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

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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 1999-2017, I find that a common monetary policy may contribute 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 (Fed) 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.

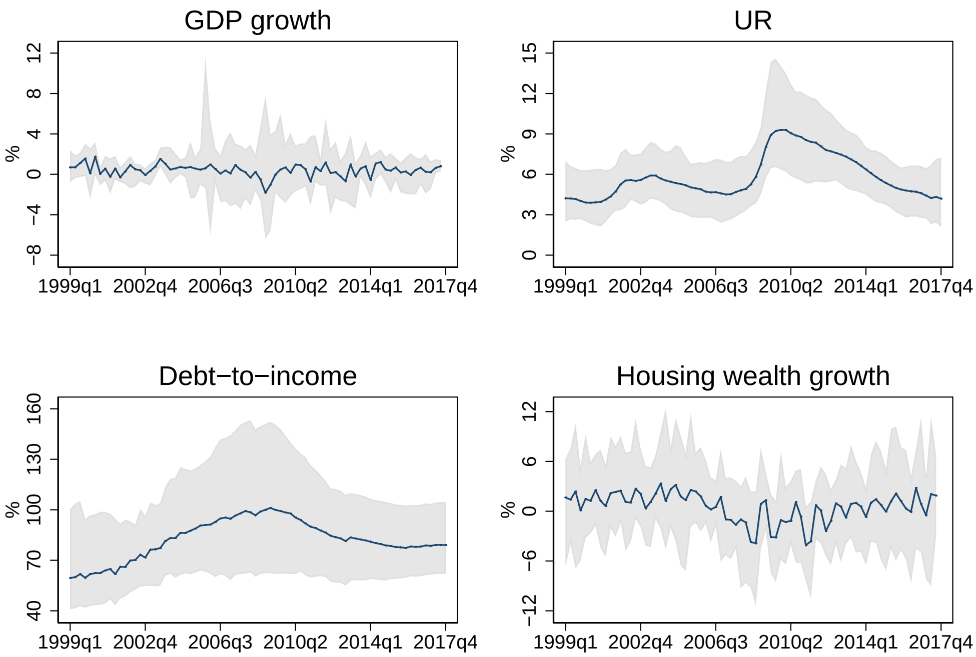
One of the candidates to explain how monetary policy may transmit differently to the US states is household debt. The choice of household debt to study the state-dependent effects of monetary policy is underscored by the considerable cross-state heterogeneity in household debt levels and dynamics over the last two decades, coupled with a significant divergence in economic performance between states with high and low household debt over the same period: while states like California and Florida went through a damaging boom-bust cycle, others such as Texas, Indiana and Ohio, did not observe large swings in household debt (and house prices), and weathered the crisis relatively well. While recent research has found that high household debt, household debt build-ups or excessive borrowing are detrimental to future economic growth, such as Albuquerque and Krustev (2018), 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.

The literature has not, in effect, reached a consensus on the effectiveness of monetary policy conditional on different household debt levels. On the one hand, monetary policy may be *more effective* when household debt is *high* since Bernanke et al. (1999)'s 'financial accelerator' implies that looser monetary policy stimulates house prices and consequently borrowers may increase consumption by extracting more equity from their houses. In addition, monetary policy

[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.

may also be more powerful when debt is high, as highly-indebted households are typically associated with a high marginal propensity to consume (Hedlund et al. 2016). On the other hand, monetary policy may be *less effective* if households are reluctant to take on more debt when their indebtedness is already high, or if borrowing constrains are binding, along the lines of the debt overhang theory of Eggertsson and Krugman (2012). In addition, the home equity loan channel may be less operational around periods of high debt, which prevents households from borrowing against their homes (Alpanda and Zubairy 2017).

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.

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. I focus on debt in the household sector as Jordà et al. (2015) document that the strong rise in private debt in several Western countries in the second half of the 20^{th} century has been driven mainly by credit to households, particularly mortgage debt. 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. (2017), 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).

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 1999-2017 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 an US aggregate Taylor rule estimated on real-time expectations data 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*. Specifically, I find that monetary policy may amplify asymmetries in the household debt dynamics and economic performance between states. While a looser state-specific monetary policy stance is supportive of borrowing and growth in states with low household debt (relative to an estimated state-specific trend), 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 is associated with a decline in economic growth over the medium term. My estimates suggest that a one-standard deviation increase in the state-specific monetary policy stance leads to lower real GDP of 1.8 p.p. in high debt states compared to low debt states over five years.

