FACULTEIT ECONOMIE
EN BEDRIJFSKUNDE

TWEEKERKENSTRAAT 2
B-9000 GENT
Tel. : 32 - (0)9 – 264.34.61
Fax. : 32 - (0)9 – 264.35.92

WORKING PAPER

One Size Fits All? Monetary Policy and Asymmetric Household Debt Cycles in US States

Bruno Albuquerque

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One Size Fits All? Monetary Policy and Asymmetric Household Debt Cycles in US States

Bruno Albuquerque*
Ghent University

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Abstract

I investigate the extent to which a common US monetary policy affects regional asymmetries through different household debt levels across states. After constructing a novel indicator of consumer prices at the state level, I compute a state-specific monetary policy stance measure as deviations from an aggregate Taylor rule for a panel of 30 states. Using local projection methods over 1999-2015, I find that a common monetary policy contributes to amplifying regional asymmetries. While a looser monetary policy stance stimulates borrowing and growth in states with low household debt, it is only the case in the short term for high debt states: household debt and real GDP decline over the medium to longer run in high debt states.

Keywords: Monetary policy, Household debt, Regional asymmetries, Local Projections, Taylor rule

JEL Classification: C33, E32, E52, G21

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1 Introduction

According to the theory of optimum currency areas by Mundell (1961) and McKinnon (1963), the costs from losing monetary policy autonomy can be particularly large when countries within a monetary union find themselves in a different phase of the business cycle. While the euro area often comes to mind when thinking about the adequacy of a single interest rate for its members, the United States is also an interesting case to analyse as economic conditions vary significantly across states.[1] For instance, the cross-state dispersion in unemployment rates, real GDP growth, household debt, and real housing wealth growth is substantial (Figure 1). The dispersion was remarkably high during the crisis period, particularly for the household debt-to-income ratio, ranging from 62% (West Virginia) to 152% (California) at the peak of the crisis.

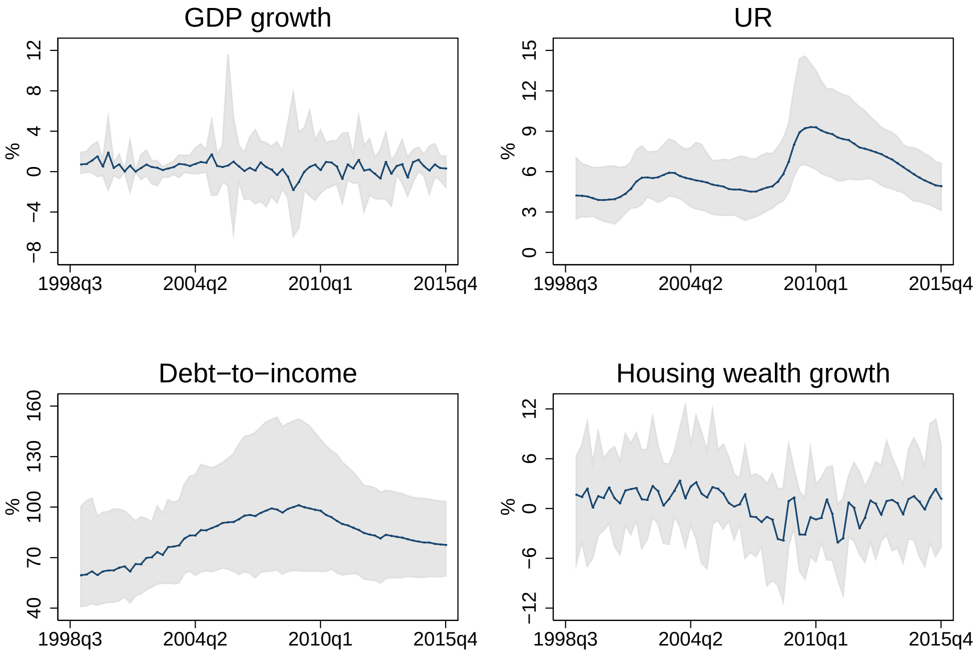
The Federal Reserve carries out monetary policy with a dual mandate of price stability and full employment for the country *as a whole* and not for a particular state. But to the extent that business cycles are not perfectly synchronised across states, divergent developments in inflation and economic growth may actually require a differentiated monetary policy stance. Since, by construction, this is not feasible, the question is the extent to which a single monetary policy may amplify on-going trends, and thus accentuate existing regional differences. Along these lines, by relying on a common monetary policy shock, Carlino and DeFina (1998*b*, 1999) find that monetary policy has significant asymmetric effects on personal income across US regions and states. By contrast, I do not focus on aggregate monetary policy shocks, but on the implicit stance of monetary policy for each state, given that economic and financial conditions differ widely across regions and states.

Furthermore, over the last years there has been a significant divergence in economic and financial performance between states with high and low household debt. While recent research has found that high household debt, household debt build-ups or excessive borrowing are detrimental to economic growth, such as Albuquerque and Krustev (2017), Jordà et al. (2013), Mian and Sufi (2010, 2011), Mian et al. (2017), and increase the probability of a financial crisis (Jordà et al. 2015), little is known about the role that a common monetary policy might play in exacerbating regional asymmetries between states with different levels of household debt.

Against this background, the aim of the paper is to investigate the extent to which the interplay between different levels of household debt and differences in the underlying monetary policy stance across states may contribute to widening regional asymmetries in the dynamics in household debt and economic performance. The paper falls into two different strands of the literature: (i) the interaction between monetary policy, household debt and the macroeconomy, such as in Alpanda and Zubairy (2017), Bauer and Granziera (2017), Bhutta and Keys (2016), Di Maggio et al. (2015), and Jordà et al. (2015); and (ii) the relationship between monetary policy and regional asymmetries, such as Beraja et al. (2017), and Carlino and DeFina (1998*b*, 1999).

[1]For example, Carlino and DeFina (1998*a*), Dornbusch et al. (1998), and Mihov (2001) find significant heterogeneity in GDP and inflation across euro area countries in response to a common monetary policy shock. More recently, Bayoumi and Eichengreen (2017) revisit their original study after 25 years, arguing that the euro area countries continue to face more asymmetric shocks than the United States.

Figure 1: Cross-state distribution of selected variables



Notes: The grey area captures the range of values at each point in time for each variable across a sample of 30 US states used throughout the paper. The solid blue line represents the mean sample values.

Using a novel state-level dataset that combines data on economic activity and debt in the household sector, I apply Jordà (2005)'s Local Projection (LP) method to a panel of 30 US states over 1999-2015 to study the sensitivity of household debt and other macro variables to state-specific monetary policy conditions, placing the focus on regional asymmetries. Specifically, the measure of monetary policy stance for the states, the Monetary Policy Stance Gap (MPSG), is computed as the difference between the interest rate prescribed by the Taylor rules for each state and the one from the US aggregate. I take the estimated coefficients from the US aggregate Taylor rule to generate the Taylor rules for the states, therefore assuming the same central bank's reaction function for all states. To compute the Taylor rules for the states, I construct a novel indicator of consumer prices at the state level, by drawing on official Consumer Price Index (CPI) data for several Metropolitan Statistical Areas (MSA).

The main finding of the paper suggests that a common monetary policy in the United States *does not fit all*. I find strong evidence that monetary policy amplifies asymmetries in the household debt dynamics and economic performance between states. Although a looser state-specific monetary policy stance is supportive of borrowing and growth in states with low household debt, this is only the case in the short term for states with high household debt. In fact, a loosening in the relative monetary policy stance in high debt states eventually leads to a decline in economic growth over the medium term, as households start deleveraging from excessive credit growth. I find that a one-standard deviation increase in the state-specific monetary policy stance leads to lower real GDP of 2.1 p.p. in high debt states compared to low debt states over five years.

The weaker economic performance in high debt states after a loosening in the state-specific monetary policy stance appears to be related to the increased borrowing in the short term that ultimately proves to be unsustainable and excessive. This excessive borrowing may result from the possibility that households in these states were already highly indebted to begin with. At the same time, I find that housing wealth declines abruptly, as deleveraging appears to start weighing on housing demand and prices. Lower house prices, in turn, feed back into lower housing wealth and equity, making it harder for households to take advantage of the home equity loan channel to refinance their mortgages, as suggested by Alpanda and Zubairy (2017). Further deleveraging forces households to cut back on consumption, reinforcing the decline in aggregate demand in the medium term, along the lines of the debt overhang theory of Eggertsson and Krugman (2012).

In contrast, looser monetary policy conditions at the state level are effective in fostering growth and borrowing in a sustainable way in low debt states. For example, house prices and housing wealth rise in low debt states, which may support borrowing through the home equity channel, in line with the findings of Bhutta and Keys (2016) that easier monetary conditions lead households to extract more equity from their homes.

Finally, I also find some evidence that the state of the business cycle can accentuate regional economic and financial asymmetries induced by monetary policy conditions. Particularly, following an expansion in the relative monetary stance, households in high debt states tend to increase their debt, but only during good times (expansions) as the debt-to-income ratio stays flat during recessions. This asymmetric behaviour may be related to the reluctance of highly-indebted households to take on more debt during bad times, in a context of more binding borrowing constraints, tighter credit conditions, or due to changes in their attitudes towards leverage, in that they become uncomfortable with their indebtedness relative to some behavioural benchmarks (Dynan 2012). I do not find statistical evidence, however, that the decline in GDP over the medium-term following looser state-specific monetary policy conditions is stronger in recessions than in expansions. In turn, a looser monetary policy stance stimulates household debt and economic activity in low debt states in both expansions and recessions, with a somewhat stronger magnitude during recessions.

The main findings remain robust to controlling for several state-specific economic and financial variables in the LP framework. In addition, the sensitivity of the impulse responses are practically insensitive to alternative specifications for the Taylor rule, from which I derive the state monetary policy stances: when accounting for the financial cycle; by using Wu and Xia (2016)'s shadow rate to deal with unconventional monetary policy during the zero lower bound (ZLB) on nominal interest rates; and by estimating a Taylor rule that assumes that the Fed reacts to past inflation and unemployment gaps.

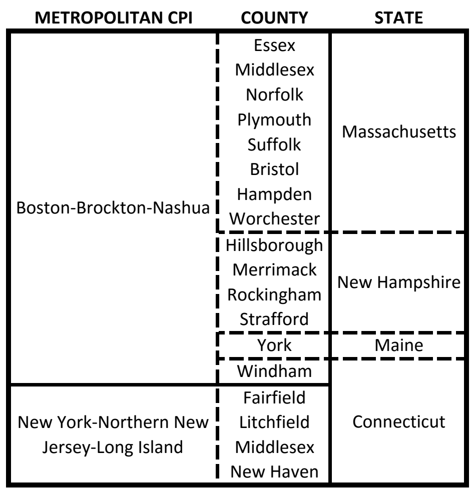
2 State-level CPI

The stance of monetary policy is typically assessed by monetary rules, of which Taylor (1993, 1999) rules are the most popular ones. To compute these rules for the US states, I need a measure of consumer prices and slack in the economy of each state. While there is data on unemployment rates and GDP growth to measure the amount of slack in the economy, data on state consumer prices are more limited. Nevertheless, having a measure of consumer inflation at the local level is critical to better capturing differences in local conditions, which likely differ from state to state. The Bureau of Economic Analysis (BEA) has recently made available quarterly data on nominal and real state GDP, from which we can derive the implicit deflator, but the time span is too limited (only since 2005). In addition, the BEA has also made available prototype estimates for state PCE deflator, but it is only annual, and it covers a short period (2008-2014).

