S. consumer price index. To avoid double-counting in the factor estimation (principal component analysis, or PCA), we do not include some of the aggregate variables such as GDP, since all its components are already included. We also do not include U.S. aggregate variables if the same variable is included at the state level (e.g., the homeownership rate). The last column of Table B.1 indicates which variables are included in the PCA.

Transformations:
1 – no transformation
2 – first (log-)differences
3 – logarithm

Table B.1. Data and Transformations

Code	Description	Transform.	Source	PCA
U.S. Variables				
Rates and Spreads				
BaaAaa Spread	Difference between Moody's seasoned Baa corporate bond yield (DBAA) and Moody's seasoned Aaa corporate bond yield (DAAA)	1	FRED	Y
FEDFUNDS	Federal funds rate	1	FRED	
GS1	One-year Treasury rate	1	FRED	
GZ Spread	Excess bond premium	1	Gilchrist and Zakrajšek (2012)	Y
Mortgage Spread	Difference between 30-year mortgage rate and market yield on U.S. Treasury securities at 30-year constant maturity, quoted on an investment basis (DGS30)	1	FRED	Y
Prime Spread	Difference between bank prime loan rate (MPRIME) and federal funds rate	1	FRED	Y
Term Spread	Difference between GS10 and GS1	1	FRED	Y
Housing Variables				
CUSR0000SEHA	Rents: CPI for all urban consumers: Rent of primary residence in U.S. city average	2	FRED	
CSUSHPISA	S&P/Case-Shiller U.S. National Home Price Index	2	FRED	
HOUST	New privately owned housing units started	3	FRED	
PERMIT	New privately owned housing units authorized in permit-issuing places	3	FRED	
RHVRUSQ156N	Home vacancy rate	1	FRED	
RRVRUSQ156N	Rental vacancy rate	1	FRED	
RSAHORUSQ156S	Homeownership rate	1	FRED	

(*continued*)

Table B.1. (Continued)

Code	Description	Transform.	Source	PCA
Financial Market Variables				
BUSLOANS	Commercial and industrial loans, all commercial banks	2	FRED	Y
CMDEBT	Households and nonprofit organizations; Debt securities and loans; Liability, level	2	FRED	Y
DRSFRMACBS	Delinquency rate on single-family residential mortgages, booked in domestic offices, all commercial banks	1	FRED	
HHMSDODNS	Households and nonprofit organizations; One-to-four family residential mortgages; Liability, level	2	FRED	Y
M2SL	M2 money stock	2	FRED	Y
NPTLTL	Nonperforming total loans (past due 90+ days plus nonaccrual) to total loans	1	FRED	
REALLN	Real estate loans, all commercial banks	2	FRED	Y
SLOOS	Net percentage share of banks reporting tightening standards for mortgage loans (Senior Loan Officer Opinion Survey on Bank Lending)	1	Haver	
SP500	S&P 500	2	FRED	Y
TLAACBW027SBOG	Total assets, all commercial banks	2	FRED	
TOTBKCR	Bank credit, all commercial banks	2	FRED	Y
TWEXMMTH	Trade-weighted U.S. dollar index: Major currencies, goods	1	FRED	Y
USROA	Return on average assets for all U.S. banks	1	FRED	
VIX	CBOE volatility index	1	FRED	Y

(*continued*)

Table B.1. (Continued)

Code	Description	Transform.	Source	PCA
Real Variables				
CBI	Change in private inventories	1	FRED	Y
DSPI	Disposable personal income	2	FRED	
EXPGS	Exports of goods and services	2	FRED	Y
FDEFX	Federal government: National defense consumption expenditures and gross investment	2	FRED	Y
FNDEFX	Federal government: Nondefense consumption expenditures and gross investment	2	FRED	Y
GDPC1	Real gross domestic product	2	FRED	
IMPGS	Imports of goods and services	2	FRED	Y
INDPRO	Industrial production: Total index	2	FRED	Y
PCE	Personal consumption expenditures	2	FRED	
PCEDG	Personal consumption expenditures: Durable goods	2	FRED	Y
PCENDG	Personal consumption expenditures: Nondurable goods	2	FRED	Y
PCES	Personal consumption expenditures: Services	2	FRED	Y
PINCOME	Personal income	2	FRED	
PNFI	Private nonresidential fixed investment	2	FRED	Y
PRFI	Private residential fixed investment	2	FRED	Y
SLCE	State and local consumption expenditures and gross investment	2	FRED	
UNRATE	Unemployment rate	1	FRED	

(*continued*)

Table B.1. (Continued)

Code	Description	Transform.	Source	PCA
Other Variables				
CPI	Consumer price index for all urban consumers: All items in U.S. city average (CPIAUCSL)	2	FRED	Y
SENTIMENT	University of Michigan: Consumer sentiment	2	FRED	Y
State-Level Variables				
Housing Variables				
HOMEOWN_i	Homeownership rate	1	Haver	Y
HOMEVAC_i	Home vacancy rate	1	Haver	Y
HPI_i	All-transactions house price index (ALSTHPI)	2	FRED	Y
HPIINC_i	House price-to-income ratio calculated by dividing HPI_i by INC_i	2	Own calculations	
HPIRENT_i	House price-to-rent ratio calculated by dividing HPI_i by RENT_i	2	Own calculations	
HSTARTS_i	New privately owned housing units started	3	Haver	Y
PERMITS_i	New private housing units authorized by building permit (ALBPPRIVSA)	3	FRED	Y
RENT_i	State-level aggregation of MSA-level real rent index (interpolated with Denton 1971 method using rent of primary residence from U.S. CPI: CUSR0000SEHA, adj. for overall CPI)	2	Howard and Liebersohn (2021)	Y
RENTVAC_i	Rental vacancy rate	1	Haver	Y

(*continued*)

Table B.1. (Continued)

Code	Description	Transform.	Source	PCA
	Financial Variables			
BA_i	Total assets for commercial banks (ALTAST)	2	FRED	Y
$FORECL_i$	All foreclosures started (in %)	1	Haver	Y
LTV_i	Loan-to-value ratio (in %)	1	Haver	
MDR_i	All mortgages past due (in %)	1	Haver	Y
$MORTDEBT_i$	State-level mortgage debt per capita (interpolated with Denton 1971 method using U.S. data)	2	Haver	Y
$NBBANK_i$	Nonbusiness bankruptcy filings	2	Haver	Y
NPL_i	Nonperforming loans (past due 90+ days plus nonaccrual) to total loans for banks: (ALNPTL)	1	FRED	Y
ROA_i	Return on average assets for banks (ALROA)	1	FRED	Y
	Real Variables			
$GOVEXP_i$	Total governmental state expenditure taken from the Annual Survey of State Government Finances (interpolated with Denton 1971 method using U.S. government total expenditures: W068RCQ027SBEA)	2	U.S. Census Bureau	Y
$GOVREV_i$	State tax collections: Total taxes (QTAXTOTALQTAX-CAT3ALNO)	2	FRED	Y
GDP_i	Real GDP. Starting 2005:Q1 ALRQGSP for Alabama. Before 2005:Q1 interpolated with Denton (1971) method using U.S. real GDP (GDPC1)	2	FRED	Y
INC_i	Personal income (ALOTOT)	2	FRED	Y
NFC_i	All employees: construction (ALCONS)	2	FRED	Y
NFP_i	All employees: Total nonfarm (ALNA)	2	FRED	Y
$STATEDEFL_i$	State-level GDP deflator (before 2005:Q1 calculated based on interpolated nominal and real GDP)	2	FRED	Y
$STATEINFL_i$	State-level inflation	1	Hazell et al. (2022)	
$STATEPCE_i$	State-level personal consumption expenditure: ALPCE (interpolated with Denton 1971 method using U.S. data)	2	FRED	Y
UEB_i	State-level unemployment benefits (ALOBEN)	2	FRED	Y
UR_i	State-level unemployment rate (ALUR)	1	FRED	Y