I hypothesise that lower economic growth in high debt states after a loosening in the state-specific monetary policy stance appears to be related to the need of households to deleverage from excessive credit. Since households in these states were already highly indebted to begin with, more borrowing in the short run may place debt at even higher levels relative to income, 'forcing' households to deleverage and cut back on consumption expenditures, along the lines of the debt overhang theory of Eggertsson and Krugman (2012). At the same time, I also find that house prices do not increase in high debt states, making it harder for households to take advantage of the home equity loan channel to extract more equity from their homes or to refinance their mortgages, as suggested by Alpanda and Zubairy (2017).

In contrast, I find that looser monetary policy conditions at the state level are effective in fostering growth and borrowing in low debt states. For example, house prices and housing wealth rise consistently over the whole horizon, 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.

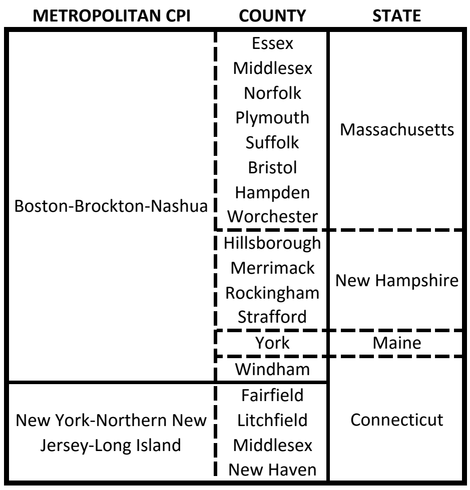
The main findings remain robust to alternative specifications for the Taylor rule, from which I derive the state monetary policy stances: by using Wu and Xia (2016)'s shadow rate to deal with unconventional monetary policy during the zero lower bound (ZLB) on nominal interest rates; when accounting for the financial cycle; by using the unemployment gap as an alternative slack measure; and by estimating a Taylor rule on actual data.

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 estimates of regional price deflators, the Implicit Regional Price Deflator (IRPD), but it is only available at a annual frequency, and it covers a short period (2008-2015).

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 1984-2017 by resorting to CPI data for 26 US MSA from the Bureau of Labor Statistics (BLS).[2] Although these MSA only cover 30 states, the states together are quite representative of the US reality, accounting for around 82% of total US GDP. I compute the state-level CPI by mapping the MSA to the states (for more details, see the online appendix). When doing the mapping, two main challenges arise. For example, Boston-Brockton-Nashua metropolitan area 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 challenge 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



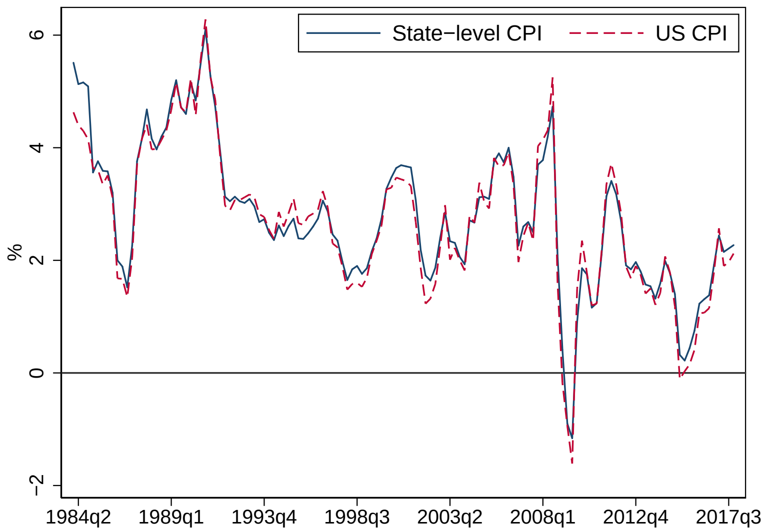
In terms of the counties covered by the CPI data for each state, states with lower coverage