Given the aforementioned data limitations, one of the contributions of the paper is to compute a quarterly measure of consumer price inflation for a sample of 30 US states over 1984-2015 (both headline and core CPI) by resorting to CPI data for 26 US MSA from the Bureau of Labor Statistics (BLS). Although these MSA only cover 30 states, the states together represent around 82% of total US GDP. I face two main issues when mapping the CPI of the MSA to the states. For example, Boston-Brockton-Nashua encompasses counties belonging to four different states: Massachusetts, New Hampshire, Maine, and Connecticut (Figure 2). This MSA will be used in the calculation of each of the latter four states' CPIs, together with any other MSA which may also cover counties belonging to the same state.

The second issue derives from the first, in that a state may include counties from different MSAs. I deal with this issue by taking personal income of the relevant counties as weights. In the case of Connecticut, its CPI is the income-weighted average of the counties (Fairfield, Litchfield, Middlesex, and New Haven counties) belonging to the CPI of New York-Northern New Jersey-Long Island, and of Windham county from Boston-Brockton-Nashua.

Figure 2: Example of the relationship between metropolitan and state-level CPIs

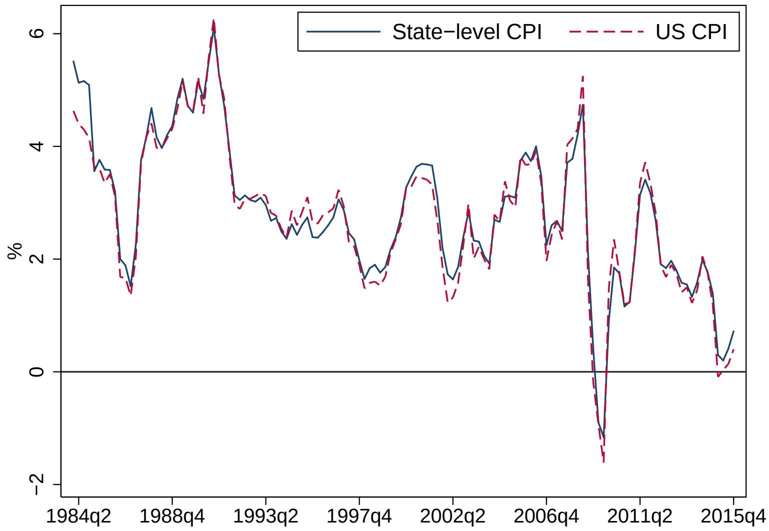


The original CPI data at the MSA level have different frequencies: monthly, bi-monthly (even or odd months) and semi-annual. To construct the state-level CPIs at a quarterly frequency, I take quarterly averages for the monthly data; for the bi-monthly data, I first interpolate them to monthly and then calculate 3-month averages for each quarter; for semi-annual data I use the Chow-Lin interpolation method to produce quarterly data points by using the US aggregate CPI as the indicator variable. I choose 1984 as the starting point because this is when the series for all but two MSA begin: Washington-Baltimore and Tampa-St.Petersburg-Clearwater start a bit later, which results in the CPIs of Washington D.C., Maryland, Virginia and West Virginia starting in 1996q1, and Florida in 1997q4 (Figure B.14 plots state-level CPIs).

In terms of the counties covered by the CPI data for each state, those states with lower coverage have, in general, a relatively lower weight in US GDP, whereas larger states tend to be better covered (Figure B.13 in Appendix B). Coverage is perfect in District of Columbia and New Jersey and reasonably high in states such as Maryland, Massachusetts, and California. In turn, it is lowest in West Virginia, Indiana, and Kentucky.

To assess the quality of the state-level CPI proxy, I do a bottom-up income-weighted aggregation and compare its annual inflation rate with that of the official US national CPI. The bottom-up aggregation of the new indicator does a pretty good job at tracking the official CPI, with a correlation of 0.98 over 1984-2015 (Figure 3).

Figure 3: Bottom-up aggregation of state-level CPI vs US official aggregate – yoy % change



3 Monetary policy rules

This section presents Taylor rules that put the Federal funds rate into perspective since the mid-1980s. Making use of the newly-built state-level CPI proxy, I then construct Taylor rules for each of the 30 US states and look at the cross-state heterogeneity. Finally, I construct an indicator that measures the state-specific monetary policy stance as the difference between the interest rate prescribed by the Taylor rules for each state and the US aggregate.

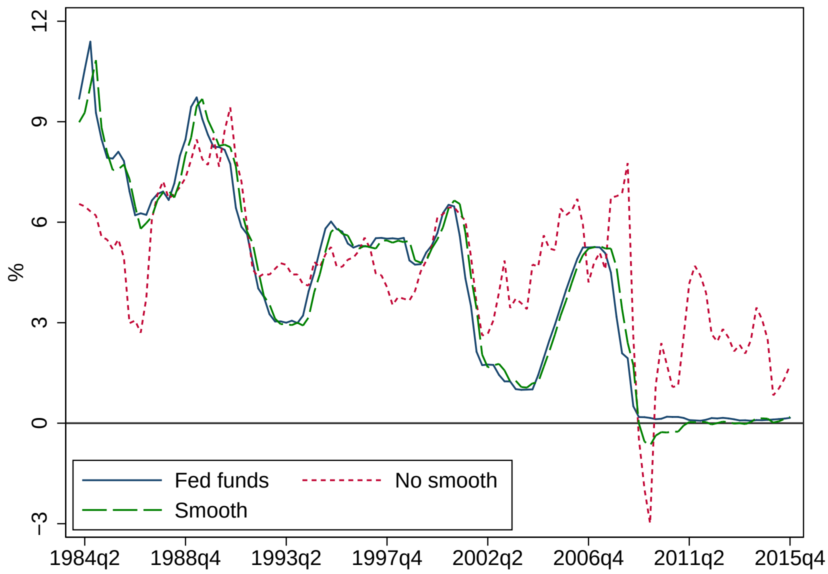
3.1 US aggregate

A monetary policy rule describes how the monetary policy stance responds when inflation and economic activity deviate from their targets. The rules should, however, not necessarily be seen as the optimal path for monetary policy, but rather as a rule-of-thumb that a credible central bank tends to follow according to its mandate. In the case of the Federal Reserve, the dual mandate refers to price stability and maximum employment. In any case, despite the flexibility to deviate from the rules in the short run, they are nevertheless important to gauge the relative stance of monetary policy, while also allowing the central bank to communicate more easily to the public a specific change in its monetary policy stance.

Taylor rules, originating from Taylor (1993, 1999), have described particularly well the conduct of monetary policy in the United States during the Great Moderation from the 1980s to the late-2000s. The early 2000s, however, brought about a change in the course of monetary policy, with a standard Taylor rule prescribing a much higher policy rate (dotted red line in Figure 4). Monetary policy has indeed been deemed by some to have been too accommodative in the run-up to the Great Recession (Belongia and Ireland 2016, Borio et al. 2017, Leamer 2015, Taylor 2011).

But, more recently, Taylor rules that allow for interest-rate smoothing have increasingly become more popular, helping to track better the actions of central banks, and therefore closing the gap or deviation between the prescribed policy rates and those effectively set by the central bank. For instance, Coibion and Gorodnichenko (2012) suggest to take into account the degree of policy inertia in central banks' reaction function by including the lagged dependent variable in the estimation of the Taylor rule.[2] In fact, only when interest-rate smoothing is accounted for in the reaction function of the central bank, are we able to track the interest rate set by the Fed over the last decade and a half (dashed green line in Figure 4).

Figure 4: The Fed funds rate vs monetary policy rules



In this context, I estimate a Taylor rule in the spirit of Coibion and Gorodnichenko (2012). Differently from them, and also from Taylor (1993, 1999), I use the unemployment gap as a measure of slack in the economy, instead of the output gap, to make the exercise comparable between the US aggregate and the states; a long series for the unemployment rate is available at the state-level, but not for GDP. Nevertheless, this should not be critical for the results, as it is common to come across in the literature with both versions of the Taylor rule, yielding similar prescribed policy rates. Rudebusch (2010), and Leduc and Sill (2013), for instance, use the unemployment gap and the unemployment rate to proxy for slack and economic activity. A

[2]Particularly, Coibion and Gorodnichenko (2012) find evidence in favour of interest rate smoothing over serially correlated policy shocks to explain the highly-persistent nature of policy rates set by the Fed.

typical Taylor rule with interest-rate smoothing is as follows:

$$i_t = \rho i_{t-1} + r^* + \pi^* + a(\pi_t - \pi_t^*) + b(u_t - u_t^*) \tag{1}$$

i is the policy rate, r^* is the real natural interest rate in the economy, $(\pi - \pi^*)$ is the deviation of year-on-year headline CPI inflation π from the central bank's inflation target π^*, and $(u - u^*)$ is the unemployment gap, a measure of slack in the economy, where u is the unemployment rate and u^* its natural rate from the Congressional Budget Office (CBO).[3] Finally, ρ is the interest rate smoothing parameter, and a and b are the elasticities of the policy rate to, or weights on, the inflation gap and the unemployment gap. The coefficient a is expected to be positive and above 1, to respect the Taylor principle, and b to be negative, as larger slack in the economy requires a lower policy rate. Assuming that the inflation target is 2%, and re-arranging the terms:

$$i_t = \rho i_{t-1} + r^* + 2(1 - a) + a\pi_t + b(u_t - u_t^*) \tag{2}$$

I estimate the Taylor rule above for the US aggregate on quarterly data over 1984-2007, thus excluding the ZLB period around and after the Great Recession that has arguably distorted the relationship between conventional monetary policy and the real economy:

$$\hat{i}_t = \underset{(0.19)}{0.05} + \underset{(0.04)}{0.92^{***}} i_{t-1} + \underset{(0.05)}{0.11^{**}} \pi_t - \underset{(0.08)}{0.17^{**}} (u_t - u_t^*) + \epsilon_t \tag{3}$$

The estimated long-term coefficient on the inflation gap for the US economy is 1.5, the same as in Taylor (1993, 1999), thus respecting the Taylor principle, while the one on the unemployment gap is larger (-2).[4] The lagged term is highly statistically significant, and in the region of 0.8-0.9 estimated by Coibion and Gorodnichenko (2012).

3.2 Heterogeneity across US states in the prescribed policy rates

With the newly-constructed state-level CPI proxy and unemployment gaps, I compute Taylor rules for the 30 US states over 1984q1-2015q4, using the estimated coefficients from Eq. (3). To be clear, I do not re-estimate Taylor rules for each state given that I assume the same reaction function for the central bank. Differences in prescribed policy rates across states come from inflation and unemployment gap differentials, not from the coefficients themselves. I compute the natural rate of unemployment for each state by taking its average over the 1990s, given the lack of official NAIRU estimates for the different states.[5] Justiniano et al. (2015) also take

[3] I use headline CPI inflation to be consistent with the state-level analysis. But the results remain practically unchanged with Personal Consumption Expenditure (PCE) deflator, the official Fed's target, or with core CPI.