(*continued*)

Table B.1. (Continued)

Code	Description	Transform.	Source	PCA
State-Level Variables for Cross-Sectional Regression				
Debt Gap	Calculated by applying the Hamilton (2018) filter to the state-level mortgage debt-to-income series (forecast horizon $h = 20$), max. value over 1999–2019	1	Own calculations	
HPI Growth	Cumulative growth of the real house price index over 1999–2019	1	Own calculations	
HW (Avg.)	Average housing wealth over 1999–2019. HW = (Homeownership rate × Housing units) × HPI × Median house price in 2000	1	Own calculations	
HW (Std.)	Standard deviation of housing wealth over 1999–2019	1	Own calculations	
LRI	Land-use restriction index (in 2014)	1	Herkenhoff, Ohanian, and Prescott (2018)	
Manufacturing	Share of manufacturing in state-level GDP (average over 1999–2019)	1	Own calculations, U.S. Bureau of Economic Analysis	
RTW	Dummy variable for states with right-to-work legislation	1	National Right to Work Legal Defense Foundation	
Sand State	Dummy variable for Arizona, California, Florida, and Nevada	1	Own calculations	
Small Firms	Share of employees in firms with less than 250 employees divided by total number of employees in that state (average over 1999–2019)	1	Own calculations, U.S. Bureau of Labor Statistics	

Table B.2. Descriptive Statistics of State-Level Variables

	Mean	**Median**	**Std.**	**5th Pctl.**	**25th Pctl.**	**75th Pctl.**	**95th Pctl.**
Housing Variables							
HOMEOWN	68.7	69.5	5.3	57.6	65.9	72.4	75.9
HOMEVAC	1.92	1.84	0.76	0.83	1.39	2.35	3.26
HPI	0.32	0.41	1.62	–2.55	–0.31	1.15	2.48
HPIINC	0.03	0.02	1.88	–3.06	–0.89	0.96	3.06
HPIRENT	0.16	0.13	1.98	–3.04	–0.77	1.13	3.16
HSTARTS	8.11	8.34	1.17	6.12	7.30	8.95	10.06
PERMITS	8.14	8.33	1.16	6.15	7.32	8.96	10.07
RENTS	0.14	0.23	1.32	–1.91	–0.52	0.88	1.92
RENTVAC	8.80	8.73	3.16	4.20	6.35	10.95	14.38
Financial Variables							
BA	0.37	0.75	14.53	–5.97	–0.69	2.17	6.70
FORECL	0.52	0.46	0.35	0.17	0.29	0.65	1.15
LTV	77.8	78.0	3.6	71.7	75.4	80.4	83.1
MDR	5.39	4.98	2.19	2.55	3.74	6.60	9.38
MORTDEBT	0.52	0.33	1.91	–1.97	–0.69	1.50	3.91
NBBANK	–0.76	0.34	22.44	–9.87	–3.15	4.65	16.22
NPL	1.50	1.00	1.27	0.41	0.74	1.73	4.32
ROA	1.12	1.11	0.77	0.11	0.89	1.34	1.97
Real Variables							
GOVEXP	0.58	0.44	1.82	–2.06	–0.45	1.50	3.65
GOVREV	0.55	0.59	9.18	–10.37	–2.30	3.46	11.32
GDP	0.47	0.50	1.15	–1.41	–0.06	1.06	2.06
INC	0.51	0.51	1.21	–1.43	–0.04	1.12	2.30
NFC	0.17	0.39	2.15	–3.67	–0.77	1.42	2.99
NFP	0.19	0.25	0.56	–0.79	–0.01	0.51	0.92
STATEDEFL	0.52	0.53	0.76	–0.11	0.32	0.72	1.31
STATEINFL	2.19	2.27	1.46	–0.32	1.32	3.15	4.44
STATEPCE	0.49	0.56	0.84	–1.12	–0.03	1.09	1.69
UEB	–0.35	–1.90	13.04	–16.31	–6.55	3.56	26.31
UR	5.44	5.12	2.00	2.93	4.00	6.50	9.50

Note: The table shows the sample mean, median, standard deviation, and the 5th, 25th, 75th, and 95th percentiles of the state-level variables (across states and over time). The variables are transformed as described in Table B.1.

Table B.3. Values of Selected State Characteristics (sample averages)

State	LRI	Debt Gap	HW (Avg.)	HW (Std.)	Sand State	RTW	Manufacturing	Small Firms	HPI Growth
AL	–1.6	13.1	34,575.3	2,680.8	0	1	16.9	77.2	3.0
AK	—	9.7	46,293.9	3,970.5	0	0	2.9	77.2	10.7
AZ	–0.9	32.7	48,327.7	11,721.2	1	1	10.0	66.1	17.7
AR	–2.6	7.7	23,412.1	1,671.7	0	1	16.8	73.6	3.6
CA	–0.3	21.6	95,388.2	23,708.3	1	0	12.1	75.3	26.8
CO	–0.7	25.3	83,949.5	10,840.5	0	0	7.5	78.8	22.1
CT	–0.3	12.4	88,095.2	13,926.8	0	0	13.5	75.1	3.5
DE	–0.7	17.3	82,772.9	12.971.6	0	0	7.7	69.5	9.5
FL	–1.0	20.6	53,897.7	13,862.7	1	1	5.4	74.2	21.4
GA	–1.4	14.8	43,434.8	6,194.0	0	1	11.7	73.5	6.7
HI	—	16.6	123,974.9	27,701.1	0	0	2.0	75.9	26.7
ID	–1.3	19.5	41,584.8	6,466.8	0	1	12.5	80.9	18.7
IL	–1.6	15.3	56,062.8	7,630.4	0	0	13.4	68.3	0.4
IN	–2.6	12.3	35,715.6	2,911.5	0	1	28.1	70.6	1.0
IA	–3.7	7.1	30,652.7	1,624.2	0	1	19.4	75.0	4.7
KS	–2.8	9.5	27,845.3	2,285.8	0	1	15.7	74.7	6.1
KY	–2.5	8.9	34,795.7	2,447.1	0	1	18.9	74.6	4.9
LA	–1.6	6.3	27,668.1	3,156.1	0	1	19.9	79.0	9.1
ME	–1.1	7.2	77,794.9	9,091.6	0	0	10.7	80.1	15.8
MD	–0.4	12.0	81,152.2	15,671.4	0	0	6.1	77.6	14.5
MA	–0.2	11.4	146,481.5	20,720.6	0	0	11.2	71.8	18.3
MI	–2.4	18.5	53,730.8	8,098.9	0	0	19.9	68.3	–0.9
MN	–1.4	18.5	61,391.1	8,284.7	0	0	14.4	70.7	12.3
MS	–2.3	7.2	23,941.7	1,641.5	0	1	16.0	74.9	1.6
MO	–2.1	11.5	36,887.9	3,089.4	0	0	13.4	73.6	5.9