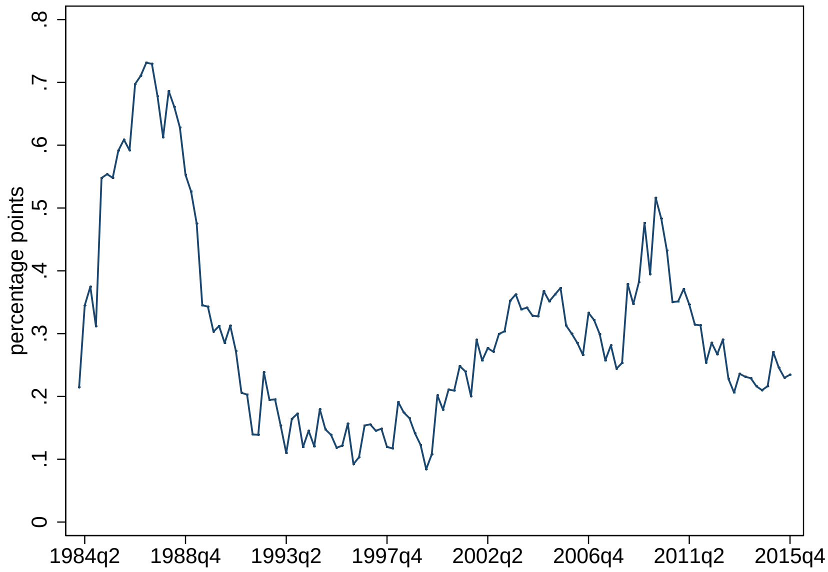
[4] The long-term coefficients result from dividing the short-run coefficients by (1-0.92). Taylor (1993) assumes that a=1.5 and b=0.5, while Taylor (1999) places a larger weight on slack (b=1). He uses the output gap, actual GDP minus potential GDP, as the slack variable, so its coefficients on slack should be multiplied by -1 to be on a comparable basis to mine.

[5] The Taylor rules are robust to taking instead the average of the unemployment rate over the full period, or the CBO's NAIRU for the US economy. Alternatively, I filtered out the unemployment rate series from its transitory component with a Hodrick-Prescott (HP) filter. I get (much) smoother fluctuations in the unemployment gap, as the HP filter does not allow the underlying series to deviate from the trend for long periods, while it tends to converge to the actual values at the end of the estimation period – the well-known end-point issue.

this period as their model's steady state for the US economy, given the relative stability of the 1990s, and because the subsequent decade is distorted by the swings in debt and house prices.

It is not a surprise that the significant heterogeneity in economic conditions among the states results in different prescribed interest rates. The dispersion of the Taylor rule for the US states, as measured by the interquartile range, has been indeed non-negligible, particularly during most of the 2000s (Figure 5). While the heterogeneity across states dropped considerably in the 1990s, it started to increase since then, a sign that economic performance across US states began to diverge, calling for different interest rates across states. At the trough of the last recession in mid-2009, the prescribed interest rate ranged from around -1.4% to 0.3%, at a time when the estimated Taylor rule for the US aggregate was at -0.7%, while the Fed funds rate was practically at zero. More recently, there have been some tentative signs that the dispersion across states has declined during the recovery from the last crisis.

Figure 5: Dispersion of Taylor rules across US states



Notes: The figure shows the interquartile range of the Taylor rules for 30 US states.

3.3 Monetary Policy Stance Gap

In a next step, I want to assess the extent to which the prescribed policy rates for the states signal a looser or tighter monetary policy stance. To accomplish that, I take the estimated Taylor rule at the national level as the benchmark, which also allows me to analyse the underlying asymmetries in the relative monetary policy stance at the local level. In this context, I construct an indicator, the Monetary Policy Stance Gap (MPSG), that measures the state-specific monetary policy stance relative to the US national by taking the difference between the interest rate prescribed by the Taylor rules for each state and the one from the US aggregate. The exogeneity assumption is supported by the fact that the Fed does not carry out monetary policy for a particular state, but rather for the country as a whole. As such, there is no single state large enough that can influence US monetary policy alone. For example, California, the largest US state, accounts for a bit above 13% of total US GDP. This new indicator thus captures the variation in state monetary conditions, where the relative stance gap depends on the weighted sum of the differences between the state inflation and unemployment gap and the equivalent variables at the aggregate level:

$$MPSG_{i,t} = a(\pi_{i,t} - \pi_{US,t}) + b[(u_{i,t} - u^*_{i,t}) - (u_{US,t} - u^*_{US,t})], \qquad i = 1, ..., 30; \tag{4}$$

States for which the MPSG is positive experienced a looser monetary policy stance compared to what the state-specific Taylor rule prescribed, and vice-versa. A positive gap is the result of a combination of higher inflation or/and a lower unemployment for a given state relative to the US aggregate.

To be clear, I compute the deviations from the fitted values of the US Taylor rule, not the actual Fed funds rate. Nevertheless, this is not a critical assumption that affects the results, as we have seen before that the fitted values from a Taylor rule with interest rate smoothing have tracked closely the actual Fed funds rate. But to alleviate potential concerns about the fact that the 'actual' policy rate might have been lower than the estimated and observed ones around the ZLB period, as a result of the use of non-standard monetary policy measures by the Fed, I will use later in the paper a concept of a shadow rate from Wu and Xia (2016) that measures the effective policy rate during ZLB periods.

By analysing the MPSG for each state, it appears at first sight that monetary policy was more accommodative in the run-up to the crisis for states that experienced a boom-bust cycle in house prices and debt, and tighter once the crisis broke out (Figure B.15 in Appendix B). For instance, states such as Florida, California and New York, which have undergone a pronounced housing market boom-bust cycle, are among the states with the loosest monetary policy stance before the crisis, while others, such as Texas, Wisconsin, Indiana and Ohio, which have not observed large swings in house prices and debt, are at the other end of the spectrum. This raises the question of the role of monetary policy in the rise of house prices and household indebtedness and whether monetary policy itself contributed to the widening in economic performance between the states. I test these hypotheses in Section 5.

4 Econometric framework

I use a novel dataset at the state level that combines data recently made available on economic activity (GDP and PCE) from the BEA, and debt in the household sector from the New York Fed Consumer Credit Panel/Equifax. In particular, PCE encompasses 16 spending categories on non-durable and durable goods, and services. Since the original PCE data are annual, I interpolate into quarterly data with the Chow-Lin method, using the aggregate PCE series as the indicator variable. In turn, household debt comprises data since 1999 on mortgage debt and consumer credit, including auto loans, credit card and student loans (see Appendix A for data definitions and descriptive statistics).[6]

I use the Local Projection method from Jordà (2005) to compute the sensitivity of household debt and other macro variables to state-specific monetary policy conditions. Compared to Vector

[6]Household debt data are not publicly available between 1999 and 2002.

Auto Regressive (VAR) models, the Jordà method has the advantage of the impulse responses being less vulnerable to misspecification while being more flexible to capture non-linearities. For instance, the Jordà method estimates local projections at each period of interest instead of extrapolating the impulse responses into increasingly distant horizons where misspecification errors are compounded with the forecast horizon. One of the features of the LP is that it tends to produce larger standard errors than the VARs, while there is often some loss of efficiency at longer horizons, resulting in erratic patterns in the dynamic effects. For each horizon h=1,2...,10 I estimate the following model with Fixed Effects over 1999q1-2015q4:

$$\Delta_h Y_{i,t+1+h} = \alpha^h + \beta^h MPSG^h_{i,t} + \lambda^h \Delta \log(X^h_{i,t-1}) + \eta^h_i + \zeta_t + \epsilon_{i,t+1+h} \tag{5}$$

The dependent variables are computed as cumulative changes from semester *t+1* to *t+1+h*: (i) household debt-to-income ratio (DTI), (ii) logarithm of real GDP, (iii) logarithm of real housing wealth, and (iv) CPI inflation. In a second stage, I also look at PCE consumption and its main components. $MPSG_{i,t}$ is the monetary policy stance gap, $X_{i,t}$ the lagged dependent variables used as controls plus lagged GDP per capita in levels in the equation for GDP to control for convergence effects, whereby poorer states have higher growth rates than richer states, i refers to the 30 states, t to time (quarters), the Δ operator to first differences expressed in percentage points, η^h_i is the state-specific fixed effect capturing unobserved time-invariant heterogeneity, and ζ_t controls for unobserved time-variant common factors across units in the panel.[7] The inclusion of time dummies is important to absorb the effect of common factors driving the dynamics of the panel, i.e. they take away the national trend which acts as a common source of variation in macro and financial variables across the states.

I use housing wealth to capture the traditional wealth effect from housing assets, with home ownership also affecting housing wealth apart from only house prices. As in Albuquerque and Krustev (2017), housing wealth is as follows (HPI is the FHFA House Price Index):

(Homeownership rate x Occupied housing units) x HPI x Median house price in 2000

I deal with the issue of reverse causality potentially running from economic and financial variables in the left-hand side to the relative monetary policy stance by computing the cumulative changes from semester *t+1* to *t+1+h*, and estimating the model starting only from h=1. With this framework, I assume that the MPSG affects the real economy in each state with a lag of one quarter, as is commonly done in the literature on monetary policy shocks.

To keep the model parsimonious, I use one lag for all variables as in Tenreyro and Thwaites (2016) in a study of monetary policy shocks and the state of the business cycle, but the main results remain robust to the inclusion of more lags. Finally, I adjust the standard errors with Driscoll and Kraay (1998)'s estimator to account for correlation in the error term across states and time, given that the Jordà method with panel data usually exhibits cross-sectional and temporal dependence.

[7] I have run alternative specifications by: (i) adding several state-specific macro and financial variables as controls, which include income per capita, inflation, unemployment rate, homeownership rate, house prices, mortgage interest rates, loan-to-value ratio, and the foreclosure rate; and (ii) controlling for the lagged levels of income per capita and DTI to account for income effects and reversion to the mean. The main results remain broadly insensitive to these alternative specifications (available upon request).

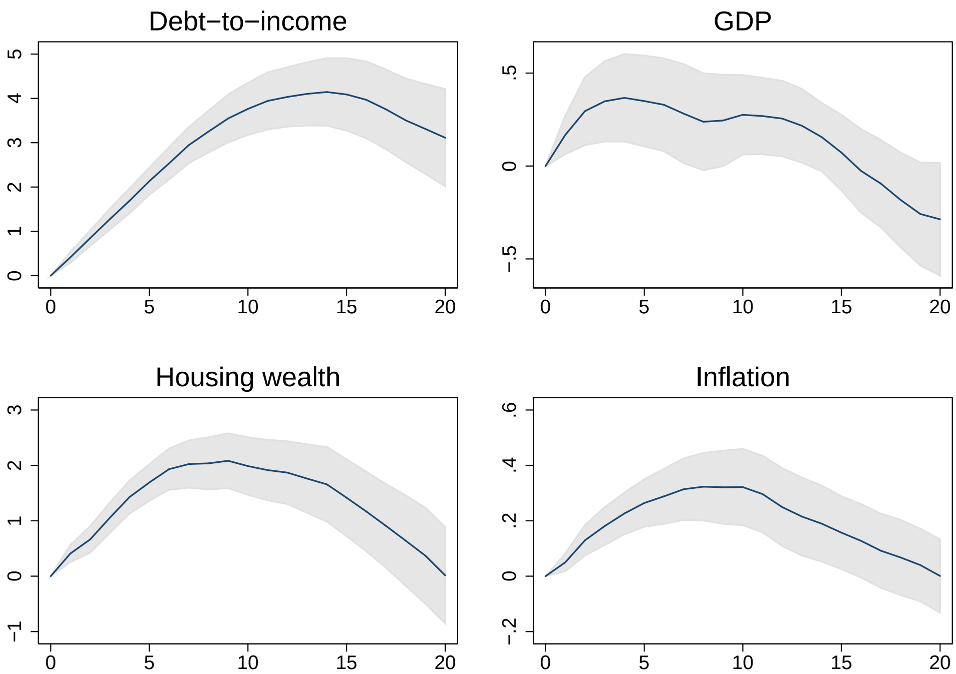
5 Baseline regressions

In this section I investigate the role of state-level monetary policy conditions on household debt and economic activity. After analysing the linear case, I focus on the interaction between monetary policy and regional asymmetries. Specifically, I explore the extent to which the state-specific stance of monetary policy may affect the dynamics in economic and financial variables differently across states, depending on their level of household debt. In this part, I also distinguish between periods characterised by state-specific recessions versus expansions.

5.1 Linear case

When estimating Eq. (5), and to better assess the economic relevance of the results, I calibrate the estimates to show the impulse responses to a one-standard deviation increase in the MPSG (0.2 p.p.). I find that an increase in the MPSG (looser monetary policy conditions in a specific state relative to the US aggregate) induces more household debt in a persistent and highly statistically significant way over the whole horizon (Figure 6). The DTI is higher by roughly 1.7 p.p. after four quarters for those states which stand at a one-standard deviation above the mean of the MPSG, and reach a peak of around 4 p.p. after three to four years. At the same time, housing wealth also follows the same dynamics, reaching a peak of 2.1% after two years, before steadily converging to the baseline.

Figure 6: IRF to an expansion in the monetary policy stance gap



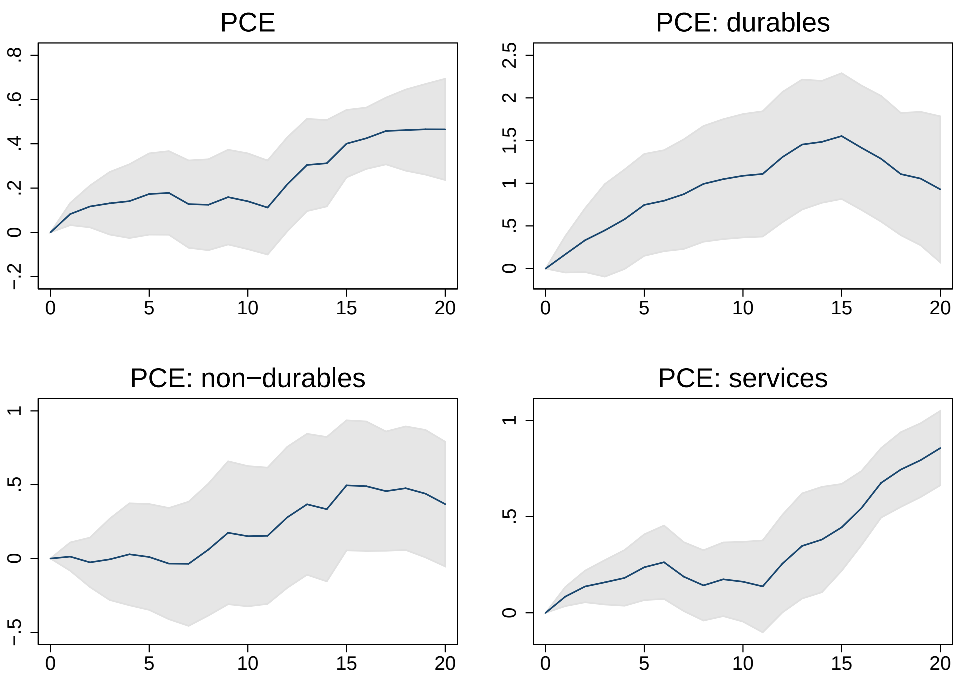
Notes: The solid blue line is the cumulative response of the change in the debt-to-income ratio, real GDP, real housing wealth, and CPI inflation, to a one-standard deviation increase in the MPSG for horizons 1 to 20 (β^h from Eq. (5)). The grey area refers to the 90% confidence bands.

The rise in household debt and housing wealth after an increase in the MPSG is in line with the macro expected effects of looser monetary policy conditions. Accordingly, expansionary monetary policy lowers the cost of financing and reduces the real value of debt through higher inflation, facilitating the access to credit and thus encourages borrowing. My estimates are also in line with the expected effect stemming from the household balance sheet channel, or the home equity loan channel. This channel plays an important role for homeowners, whereby easier monetary conditions and higher house prices lead to higher housing wealth or home equity, allowing households to borrow more, in line with the findings of Bhutta and Keys (2016).

The response of real GDP has the usual hump-shaped profile, increasing in the short to medium term, with a response that peaks at 0.4% after four quarters, before steadily converging to the baseline. Moreover, consumer prices also exhibit the same hump-shaped pattern, with their increases remaining statistically significant for three to four years.

The increase in economic activity for states that experience a loosening in their monetary conditions relative to the US aggregate is probably connected to the increase in housing wealth and household borrowing that allows households to expand their purchases of goods and services. I find evidence for this mechanism when I use household consumption and its main components as dependent variables in Eq. (5). Consumption rises when monetary policy conditions become looser, with stronger responses in durable goods, followed by services, while the response of non-durables is more muted (Figure 7). Although Tenreyro and Thwaites (2016) focus on the macro effects of monetary policy shocks while I deal with state-specific monetary policy conditions, my results are in line with their findings that durables, and housing investment, are more sensitive to monetary policy shocks.[8] The precision of the estimates, however, is a bit low over the shorter horizons, with the exception of durable goods, which might be related to the statistical noise from interpolating the original annual PCE data into quarterly.

Figure 7: IRF of consumption to an expansion in the monetary policy stance gap



Notes: The solid blue line is the cumulative response of each variable to a one-standard deviation increase in the MPSG for horizons 1 to 20 (β^h from Eq. (5)). The grey area refers to the 90% confidence bands.

[8]The analysis for the household sector would be more complete by adding residential investment to the picture, but unfortunately residential investment data are not available at the state-level.

5.2 Household debt and regional asymmetries in the transmission of monetary policy

I delve further into the interplay between monetary policy, regional asymmetries and household debt. The motivation to carry out this analysis with the focus on household debt stems from the fact that we still do not know enough about how different levels of household debt affect the impact of a change in the monetary policy stance on the real economy.

In the spirit of Bernanke et al. (1999) 'financial accelerator', a collateral constraint dictates the ability of a household to extract equity from housing. This mechanism might therefore amplify the effect of monetary policy when debt is high, since looser monetary policy stimulates house prices and consequently borrowers' home equity levels, which also spurs borrowing. In a similar vein, through a model focused on housing and mortgage debt, Hedlund et al. (2016) argue that monetary policy is more powerful in a high-LTV economy, as a result of more households having a high marginal propensity to consume. But, on the other hand, even if monetary conditions become looser, households might still be reluctant to take on more debt if their indebtedness is already high, or if they are borrowing constrained, which prevents them from increasing debt. Monetary policy in this case might be less effective. This mechanism appears to be reminiscent of the debt overhang theory of Eggertsson and Krugman (2012), in which households are forced into deleveraging when debt is high, and of empirical estimates of Albuquerque and Krustev (2017) who show that US states with higher household debt levels cut consumption by more during the Great Recession. Furthermore, Alpanda and Zubairy (2017) find that monetary policy is less effective during periods of high household debt, which they argue is probably linked to the weakening of the home equity loan channel around those periods.

By looking at the data over the last years, we know that there has been a significant divergence in economic and financial performance between states with high and low household debt. For instance, the rise and fall in house prices and household debt in the United States in the last decade and a half was far from being uniform across states.[9] Is a common monetary policy to blame for these regional asymmetries? By fuelling asset prices beyond their fundamentals in some parts of the country, monetary policy can indeed possibly have played a role in exacerbating financial imbalances between states with different levels of household debt.

Against this background, I explore the link between the transmission mechanism of monetary policy and regional asymmetries between high and low debt states. This split is in the spirit of Alpanda and Zubairy (2017), but in contrast with their study, where they use US aggregate data to define high and low debt states as debt-to-GDP being above or below its smooth trend, I make advantage of the panel dataset by looking at the full distribution of household debt by time and state. Specifically, I extend Eq. (5) with $\Phi^H_{i,t-1}$, a pre-determined time-varying dummy where 1 refers to states with high debt, those belonging to the top quintile of the household debt-to-income ratio distribution at each point in time, and with $\Theta^L_{i,t-1}$ that takes the value

[9] As documented by Albuquerque et al. (2015), household debt and, implicitly, house prices were not aligned with their fundamentals in some states in the run-up to the last recession, particularly in California and Florida, which led to an abrupt correction that deepened the magnitude of the economic downturn. For example, the different dynamics in house prices is quite telling: real house prices in California and Florida increased by around 116% and 97% between 1999 and their respective peaks in 2006, but then suffered a severe adjustment which has left real house prices at the end of 2016 still well below their previous peak. By contrast, house prices in Texas increased by 'only' 15% during the same period, recording a mild decline during the crisis period.

of 1 for states with low debt, those in the first quintile. The remainder states with moderate debt belong to the quintiles in between. The subscripts M, H, and L indicate the coefficients for moderate, high and low debt states:

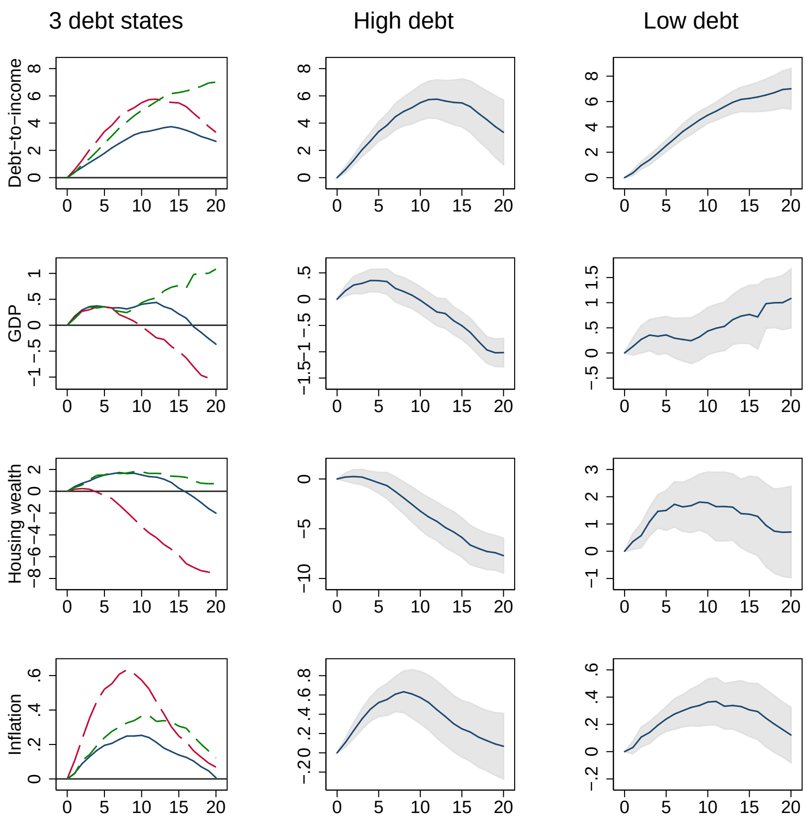
$$\begin{aligned}\Delta_h Y_{i,t+1+h} =& \alpha_M^h + \beta_M^h MPSG_{i,t}^h + \lambda_M^h \Delta \log(X_{i,t-1}^h) \\ &+ \Phi_{i,t-1}^H \left[\alpha_H^h + \beta_H^h MPSG_{i,t}^h + \lambda_H^h \Delta \log(X_{i,t-1}^h)\right] \\ &+ \Theta_{i,t-1}^L \left[\alpha_L^h + \beta_L^h MPSG_{i,t}^h + \lambda_L^h \Delta \log(X_{i,t-1}^h)\right] \\ &+ \eta_i^h + \zeta_t + \epsilon_{i,t+1+h}\end{aligned} \tag{6}$$

The new estimates of a one-standard deviation increase in the MPSG show that the initial increase in household debt in high and low debt states is similar (Figure 8). But while loose monetary policy is supportive of household debt in low debt states for the whole horizon, there is an indication that the boost from monetary policy to household debt in high debt states is short-lived; in non-cumulative terms, the change in the DTI becomes negative after two to three years, when households start adjusting downwards their level of indebtedness relative to income. There is also a denominator effect for high debt states, with lower income in the medium term attenuating the decline in the debt ratio, as the fall in nominal debt is more marked, and starts early (roughly after two years).