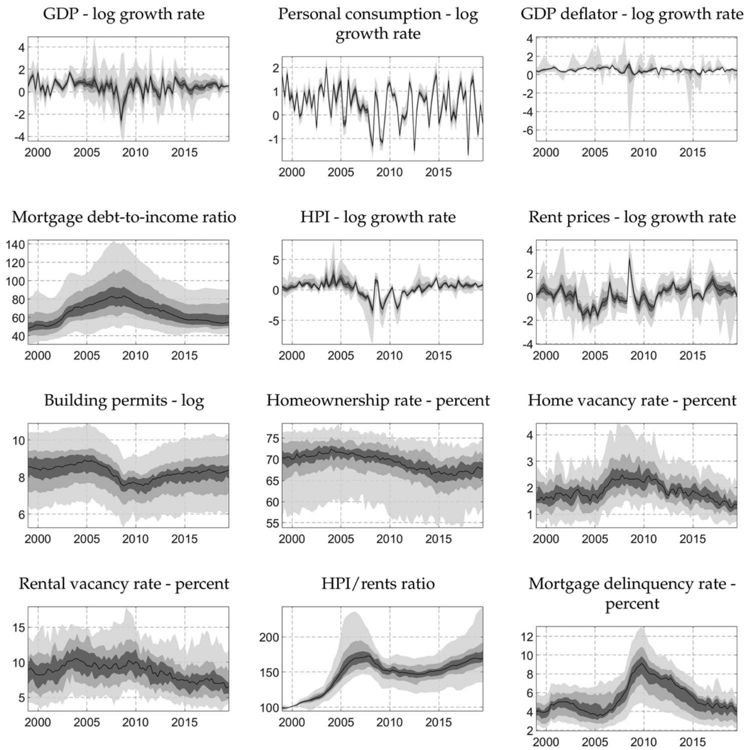
(*continued*)

Table B.3. (Continued)

State	LRI	Debt Gap	HW (Avg.)	HW (Std.)	Sand State	RTW	Manufacturing	Small Firms	HPI Growth
MT	–1.0	10.1	45,454.9	5,232.7	0	0	6.3	90.7	19.2
NE	–3.9	7.9	32,839.0	1,876.8	0	1	11.7	73.7	6.7
NV	–1.4	35.0	46,727.7	14,477.1	1	1	4.2	65.9	14.6
NH	–0.4	11.3	82,126.1	12,054.2	0	0	12.0	79.6	15.9
NJ	–0.3	10.8	98,786.8	17,296.3	0	0	10.2	73.7	13.2
NM	–1.0	17.1	39,574.8	4,350.5	0	0	7.0	79.7	5.1
NY	–0.9	9.3	84,779.7	12,255.1	0	0	5.8	68.8	17.5
NC	–1.2	14.8	47,495.6	3,983.4	0	1	20.7	75.4	6.7
ND	–3.6	5.8	28,846.2	3,621.0	0	1	7.7	82.3	19.1
OH	–2.4	13.1	38,901.0	4,479.3	0	0	18.3	73.1	–1.9
OK	–3.0	9.0	19,922.3	981.3	0	1	10.8	77.6	7.7
OR	–0.7	19.1	75,455.6	11,661.2	0	0	16.1	80.4	20.1
PA	–1.1	7.3	51,352.5	4,847.8	0	0	13.8	73.0	10.6
RI	–0.5	14.5	78,369.0	15,649.9	0	0	9.5	78.4	17.2
SC	–1.2	16.0	44,551.8	3,875.8	0	1	17.3	74.9	8.4
SD	–3.4	9.2	33,969.7	3,052.4	0	1	9.9	80.8	13.4
TN	–1.4	12.5	37,205.9	3,138.8	0	1	16.5	69.3	9.9
TX	–2.6	10.7	21,499.6	2,044.7	0	1	13.9	72.8	17.9
UT	–0.9	26.1	57,734.2	7,684.4	0	1	12.1	76.0	15.0
VT	–1.1	13.1	76,772.0	10,910.2	0	0	11.6	80.3	14.2
VA	–0.7	9.9	67,313.7	9,866.5	0	1	9.8	75.6	16.1
WA	–0.6	33.4	90,072.7	15,094.9	0	0	13.2	76.0	22.9
WV	–2.8	4.4	24,635.9	1,759.7	0	1	10.9	79.9	1.8
WI	–1.8	14.7	50,970.8	4,821.8	0	1	20.2	72.6	5.5
WY	–1.3	13.1	34,747.0	4,277.5	0	1	5.8	89.5	17.6

Note: Debt gap is the maximum value over the sample period, while HPI growth is the cumulative real growth rate over the sample period. Values in blue (red) indicate states belonging to the top (bottom) decile of the respective characteristic.

Figure B.1. Dispersion of Variables across U.S. States



Note: Distribution of selected variables across U.S. states. The black line is the median realization, and the gray areas include 30 percent (35–65 percentile), 60 percent (20–80 percentile), and 90 percent (5–95 percentile) of the realizations, going from dark to lighter gray.

Appendix C. Additional Tables and Figures

Table C.1. Explanatory Power of Factors for Variables

	Series	R^2
All Factors	New Housing Units Started: U.S.	0.9809
	Nonperforming Loan Share: Michigan	0.9784
	Nonperforming Loan Share: U.S.	0.9783
	New Permits: U.S.	0.9777
	Nonperforming Loan Share: Tennessee	0.9769
Factor 1	Nonperforming Loan Share: Minnesota	0.9440
	Nonperforming Loan Share: Florida	0.9365
	Mortgage Delinquency Ratio: California	0.9365
	Nonperforming Loan Share: Georgia	0.9345
	Nonperforming Loan Share: Illinois	0.9320
Factor 2	Homeownership Rate: Nevada	0.7793
	Homeownership Rate: U.S.	0.7401
	Homeownership Rate: California	0.6758
	Homeownership Rate: Colorado	0.6482
	Homeownership Rate: Georgia	0.6473
Factor 3	Rents: Washington	0.6137
	Rents: North Carolina	0.5180
	Rents: Oregon	0.5116
	Rents: Utah	0.4834
	Rents: Georgia	0.4742
Factor 4	Consumer Price Index: U.S.	0.5531
	Personal Expenditures: Ohio	0.5459
	Personal Expenditures: Louisiana	0.5268
	Personal Expenditures: Michigan	0.5254
	Personal Expenditures: Kentucky	0.5236
Factor 5	Nonbusiness Bankruptcies: Pennsylvania	0.6268
	Nonbusiness Bankruptcies: Texas	0.6253
	Nonbusiness Bankruptcies: Oklahoma	0.6114
	Nonbusiness Bankruptcies: Kansas	0.6034
	Nonbusiness Bankruptcies: Ohio	0.6021
One-Year Rate	Federal Funds Rate: U.S.	0.9728
	Return on Bank Assets: Wyoming	0.7094
	Mortgage Spread: U.S.	0.6819
	Unemployment Rate: Connecticut	0.6051
	Unemployment Rate: New Mexico	0.6049

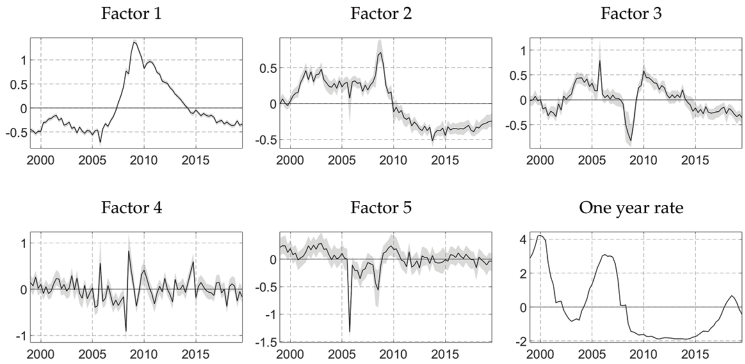
Note: List of series that are best explained by the extracted factors, according to the R-squared of a linear regression of the (transformed) series on the respective factor.

Table C.2. Pairwise Correlations with State-Level Responses after Three Years

	GDP	PCE	HPI	Rents	Permits	HOR	HPI/Rents	MDR	Mortg. Debt
LRI	–0.12	–0.43***	–0.64***	–0.17	–0.33**	–0.01	–0.61***	0.60***	–0.35**
	(0.43)	(0.00)	(0.00)	(0.27)	(0.02)	(0.95)	(0.00)	(0.00)	(0.01)
Debt Gap	–0.45***	–0.55***	–0.53***	0.08	–0.50***	–0.43***	–0.62***	0.46***	–0.44***
	(0.00)	(0.00)	(0.00)	(0.61)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
HW (Avg.)	0.15	–0.14	–0.54***	–0.08	–0.19	0.14	–0.50***	0.53***	–0.51***
	(0.30)	(0.35)	(0.00)	(0.61)	(0.18)	(0.34)	(0.00)	(0.00)	(0.00)
HW (Std.)	–0.12	–0.34**	–0.78***	–0.21	–0.32**	–0.06	–0.73***	0.66***	–0.68***
	(0.40)	(0.01)	(0.00)	(0.16)	(0.02)	(0.69)	(0.00)	(0.00)	(0.00)
Sand State	–0.55***	–0.56***	–0.66***	–0.27*	–0.53***	–0.42***	–0.60***	0.51***	–0.59***
	(0.00)	(0.00)	(0.00)	(0.07)	(0.00)	(0.00)	(000)	(0.00)	(0.00)
RTW	–0.32**	–0.15	0.32**	0.01	0.28*	–0.14	0.33**	–0.27*	0.28*
	(0.02)	(0.29)	(0.02)	(0.94)	(0.05)	(0.34)	(0.03)	(0.05)	(0.05)
Manufacturing	–0.04	0.31**	0.55***	0.20	0.05	0.01	0.48***	–0.19	0.45***
	(0.79)	(0.03)	(0.00)	(0.18)	(0.75)	(0.93)	(0.00)	(0.18)	(0.00)
Small Firms	0.09	0.06	0.16	0.15	0.49***	0.36***	0.11	–0.41***	0.26*
	(0.51)	(0.68)	(0.26)	(0.33)	(0.00)	(0.01)	(0.45)	(0.00)	(0.07)
HPI Growth	–0.02	–0.27*	–0.53***	–0.01	0.07	0.08	–0.53***	0.20	–0.45***
	(0.91)	(0.05)	(0.00)	(0.96)	(0.61)	(0.60)	(0.00)	(0.17)	(0.00)

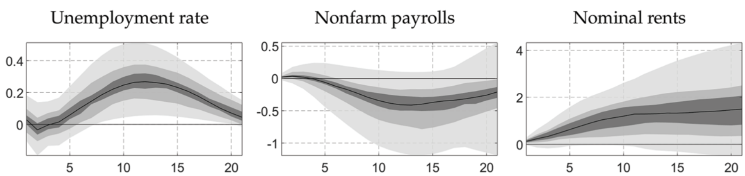
Note: GDP = real GDP. PCE = real personal consumption expenditure. HPI = real house price index. HOR = homeownership rate. MDR = mortgage delinquency rate. LRI = land-use restriction index of Herkenhoff, Ohanian, and Prescott (2018) for the year 2014. Debt gap = max. value of Hamilton-filtered mortgage debt-to-income ratio over 1999–2019. HW (Avg.) = average housing wealth over 1999–2019. HW (Std.) = standard deviation of housing wealth over 1999–2019. Sand state = dummy variable for Arizona, California, Florida, and Nevada. RTW = dummy variable for right-to-work states. Manufacturing = share of manufacturing in state-level GDP (average over 1999–2019). Small firms = share of small firms in total employment (average over 1999–2019). HPI growth = growth rate of house prices over 1999–2019. Standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Figure C.1. Principal Components and One-Year U.S. Treasury Rate



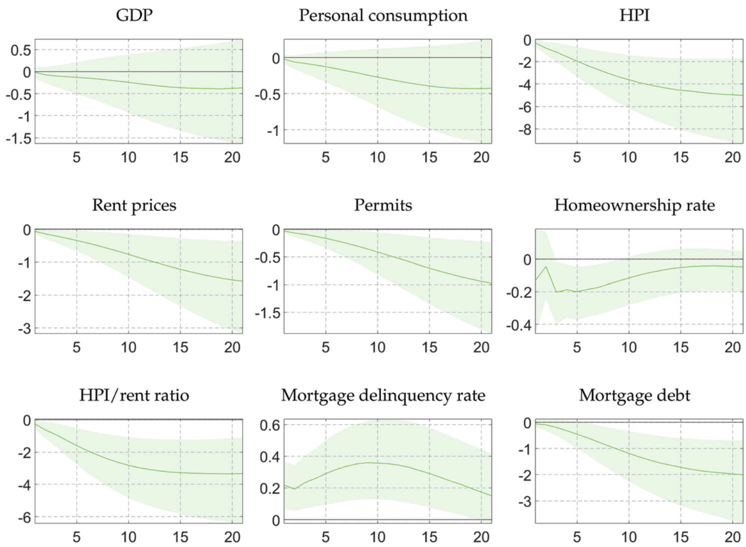
Note: Five unobserved factors (principal components) obtained from the normalized data as described in Table B.1 as well as the single observed factor (one-year Treasury rate). The gray shaded areas are the bootstrapped confidence bands (90 percent) around the principal components based on Gonçalves and Perron (2020).

Figure C.2. Dispersion of Additional State-Level Impulse Response Functions



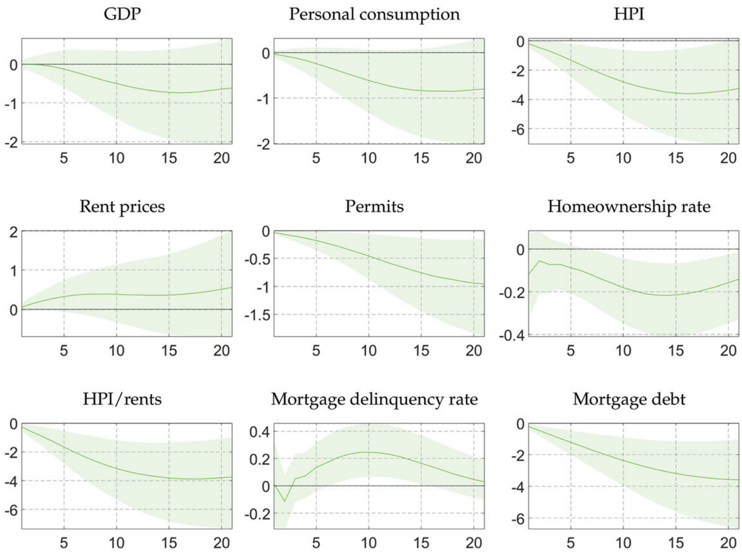
Note: See Figure 3.

Figure C.3. Differences in IRFs across Herkenhoff, Ohanian, and Prescott (2018) LRI (decile averages)



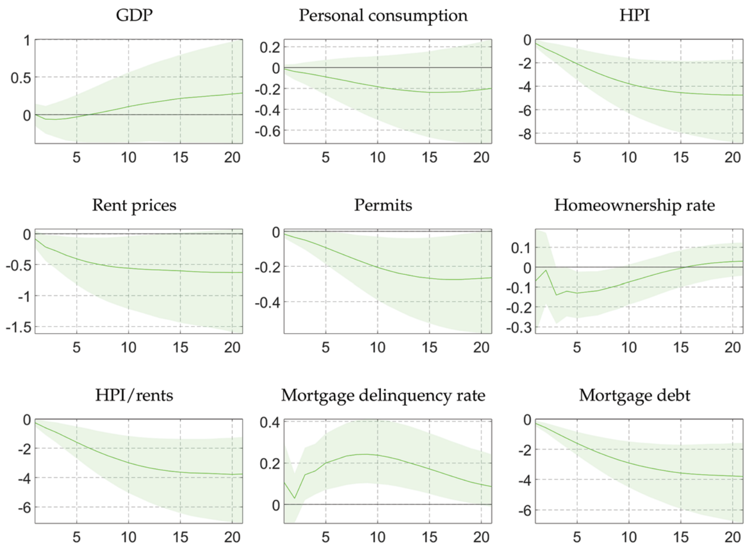
Note: Posterior distribution of the differences between the average (cumulative) IRFs across U.S. states that belong to the top and bottom decile of the respective state characteristic. The shaded area reflects the 68 percent HDI.