Monetary policy has a short-lived positive impact on economic activity in high debt states, at a time when debt is still rising. This short-term gain in growth, which appears to be related to higher household borrowing, however, comes at the expense of long-term pain: real GDP goes below baseline after roughly two years. By contrast, I find evidence that looser state-specific monetary policy conditions are expansionary for real GDP over the whole period in states with low debt. The asymmetrical effects of monetary policy show up strongly: real GDP in high debt states would be roughly 2.1 p.p. lower than in low debt states over five years.

The interaction of housing wealth with household debt is key to understanding the asymmetric dynamics between high and low debt states, following an expansion in state-specific monetary policy conditions relative to the US aggregate. Since household debt is already at elevated levels in high debt states, more borrowing may eventually lead to excessive credit growth that 'forces' households to deleverage and cut back on consumption (Figure B.16 in Appendix B). At the same time, house prices, and consequently housing wealth, suffer an abrupt correction in high debt states, as deleveraging starts to weigh on housing demand and prices. Lower house prices, in turn, feed back into lower housing wealth and equity, which leads to more deleveraging, reinforcing the decline in aggregate demand. By contrast, housing wealth never declines in low debt states, which is in line with the expectation that households would increase borrowing through the home equity channel when house prices go up, in line with the findings of Bhutta and Keys (2016) that easier monetary conditions and higher house prices lead households to extract more equity from their homes. These findings may be placed in the context of recent work focusing on the role of the household balance-sheet channel for economic activity, particularly that excessive borrowing or household debt build-ups are detrimental to growth in the medium to longer run (Mian and Sufi 2010, 2011, for the United States; and Jordà et al. 2013, Mian et al. 2017, for a panel of countries), and increase the probability of a financial crisis taking place in the future (Jordà et al. 2015).

Figure 8: Household debt and the transmission of state-specific monetary policy conditions



Notes: Cumulative response of each variable to a one-standard deviation increase in the MPSG for h=1 to 20. 1st column: the long-dashed red line refers to states with high household debt; the short-dashed green line to states with low debt; the solid blue line to states with moderate debt. 2nd and 3rd columns show the point estimates for high and low debt states with the associated 90% confidence bands.

Although the nature of the analysis is different, the dynamics above seems to fit the mechanism described by Alpanda and Zubairy (2017). Particularly, they suggest that monetary policy is less effective in stimulating economic activity in periods when household debt is high, arguing that the main mechanism at play may be the home equity loan channel not being operational, as house prices do not increase in these states, preventing households from borrowing further. The difference in my estimates is that house prices and housing wealth actually *decline* in states with high debt, creating challenges for households to refinance their mortgages or extract more equity from their homes. A tightening in credit supply standards following a decline in the value of the collateral might also be playing a role in explaining the weaker dynamics in borrowing in high debt states, as states with high leverage tend to concentrate a larger fraction of less credit-worthy borrowers who are more prone to defaults under an adverse house price scenario (Fuster et al. 2016).

An alternative explanation for the asymmetries in the behaviour of high versus low debt states, following looser monetary policy conditions, can be linked to the findings of Keys et al. (2014). Specifically, the authors find that a shock to mortgage rates that reduces mortgage payments lead credit-constrained households – those with high debt – to allocate a substantial part of that additional income to paying down their non-mortgage debt. While unconstrained households expand their consumption, the authors find that the debt deleveraging by the credit-constrained dampens significantly the effectiveness of monetary policy to stimulate the consumption response of these households.

Overall, the results presented in this section suggest that monetary policy can stimulate household debt in states that have already high levels of debt, but this can pave the way to an abrupt adjustment after the bubble in house prices and debt bursts. By contrast, looser monetary policy is effective in stimulating growth and borrowing in a sustainable way in low debt states. It thus appears that over the medium to long term, monetary policy might accentuate the economic differences between the states. Along the same lines, Beraja et al. (2017) find that the sizeable heterogeneity in the distribution of housing equity implies that monetary policy can have important regional asymmetric effects. In particular, they point out that an expansion in monetary policy in the wake of the Great Recession was weaker in stimulating consumption for US metropolitan areas where house prices dropped by more, as it was more difficult for underwater homeowners to refinance their mortgages and to extract equity from their houses.

5.3 Monetary policy and household debt during recessions and expansions

After finding a relationship between monetary policy, different household debt levels and regional asymmetries, I investigate whether my findings are conditional on the state of the economy. One could think that the reaction of the states to a loosening in their relative monetary policy stance might depend on the stage of the business cycle they find themselves in; macro and financial variables may behave differently to a loosening in monetary conditions in recessions – periods characterised by under-utilisation of resources in the economy – compared to a situation when their economies would be operating in normal circumstances. For instance, and as summarised by Tenreyro and Thwaites (2016), the transmission of monetary policy may depend on the health of the financial system, the degree of price stickiness and, on the household side, on the response of consumption to real interest rates at different stages of the business cycle.

The available empirical evidence on the effectiveness of monetary policy in recessions versus expansions is mixed. On the one hand, Peersman and Smets (2002) show that monetary policy tends to be more effective in recessions, which is in line with Bernanke et al. (1999)'s financial accelerator effect in which the decline in net worth during a recession amplifies the size of the initial shock. But, more recently, Berger and Vavra (2015), and Tenreyro and Thwaites (2016) find that monetary policy is more effective during expansions, with durables and investment responding more strongly in good times. According to Tenreyro and Thwaites (2016), one of the main reasons why monetary policy is more powerful in expansions is related to the pro-cyclicality of fiscal policy during expansions. In turn, Berger and Vavra (2015) show that the presence of adjustment costs leads households to adjust durable goods by much less in recessions.

Surprisingly, little is known about the interplay between monetary policy and different household debt levels during recessions and expansions. One of the exceptions is Alpanda and Zubairy (2017), who find some evidence, by using US aggregate time series data, that the effectiveness of monetary policy is further reduced during periods of high debt that coincide with recessions.

Defining recessions according to the US business cycle would probably not be informative in my dataset, as it does not allow the state of the economy to differ across the US states. Given the substantial heterogeneity in their economic performance, I thereby explore both the time and the cross-section dimension by defining state-specific recessions as those periods with the weakest real GDP growth for each state. Specifically, recessions refer to the first quintile of the lagged 3-quarter moving average of real GDP growth in each state. Using a moving average of GDP growth to compute recessions is in the spirit of Auerbach and Gorodnichenko (2012) for fiscal policy shocks, and of Tenreyro and Thwaites (2016) for monetary policy shocks.[10]

I expand Eq. (6) with $\Omega^R_{j,t-1}$, a pre-determined time-varying dummy for state-specific recessions, where 1 refers to recessions, and 0 to expansions. The recession dummy is interacted with all coefficients for all debt groups:[11]

$$
\begin{aligned}
\Delta_h Y_{i,t+1+h} =& \alpha^h_M + \beta^h_M MPSG^h_{i,t} + \lambda^h_M \Delta\log(X^h_{i,t-1}) \\
&+ \Omega^R_{j,t-1}\left[\alpha^h_{MR} + \beta^h_{MR} MPSG^h_{i,t} + \lambda^h_{MR}\Delta\log(X^h_{i,t-1})\right] \\
&+ \Phi^H_{i,t-1}\left[\alpha^h_H + \beta^h_H MPSG^h_{i,t} + \lambda^h_H \Delta\log(X^h_{i,t-1})\right] \\
&+ \Phi^H_{i,t-1} * \Omega^R_{j,t-1}\left[\alpha^h_{HR} + \beta^h_{HR} MPSG^h_{i,t} + \lambda^h_{HR}\Delta\log(X^h_{i,t-1})\right] \\
&+ \Theta^L_{i,t-1}\left[\alpha^h_L + \beta^h_L MPSG^h_{i,t} + \lambda^h_L \Delta\log(X^h_{i,t-1})\right] \\
&+ \Theta^L_{i,t-1} * \Omega^R_{j,t-1}\left[\alpha^h_{LR} + \beta^h_{LR} MPSG^h_{i,t} + \lambda^h_{LR}\Delta\log(X^h_{i,t-1})\right] \\
&+ \eta^h_i + \zeta_t + \epsilon_{i,t+1+h}
\end{aligned} \tag{7}
$$

I focus on high versus low debt states during recessions and expansions. Following an expansion in the relative monetary stance, I find that households in high debt states increase their borrowing but only during expansions, as debt stays relatively flat in a statistically significant way during recessions (Figure 9). One of the possible explanations for the different debt dynamics in the two regimes is related to the reluctance of highly-indebted households to take on more debt during bad times, given that borrowing constraints can be more binding as a result of tighter credit conditions during recessionary periods, or due to changes in households' attitudes towards leverage, i.e. households may become uncomfortable with their indebtedness relative to some behavioural benchmarks, as put forward by Dynan (2012). But having said this, and in contrast with Alpanda and Zubairy (2017), I do not find statistical evidence that the decline in GDP over the medium-term following looser state-specific monetary policy conditions differs between the two periods. This appears to be explained by a muted response of housing wealth during recessions while it declines during expansions.

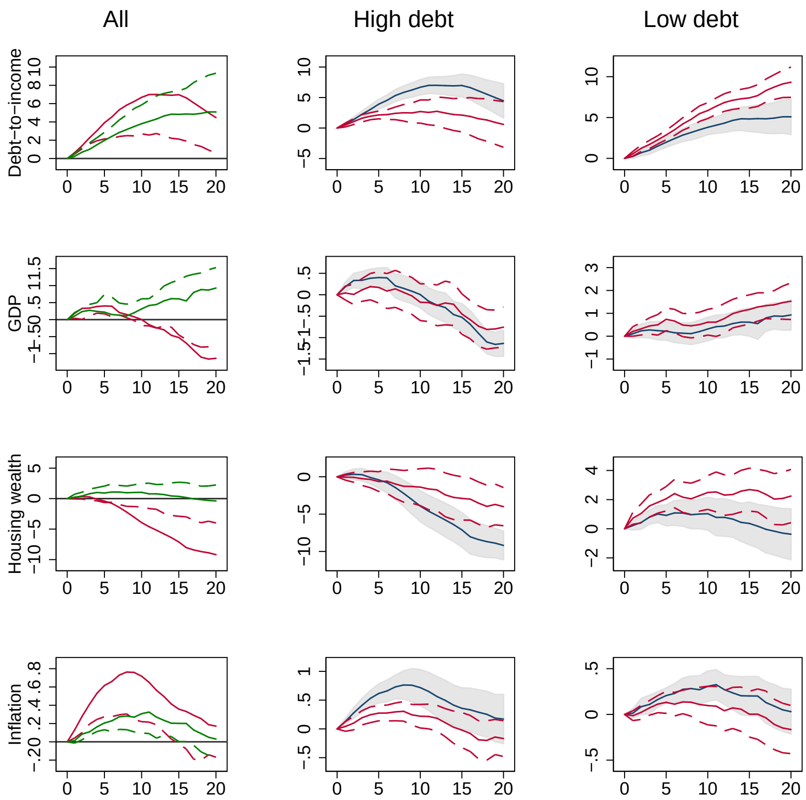
The picture is different for low debt states. A looser monetary policy stance stimulates household debt and economic activity in both periods, although the economic magnitude of these increases appears to be somewhat stronger during recessions. The statistical evidence is stronger for the response of consumption, suggesting that households in low debt states tend to increase their purchases of goods and services by more during recessions (Figure B.17 in Appendix B). In addition, housing wealth rises during recessions, while it is relatively muted during expansions. Overall, these findings support the view that looser monetary policy conditions at the state-level

[10] I get qualitatively similar results when defining recessions as two consecutive quarterly declines in real GDP.