Figure C.4. Differences in IRFs across the Debt Gap Distribution (decile averages)



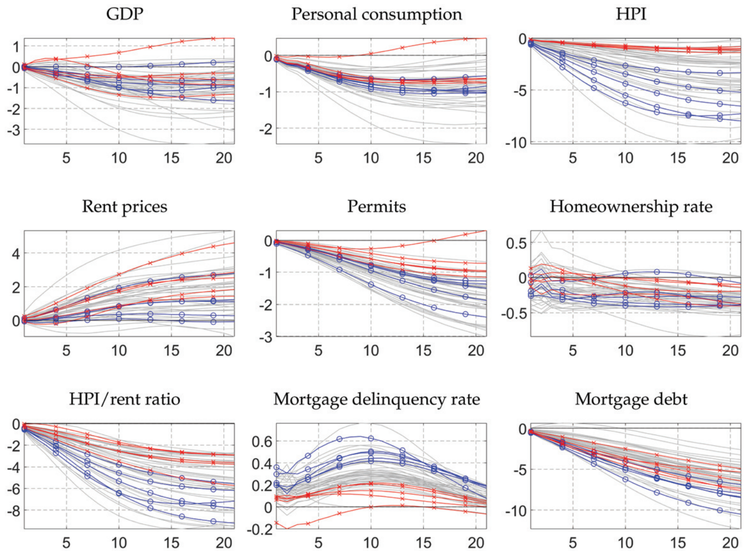
Note: See Figure C.3.

Figure C.5. Differences in IRFs across Housing Wealth Volatility (decile averages)



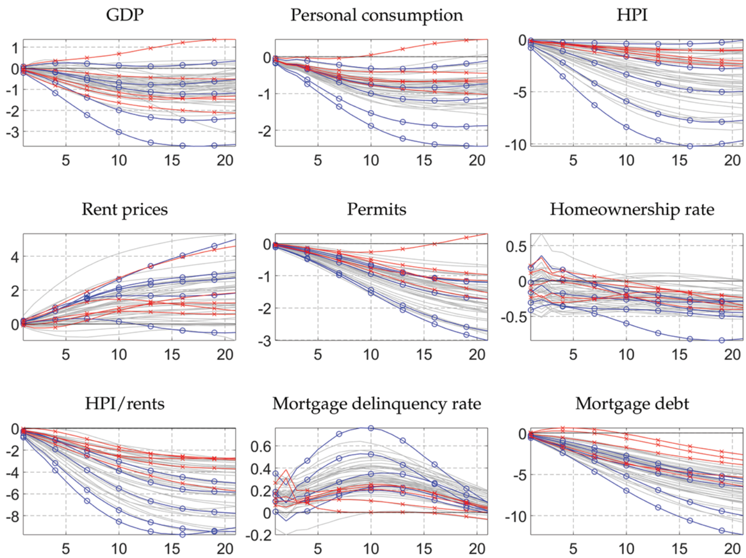
Note: See Figure C.3.

Figure C.6. Impulse Responses across Herkenhoff, Ohanian, and Prescott (2018) LRI



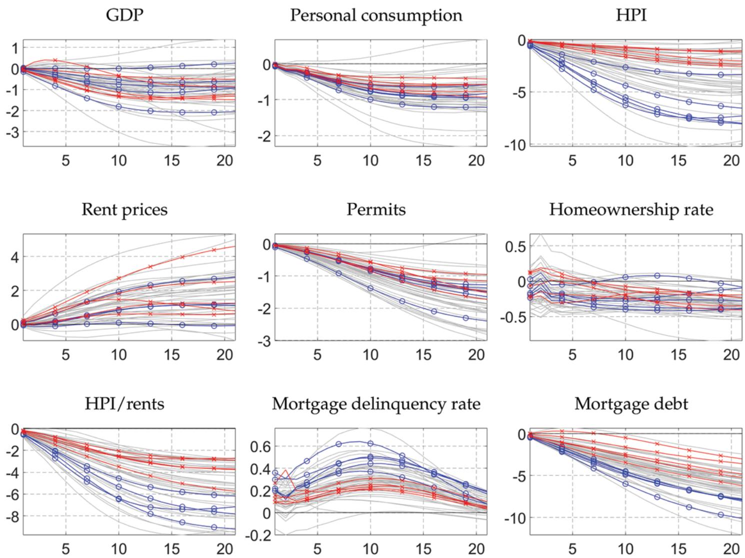
Note: Median (cumulative) IRFs across U.S. states after a monetary policy tightening that increases the one-year Treasury rate by 25 bps. The blue (red) lines with circles (crosses) show the responses of the states belonging to the top (bottom) decile of the respective state characteristic.

Figure C.7. Impulse Responses across the Debt Gap Distribution



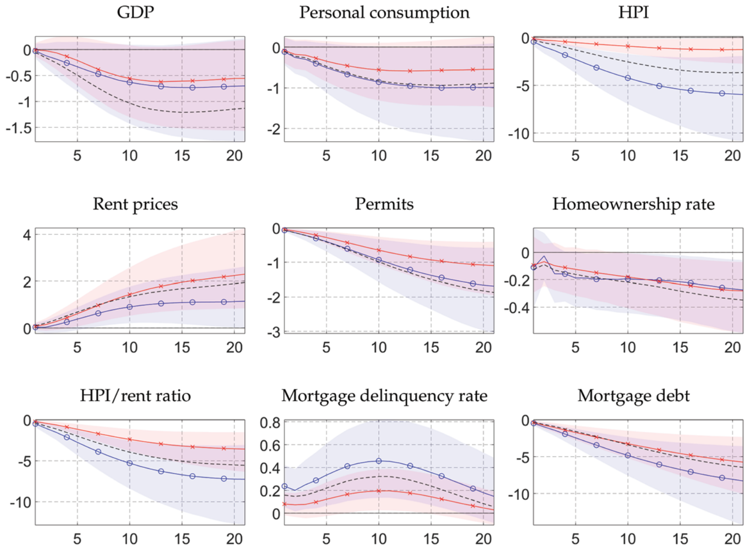
Note: See Figure C.6.

Figure C.8. Impulse Responses across Housing Wealth Volatility



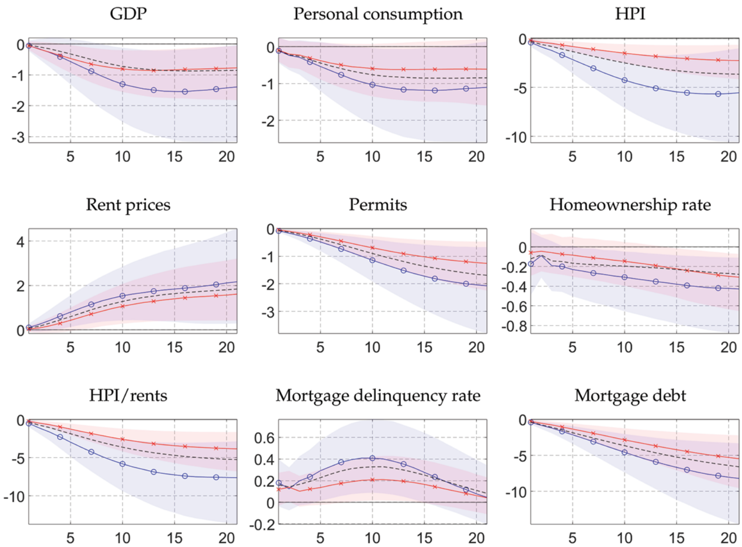
Note: See Figure C.6.

Figure C.9. Impulse Responses across Herkenhoff, Ohanian, and Prescott (2018) LRI (quintile averages)



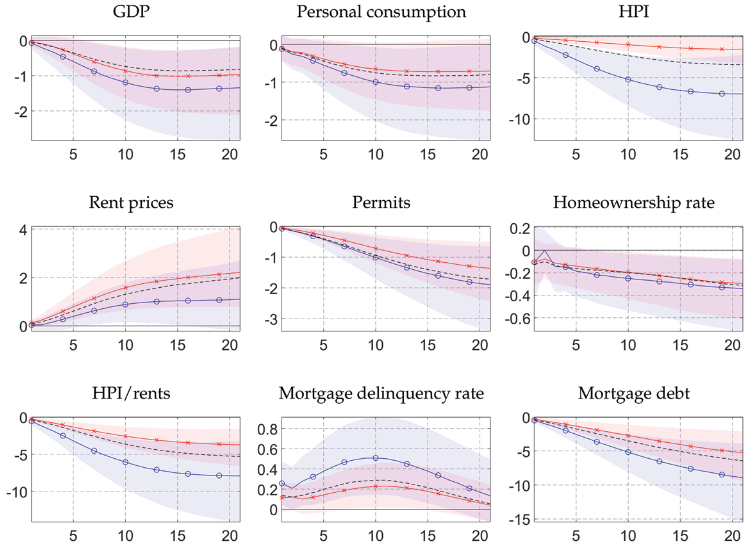
Note: Posterior distributions of the average (cumulative) IRFs across U.S. states after a monetary policy tightening that increases the one-year Treasury rate by 25 bps. The blue (red) line with circles (crosses) indicates the median (over all MCMC draws) of the average responses of the states belonging to the top (bottom) quintile of the respective state characteristic. Shaded areas reflect the 68 percent HDI. The dashed black line is the median of the average IRFs across all the other states.

Figure C.10. Impulse Responses across the Debt Gap Distribution (quintile averages)



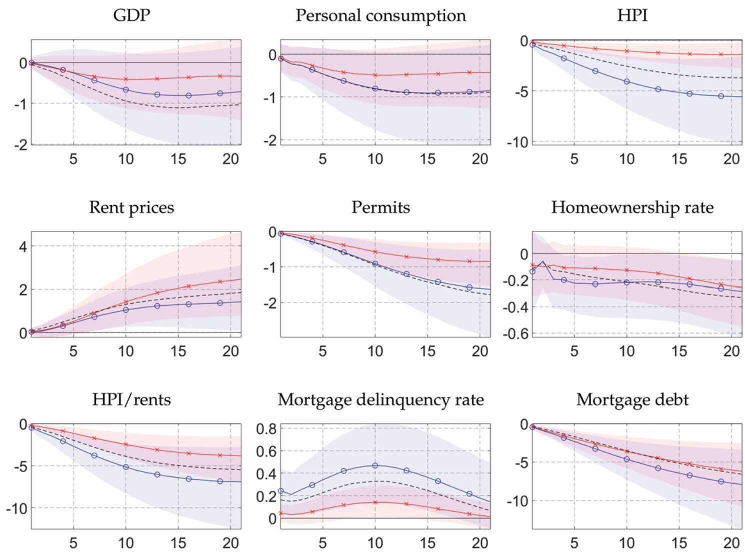
Note: See Figure C.9.

Figure C.11. Impulse Responses across Housing Wealth Volatility (quintile averages)



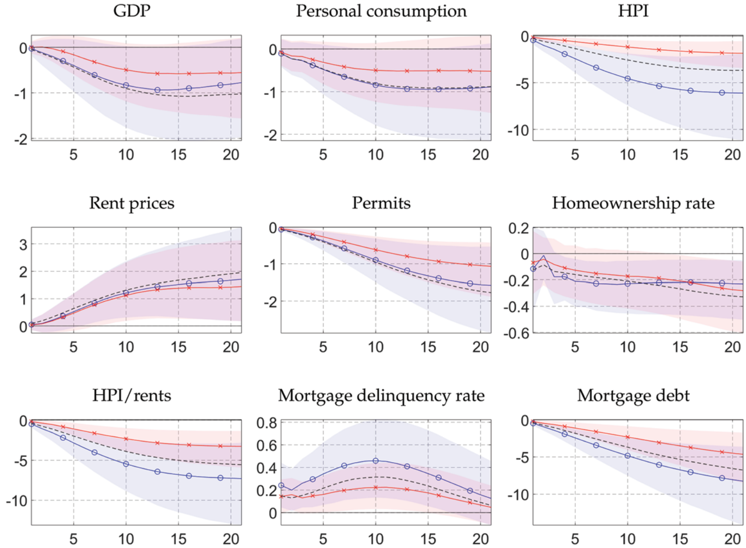
Note: See Figure C.9.

Figure C.12. Impulse Responses across Herkenhoff, Ohanian, and Prescott (2018) LRI in 2000 (decile averages)



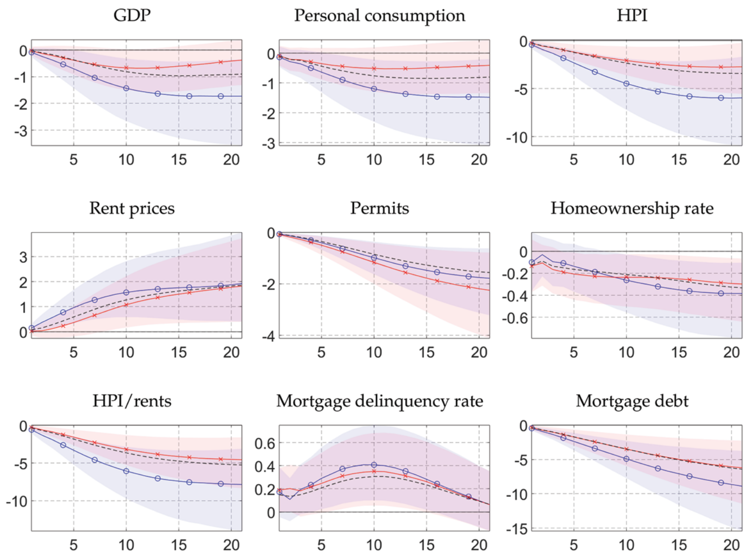
Note: See Figure 5.

Figure C.13. Impulse Responses across Home Values in 2000 (decile averages)



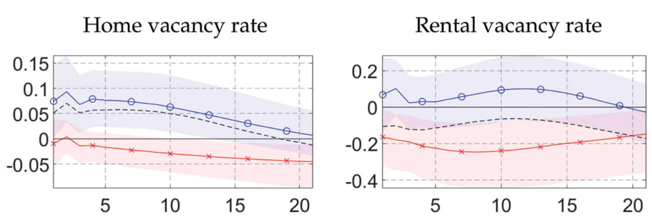
Note: See Figure 5.