[11] The total coefficient during recessions for low debt states is $\beta^h_L + \beta^h_{LR}$, for high debt states is $\beta^h_H + \beta^h_{HR}$, and for moderate debt states is $\beta^h_M + \beta^h_{MR}$.

can be more stimulative in states with low levels of debt, especially during bad times.[12]

Figure 9: Household debt and the state of the economy



Notes: Cumulative response of each variable to a one-standard deviation increase in the MPSG for h=1 to 20. 1^{st} column: red lines refer to high debt states, and green lines to low debt states; solid lines to expansions, and dashed lines to recessions. 2^{nd} and 3^{rd} columns show the point estimates for high and low debt states, where the solid blue (red) line is the point estimate for expansions (recessions) with the respective 90% confidence bands.

6 Robustness checks

I cross-check the sensitivity of the baseline results to alternative Taylor rules, which will then be used to replicate the impulse responses as in Section 5.

6.1 Alternative Taylor rules

The first alternative specification is an extended Taylor rule with financial indicators. In the standard framework, a central bank only reacts to financial imbalances to the extent that financial indicators, such as credit aggregates or house prices, impact directly on inflation and

[12] For the sake of completeness, I also provide estimates that rely on a different definition of 'bad' versus 'good' times: slack and non-slack periods. According to Ramey and Zubairy (2017), slack periods are more long-lasting than recessions. Moreover, while recessions indicate periods in which the economy is moving from its peak to its trough, slack periods measure the deviation of the economy from its steady-state or full employment, signalling under-utilisation of resources. Accordingly, I define state-specific slack periods as those when the unemployment gap for each state is above zero, and otherwise as non-slack periods. The estimates in Figure B.18 of Appendix B yield similar results as those from recessions versus expansions. One of the differences is in the muted response of GDP for high debt states during good times (non-slack periods), while it declines during expansions in the baseline framework.

economic activity. This implies that, for example, in a scenario where inflation is on, or close to, target, and economic activity is also close its potential, the prescribed policy rate may be too low if financial imbalances are building up in the economy. Consequently, the traditional Taylor rule might not capture adequately existing financial stability risks, implicitly creating a downward bias in the prescribed policy rate during financial booms and an upwards bias during financial busts (Borio et al. 2017, Hofmann and Bogdanova 2012).

The debate on the role of monetary policy in stabilising the business cycle and the financial cycle is, however, far from being settled. Svensson (2016), for instance, defends that, although leaning against the wind with higher interest rates might reduce real debt growth, it comes at a great cost in terms of higher unemployment and lower inflation. The alternative to address financial imbalances, he argues, is to use micro- and macro prudential policy, housing policy, or fiscal policy, and not monetary policy. Furthemore, Coibion and Gorodnichenko (2012) do not find evidence that financial variables matter *per se* in a statistically significant way in Taylor rules with US data. But the challenges on the trade-off between price stability and financial stability, which have been brought to the fore with the Great Recession, have led research to increasingly focus on taking financial vulnerabilities into account in the reaction function of the central bank (see, for instance, Adrian and Duarte 2016, Disyatat 2010, Juselius et al. 2016, Woodford 2012).

The related literature argues that financial cycles tend to be much longer (3 to 4 times) than business cycles, which usually last between 4 to 8 years. Following Drehmann et al. (2011), I capture the dynamics of financial cycles with the debt-to-income gap, which is computed as the deviation of the mortgage debt ratio from its long-term trend derived by a one-sided HP filter, using a smoothing parameter λ of 400,000 over a longer sample starting in the late-50s.[13] The high value for λ assumes that financial cycles could last up to 30 years, as a result of multiplying 1,600, the typical value for business cycles lasting 8 years, by the fourth power of the observation frequency ratio: $\lambda = 4^4.1{,}600 \simeq 400{,}000$. The (backward-looking) one-sided filter is more appropriate as it takes information that was only available at the time the assessment is made – i.e. the actual information set available to policy makers at each point in time – which differs from the two-sided filter that takes the full sample into account. I estimate this extended Taylor rule over 1984-2015 to account for both the leverage and subsequent substantial deleveraging in mortgage debt over the most recent period.

The second alternative Taylor rule deals with the challenge of the ZLB on nominal interest rates and the use of non-standard monetary policy measures by the Fed after 2008, which may have rendered the Fed funds rate less indicative of the actual monetary accommodation since that period. Lombardi and Zhu (2014) and Wu and Xia (2016) try to translate changes in the Fed's balance sheet into Fed funds rate equivalents by computing a shadow rate that measures the effective policy rate in the economy during ZLB periods. Their methods and estimates differ somewhat, but the main message is that the shadow rate has been significantly below zero after the Fed announced its first round of QE in November 2008 and cut its policy rate to a range of 0-0.25% in December 2008. Against this background, I re-estimate a Taylor rule using Wu and Xia (2016)'s shadow rate instead of the Fed funds rate as the dependent variable, and over

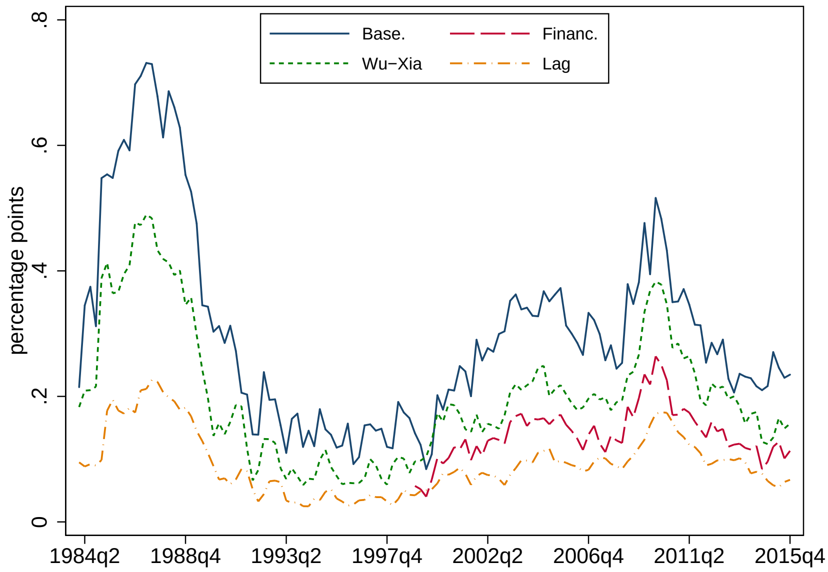
[13] I choose the mortgage debt gap as the main proxy for the financial cycle as it yields the best fit for the Taylor rule. But I get qualitatively similar results with the total debt gap or real house prices gap.

1984-2015 instead of ending the estimation in 2007.

The third and final specification takes a Taylor rule in which the central bank is assumed to react to past inflation and past unemployment gap (in practice I include inflation and unemployment gap with a lag in the Taylor rule). This specification tries to be more in the spirit of the actual available information for the Fed before each monetary policy meeting; the Fed observes inflation and unemployment only with a lag.

The dispersion of the baseline Taylor rule, as measured by the interquartile range, is generally somewhat higher with respect to the alternative specifications (Figure 10). In particular, the lower dispersion of the extended Taylor rule with the mortgage debt gap *(Finan.)* indicates that cross-state differences in the prescribed policy rates can be mitigated somewhat with a central bank that incorporates the financial cycle into its reaction function.[14] The second observation is that the dispersion of the specification with lagged inflation and unemployment gap *(Lag)* is the lowest. Nevertheless, this is related to the fact that the coefficient on the lagged interest rate increases compared with the baseline, while the coefficients on lagged inflation and unemployment gap decrease, and lose their statistical significance. What this specification tells us is that the heterogeneity in inflation and unemployment gaps across states does not matter so much to determine the relative stance of monetary policy; it is rather the result of a common policy inertia in the reaction function of the central bank.

Figure 10: Dispersion of alternative Taylor rules across US states



Notes: The figure plots the interquartile range of alternative Taylor rules for 30 US states. *Base.* is the baseline estimated Taylor rule, *Financ.* is the extended rule with the mortgage debt-to-income ratio gap, *Wu-Xia* takes Wu and Xia (2016)'s shadow rate, and *Lag* is an estimated Taylor rule with lagged inflation and unemployment gap.

6.2 Robustness of the impulse responses

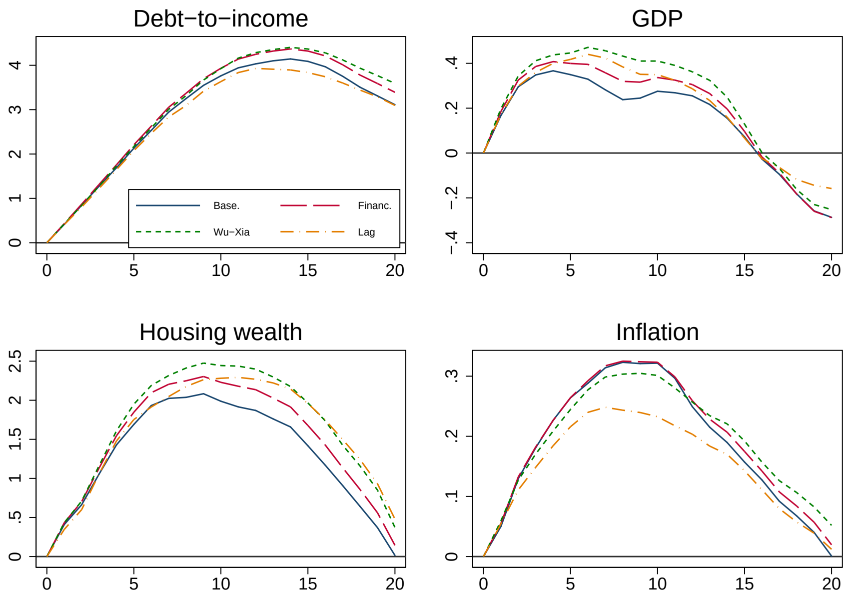
To check the robustness of the baseline impulse responses with the alternative Taylor rules, I recompute the MPSG for each state, as in Section 3.3, and then replicate Figure 6 which draws

[14]The dispersion for *Finan.* is computed since 1999q1, given data availability of mortgage debt for the states.

on Eq. (5), and Figure 8 from Eq. (6). I find that following a one-standard deviation increase in the state-specific MPSG, the baseline results remain strongly robust to all alternative Taylor rule specifications, both for the linear case (Figure 11) and when considering non-linearities related to different household debt levels across states (Figure 12).