Figure C.14. Impulse Responses across the House Price-to-Rent Ratio (decile averages)



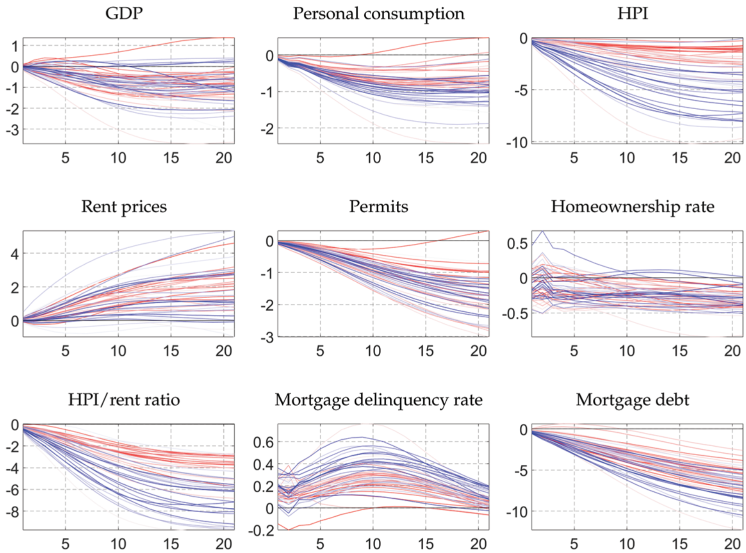
Note: See Figure 5.

Figure C.15. Impulse Responses of House Vacancy Rates across Herkenhoff, Ohanian, and Prescott (2018) LRI (decile averages)



Note: See Figure 5.

Figure C.16. IRFs across Housing Supply Elasticities from Blue (inelastic) to Red (elastic)



Note: Posterior median (cumulative) IRFs across U.S. states after a monetary policy tightening that increases the one-year Treasury rate by 25 bps. The coloring indicates the value of the respective state characteristic, ranging from blue (high) to red (low) values.

Figure C.17. Correlation between Land-Use Restrictions in 2014 (Herkenhoff, Ohanian, and Prescott 2018) and Housing Wealth per capita (avg. 1999–2019)

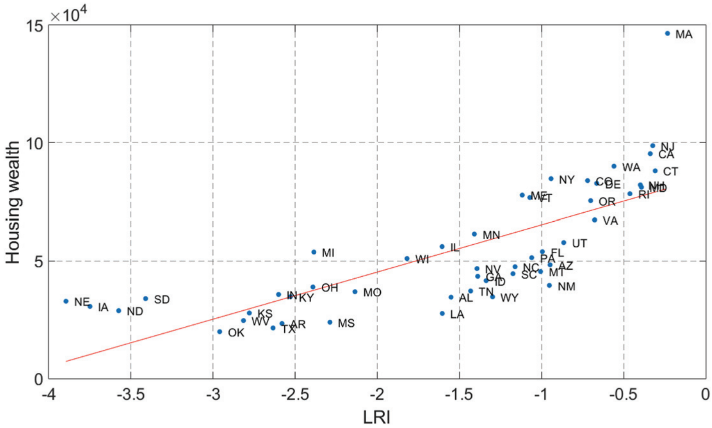


Figure C.18. Correlation between Land-Use Restrictions in 2014 (Herkenhoff, Ohanian, and Prescott 2018) and Consumption per capita (avg. 1999–2019)

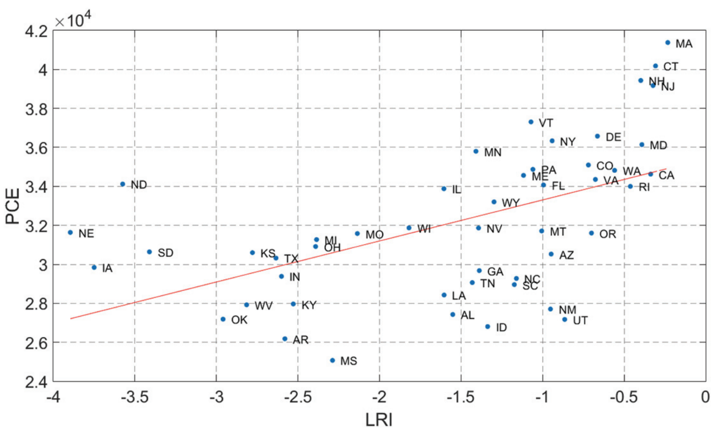


Figure C.19. Correlation between Land-Use Restrictions in 2014 (Herkenhoff, Ohanian, and Prescott 2018) and Personal Disposable Income per capita (avg. 1999–2019)

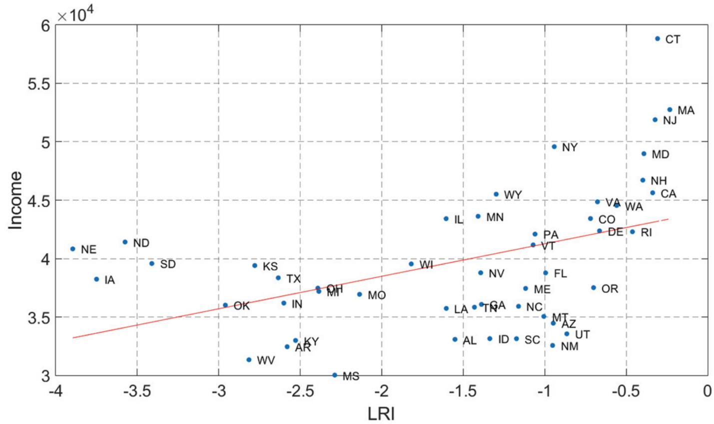


Figure C.20. Correlation between Land-Use Restrictions in 2014 (Herkenhoff, Ohanian, and Prescott 2018) and the Debt Gap (max. value over 1999–2019)

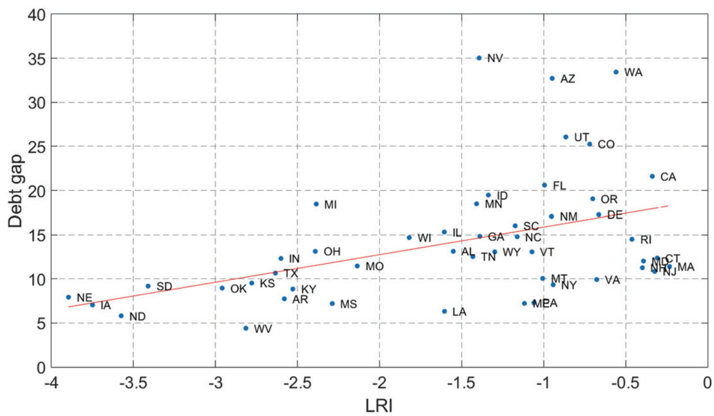
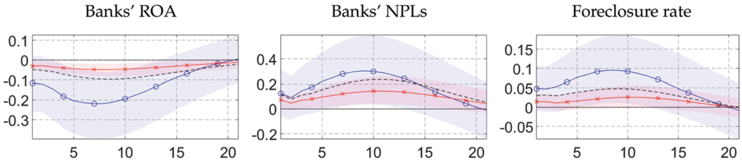
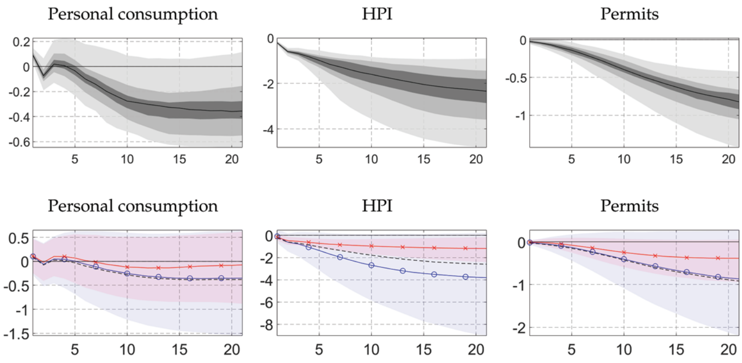


Figure C.21. Impulse Responses of Selected Banks' Indicators across the Debt Gap Distribution (decile averages)



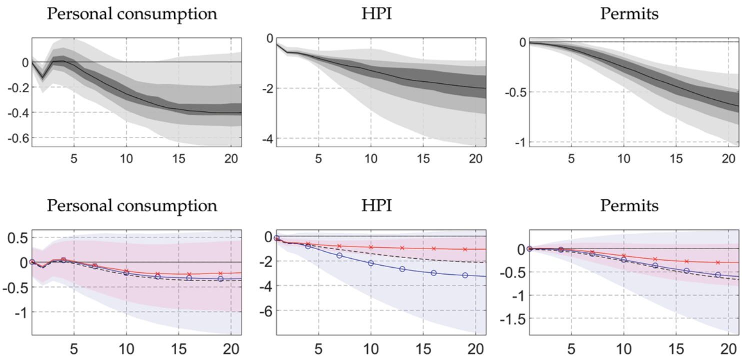
Note: See Figure 5.

Figure C.22. Alternative Monetary Policy Surprises (Swanson 2021 Forward Guidance)



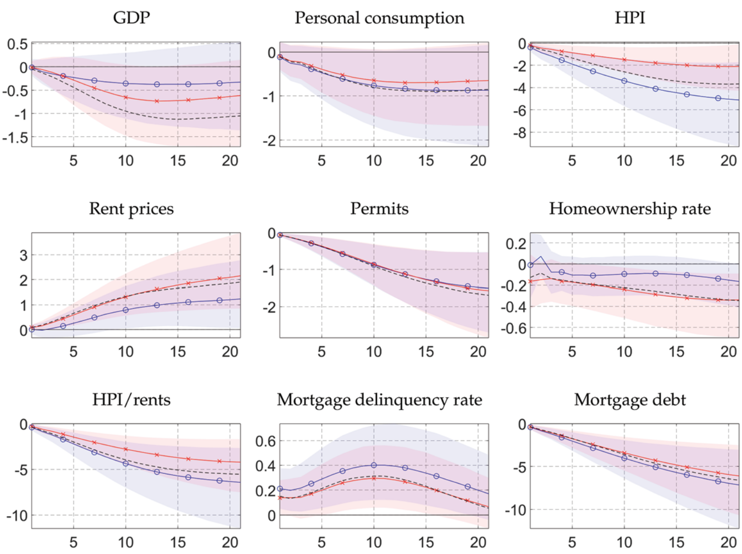
Note: The first row of this figure shows the distribution of the median (cumulative) IRFs across U.S. states after a monetary policy tightening that increases the one-year Treasury rate by 25 bps. The black line is the median response of all state-level (median) responses. The gray areas include 30 percent (35–65 percentile), 60 percent (20–80 percentile), and 90 percent (5–95 percentile) of the median responses, respectively, going from dark to lighter gray. The second row shows the posterior distributions of the average (cumulative) IRFs across U.S. states. The blue (red) line with circles (crosses) indicates the median (over all MCMC draws) of the average responses of the states belonging to the top (bottom) decile of the land-use restriction index in 2014 (Herkenhoff, Ohanian, and Prescott 2018). Shaded areas reflect the 68 percent HDI. The dashed black line is the median of the average IRFs across all the other states.

Figure C.23. Alternative Monetary Policy Surprises (Jarociński and Karadi 2020)



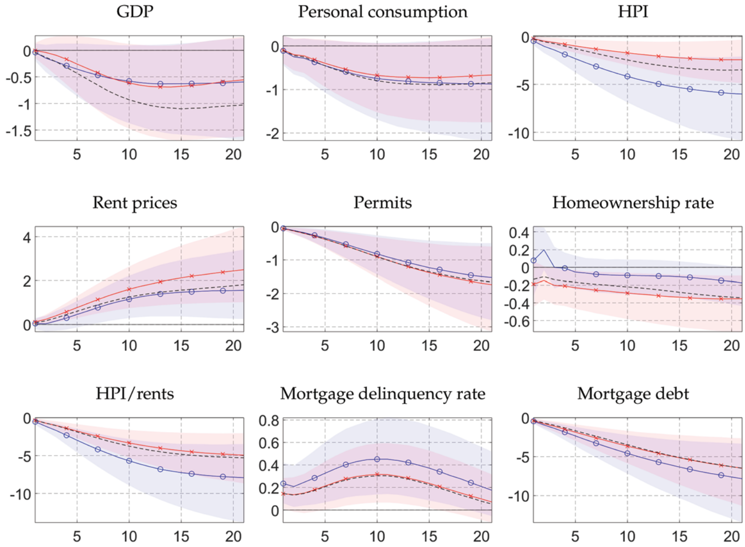
Note: See Figure C.22.

Figure C.24. Impulse Responses across Aastveit, Albuquerque, and Anundsen (2023) Supply Elasticities over 1996–2006 (decile averages)



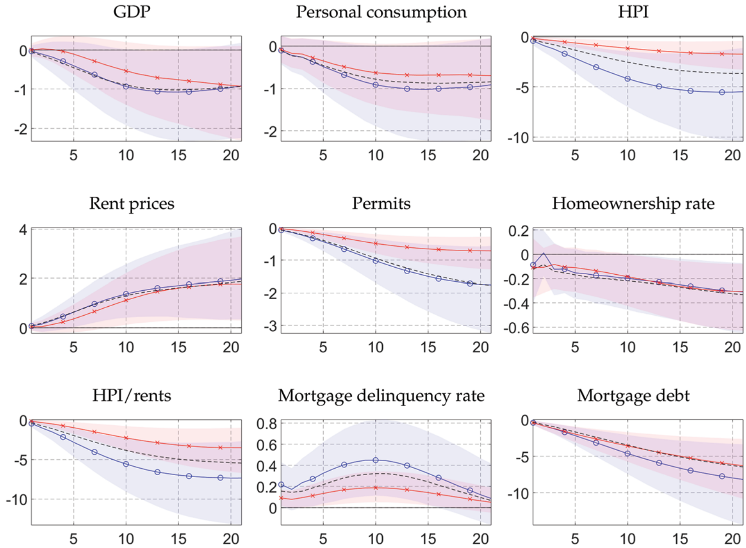
Note: See Figure 5.

Figure C.25. Impulse Responses across Aastveit, Albuquerque, and Anundsen (2023) Supply Elasticities over 2012–19 (decile averages)



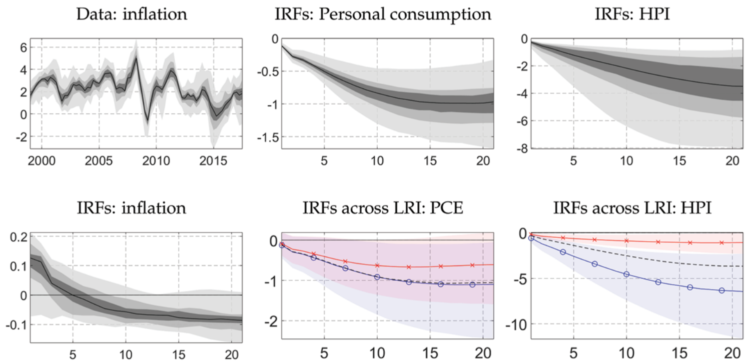
Note: See Figure 5.

Figure C.26. Impulse Responses across Saiz (2010) Supply Elasticities (decile averages)



Note: See Figure 5.

Figure C.27. Alternative State-Level Inflation Series (Hazell et al. 2022)



Note: See Figure B.1 (first chart), Figure 3 (second, third, and fourth chart), and Figure 5 (fifth and sixth chart).

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