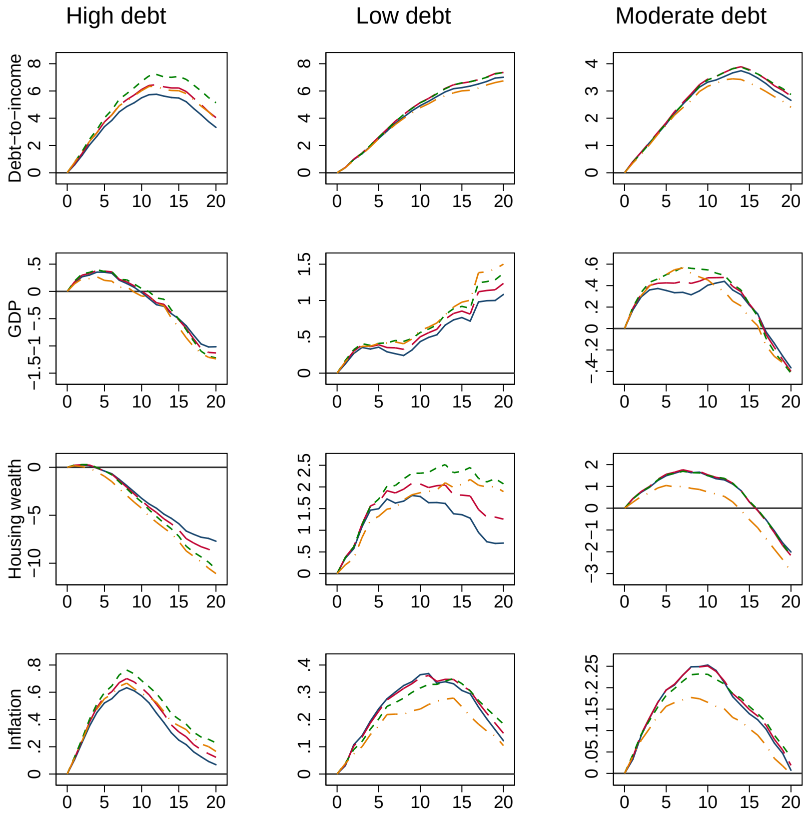
Furthermore, the fact that the extended Taylor rule that accounts for the financial cycle yields practically the same results as the baseline suggests that heterogeneity in the macro and financial responses between states can be captured reasonably well with a standard Taylor rule. In other words, it appears that when accounting for economic imbalances, the financial cycle does not produce additional significant heterogeneity in the impulse responses, even if the dispersion between the state-specific MPSG is lower than the baseline. This does not mean, however, that the financial cycle does not matter at the aggregate level; this analysis only hints at the financial cycle not being the crucial element in uncovering differences between the states when economic conditions are already accounted for.

Figure 11: IRF to an expansion in the MPSG for alternative Taylor rules



Notes: Cumulative response of each variable to a one-standard deviation increase in the MPSG for h=1 to 20. *Base.* is the baseline estimated Taylor rule, *Financ.* is the extended rule with the mortgage debt-to-income ratio gap, *Wu-Xia* takes Wu and Xia (2016)'s shadow rate, and *Lag* is an estimated Taylor rule with lagged inflation and unemployment gap.

Figure 12: Household debt: IRF to an expansion in the MPSG for alternative Taylor rules



Notes: Cumulative response of each variable to a one-standard deviation increase in the MPSG for h=1 to 20. The solid blue line is the baseline estimated Taylor rule, the long-dashed red line the extended rule with the mortgage debt-to-income ratio gap, the short-dashed green line the rule with Wu and Xia (2016)'s shadow rate, and the dashed-dotted orange line employs a Taylor rule with lagged inflation and unemployment gap.

7 Final remarks

In this paper, I have investigated the extent to which a common monetary policy in the United States might play a role in accentuating regional asymmetries in the macroeconomic and financial dynamics for a sample of 30 US states. The main finding of the paper suggests that the interaction of different levels of household debt with significant heterogeneity in the underlying monetary policy stance across states contributes to amplifying regional asymmetries. Particularly, I have found that a looser state-specific monetary policy stance is supportive of borrowing and growth in states with low household debt over five years, but that this is only the case in the short term for states with high household debt. Economic growth turns negative over the medium to longer run in high debt states, probably due to household deleveraging from excessive credit growth. At the same time, a decline in house prices may lead to lower housing wealth and equity, making it harder for households to take advantage of the home equity loan channel to refinance their mortgages. Further deleveraging may force households to cut back on consumption, reinforcing the decline in aggregate demand in the medium term, along the lines of the debt overhang theory of Eggertsson and Krugman (2012).

I have also found some evidence that the business cycle can accentuate the impact of monetary policy conditions on regional asymmetries in the dynamics of household debt, housing wealth and economic growth. Accordingly, looser monetary policy conditions can be more stimulative in states with low levels of debt, especially during bad times, while the decline in economic growth over the medium term in high debt states is statistically similar between recessions and expansions, although the debt dynamics is different in the two regimes.

Overall, this paper lends support to the view that a common monetary policy in the United States *does not fit all*. In fact, by stimulating borrowing in states that had already high household debt levels, a loose monetary policy stance might act as an amplification mechanism to on-going state-specific trends, producing regional asymmetries. The run-up to the last recession is a case in point. Since house prices and household debt proved to be on an unsustainable trajectory in some states, at a time when monetary policy appears to have been too accommodative in these states, a correction ensued which deepened the magnitude of their downturn. Against this background, the non-linear interactions between the heterogeneity in the monetary policy stance and household debt across US states play an important role in shedding more light on the distributional effects of monetary policy.

Appendix

A State-level data – 1999q1-2015q4

Total debt-to-income: sum of mortgage debt and consumer credit, including auto loans, credit card and student loans, divided by personal income. From 2013 to 2015, I interpolate annual data into quarterly with the Chow-Lin method, using the US aggregate household debt-to-income as the indicator variable. Source: NY Fed/Equifax.

Personal income per capita: income from labour (wages and salaries), from owning a home or business, from the ownership of financial assets, and government transfers, divided by population. Source: BEA.

Real GDP: Gross Domestic Product computed through the output or value-added approach. Annual data interpolated into quarterly from 1999 to 2004. Source: BEA.

House price index: Weighted, repeat-sales index measuring average price changes in repeat sales or refinancings on the same properties. It tracks the movement of single-family house prices. Source: Federal Housing Finance Agency (FHFA).

Homeownership rate: proportion of housing units that is owner-occupied, defined as the number of housing units that are occupied by owners divided by the total number of occupied housing units. Source: Census Bureau.

Real PCE: Spending on non-durable and durable goods, and services. Annual data interpolated into quarterly with the Chow-Lin method, using the relevant aggregate PCE series as the indicator variable. Source: BEA.

Unemployment rate: the unemployed aged 16 and over in percentage of total labour force, taken from the household survey. Time span: 1984q1-2015q4. Source: BLS.

Mortgage interest rate: effective interest rate on conventional mortgages (interpolated from annual data). Source: Federal Housing Finance Board.

Loan-to-value ratio: on conventional mortgages for previously occupied homes, excluding refinancing loans (interpolated from annual data). Source: FHFA.

Foreclosure rate: total number of loans in the legal process of foreclosure as a percentage of total number of mortgages in the pool. Source: Mortgage Bankers Association.

Table A.1: Descriptive statistics over 1999q1-2015q4

In levels

Variable	Obs	Mean	Std. Dev.	Min	Max
Monetary policy stance gap	2040	0.1	0.2	-0.8	1.0
State-level CPI proxy (% yoy)	2040	2.2	1.3	-3.8	5.7
Debt-to-income ratio	2040	82.8	20.5	40.9	153.3
Real GDP (log)	2040	12.4	1.0	10.5	14.6
Real housing wealth (log)	2040	23.6	1.2	21.0	26.0
Total real PCE (log)	2040	9.9	1.0	7.9	12.0
Real PCE: durables (log)	2040	7.8	1.0	5.7	9.8
Real PCE: non-durables (log)	2040	8.4	1.0	6.4	10.3
Real PCE: services (log)	2040	9.5	1.0	7.4	11.6
Unemployment rate (%)	2040	6.0	2.0	2.1	14.6
Real personal income p.c.	2040	27.1	7.3	18.5	57.5
Homeownership rate (%)	2040	67.9	7.3	37.6	82.4
Mortgage interest rate (%)	2040	5.7	1.2	3.6	8.5
Loan-to-value ratio (%)	2040	76.6	3.5	64.8	85.4
Foreclosure rate (%)	2040	2.2	1.8	0.2	14.5

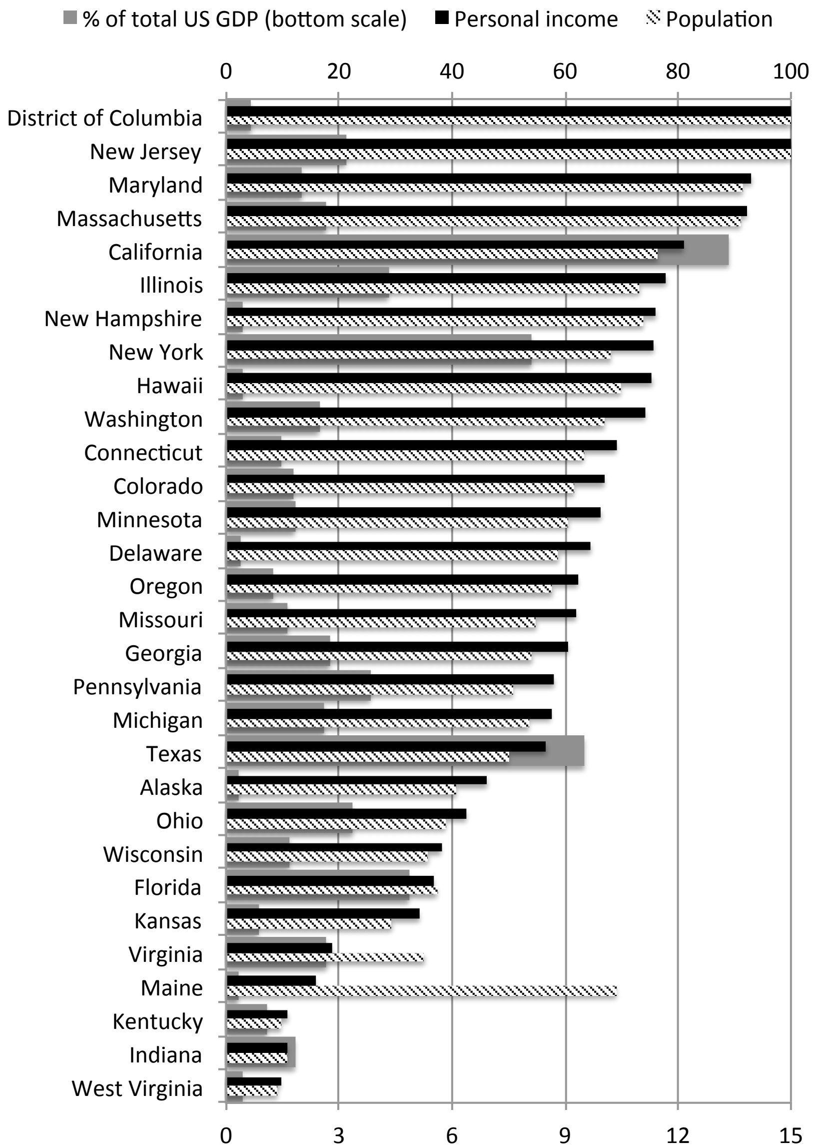
In first differences

Variable	Obs	Mean	Std. Dev.	Min	Max
ΔMonetary policy stance gap	2040	0.0	0.1	-0.4	0.5
ΔState-level CPI proxy	2040	0.0	0.8	-4.8	3.7
ΔDebt-to-income ratio	2010	0.3	2.6	-13.0	17.6
ΔReal GDP (%)	2040	0.4	1.2	-6.4	11.6
ΔReal housing wealth (%)	2040	0.5	3.1	-11.2	12.3
ΔTotal real PCE (%)	2040	0.5	0.7	-3.2	2.8
ΔReal PCE: durables (%)	2040	0.2	2.2	-9.5	9.2
ΔReal PCE: non-durables (%)	2040	0.4	1.3	-8.4	4.1
ΔReal PCE: services (%)	2040	0.6	0.7	-1.6	4.1
ΔUnemployment rate	2040	0.0	0.3	-0.8	2.6
ΔReal personal income p.c.	2040	0.1	0.4	-2.1	2.6
ΔHomeownership rate	2040	0.0	1.5	-5.7	6.8
ΔMortgage interest rate	2040	0.0	0.1	-0.3	0.2
ΔLoan-to-value ratio	2040	0.0	1.2	-9.9	10.8
ΔForeclosure rate	2040	0.0	0.2	-1.1	1.6

Sources: Bureau of Economic Analysis, Bureau of Labor Statistics, Census Bureau, Federal Housing Finance Agency, Federal Housing Finance Board, Mortgage Bankers Association, NY Fed/Equifax, and author's calculations.

B Tables and figures

Figure B.13: State coverage according to personal income and population - in %



Notes: Sorted by decreasing personal income coverage.

Figure B.14: State-level CPIs – yoy % change

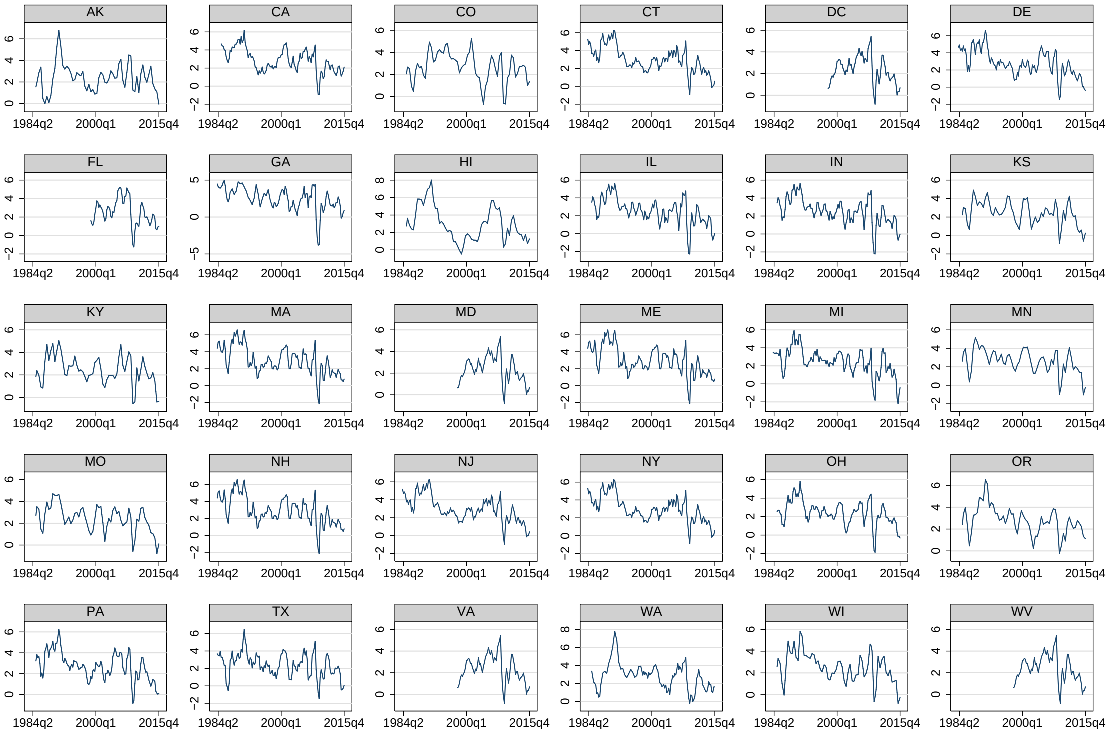
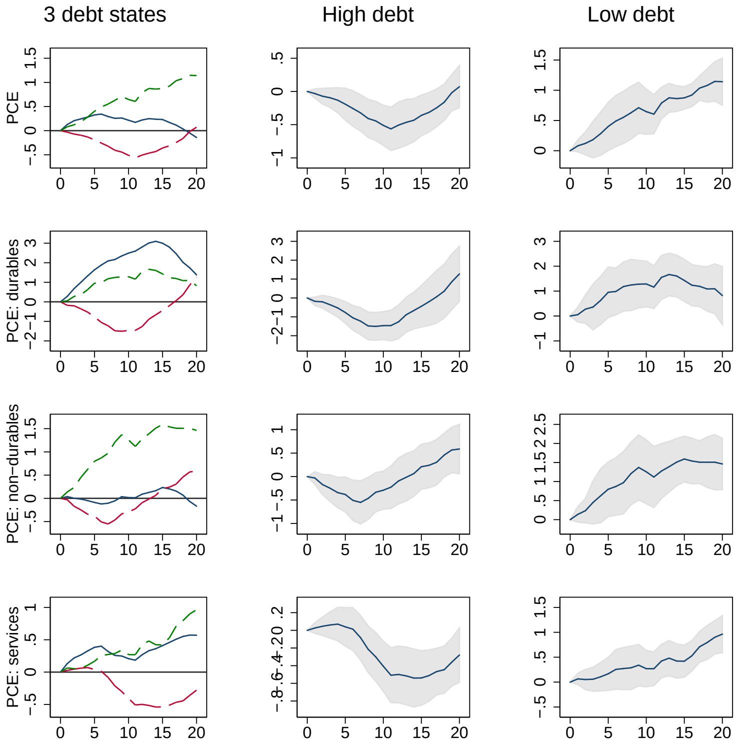


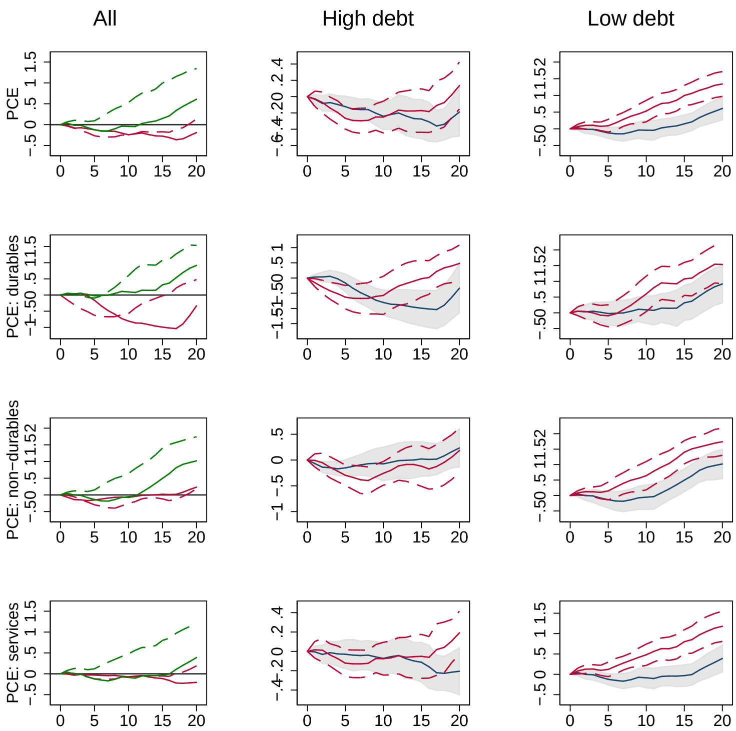
Figure B.15: Monetary policy stance gaps for US states

Figure B.16: Consumption: Household debt and state-specific monetary policy conditions



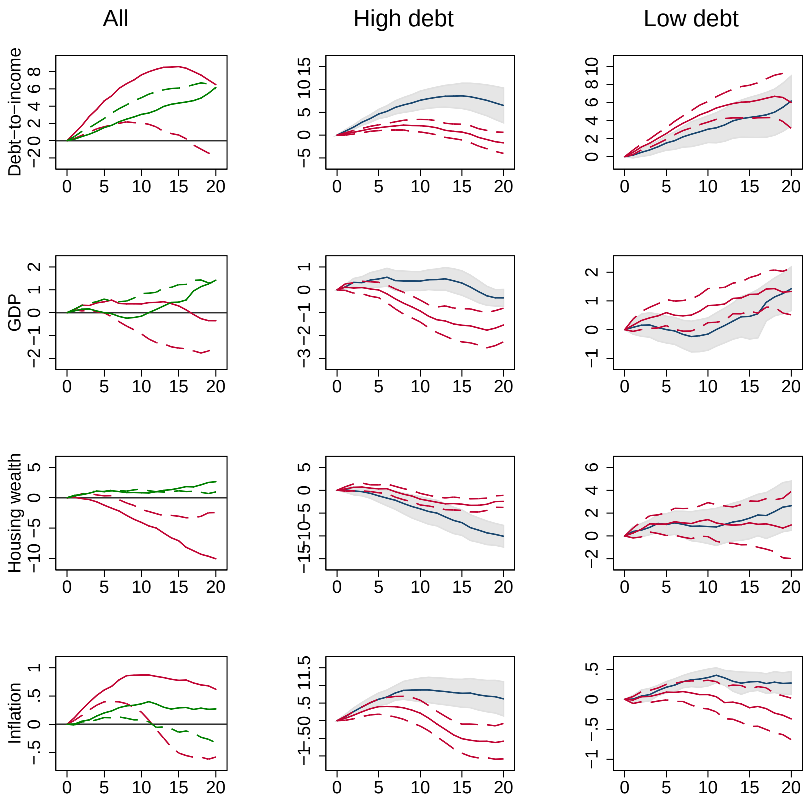
Notes: Cumulative response of each variable to a one-standard deviation increase in the MPSG for h=1 to 20. 1st column: the long-dashed red line refers to states with high household debt; the short-dashed green line to states with low debt; the solid blue line to states with moderate debt. 2nd and 3rd columns show the point estimates for high and low debt states with the associated 90% confidence bands.

Figure B.17: Consumption: Household debt and the state of the economy



Notes: Cumulative response of each variable to a one-standard deviation increase in the MPSG for h=1 to 20. 1st column: red lines refer to high debt states, and green lines to low debt states; solid lines to expansions, and dashed lines to recessions. 2nd and 3rd columns show the point estimates for high and low debt states, where the solid blue (red) line is the point estimate for expansions (recessions) with the respective 90% confidence bands.

Figure B.18: Household debt and the state of the economy: slack vs non-slack



Notes: Cumulative response of each variable to a one-standard deviation increase in the MPSG for h=1 to 20. 1^{st} column: red lines refer to high debt states, and green lines to low debt states; solid lines to non-slack periods, and dashed lines to slack periods. 2^{nd} and 3^{rd} columns show the point estimates for high and low debt states, where the solid blue (red) line is the point estimate for non-slack (slack) periods with the respective 90% confidence bands.

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