[2]The BLS actually published data for 27 MSAs until end-2017, but I dropped Phoenix-Mesa, Arizona, as it is only available from 2002. Some of these MSAs, however, have been discontinued in January 2018 – which does not affect the construction of the CPI proxy for the period I am covering in the paper – as the BLS introduced a new geographic area sample for the CPI. Specifically, from January 2018, the BEA has started using the 2010 Decennial Census, while also incorporating an updated area sample design. It has also changed the frequency of publication for some areas, and has created new local area and aggregate indexes. All in all, the BEA is currently publishing CPI data for 23 MSA.

have, in general, a relatively lower weight in US GDP, whereas larger states tend to be better covered (see the online appendix). 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. One of the concerns is, therefore, that the CPI of these states with low coverage may be biased if the counties not covered by the MSA data exhibit different price dynamics. In the online appendix, I show that there is not any association between how much of the state is covered by MSA data and the 'quality' of the resulting CPI inflation when compared with the BEA's IRPD.

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 1984-2017 (Figure 3). In the online appendix, I also show that the annual inflation rates of my CPI indicator for each state are closely in line with those from the BEA's IRPD.

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 – also called the *reaction function* of the central bank. The rule 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 Fed, 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.

Since the early 90's, and until a few years ago, the most common and widely used interest rate rules originated from Taylor (1993, 1999), who assume that the central bank reacts contemporaneously to deviations in inflation and output. Nevertheless, the estimated contemporaneous response of the central bank to economic fluctuations in these early specifications might be biased on grounds of endogeneity issues. Related to this point, by using actual data, the traditional Taylor rules fail to incorporate the forward-looking aspect of the monetary policy decision process, whereby policy makers set interest rates according to their forecasts on inflation and economic slack. In addition, and although these traditional rules have described particularly well the conduct of US monetary policy 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. This has led some economists to deem monetary policy 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).

Against this background, I depart from the aforementioned traditional Taylor rules in three ways. First, to minimise the endogeneity concerns and to model more adequately the interest-rate decision process in a forward-looking manner, I follow a recent strand of the literature and use real-time expectations data for the central bank, instead of actual data (Coibion and Gorodnichenko 2011, 2012, Orphanides 2003). In particular, I use the Greenbook forecasts prepared by the Fed Board staff to inform Fed officials prior to each FOMC meeting. These forecasts are made available to the public with a five-year lag. Since the Fed forecasts on inflation and economic activity are made *before* each FOMC meeting, at which the interest rate is set, I can treat the forecasts as exogenous, and estimate the modified Taylor rule by OLS (for a more detailed discussion on why OLS is appropriate to estimate the Taylor rule using Greenbook forecasts, see Coibion and Gorodnichenko 2011).

Second, I allow for interest-rate smoothing in the Taylor rule, which means that the central bank adjusts the policy rate to changes in economic conditions in a gradually fashion, rather than immediately as implied by the classical Taylor rule. More specifically, I include the lagged dependent variable in the estimated regression, as in Coibion and Gorodnichenko (2012).[3] Taylor rules that take into account the degree of policy inertia in central banks' reaction function have increasingly become more popular, helping to track better the actions of central banks, and therefore closing the gap between the prescribed policy rates and those effectively set by the central bank (Coibion and Gorodnichenko 2011, 2012).

The last modification I make to the classical Taylor rule is to allow the central bank to react

[3]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.

also to GDP growth, as advocated by Ireland (2004), and not only to inflation and the amount of slack in the economy (measured with the output gap). Following Coibion and Gorodnichenko (2012), the Taylor rule used in this paper is as follows:

$$i_t = c + \phi_\pi E_{t-}\pi_{t+h_\pi} + \phi_x E_{t-}x_{t+h_x} + \phi_{\Delta y} E_{t-}\Delta y_{t+h_{\Delta y}} + \rho i_{t-1} + \epsilon_t \tag{1}$$

where i is the policy rate (Fed funds rate), E_{t-} refers to the forecast of a given macroeconomic variable made prior to the FOMC meeting, i.e., before setting the interest rate, where h is the forecasting horizon, π is annualised CPI inflation, x is the output gap measured as the deviation of actual output from potential, and Δy is GDP growth.[4] Regarding the parameters, the coefficient ϕ_π is expected to be positive and above 1, to respect the Taylor principle, ϕ_x to be negative, as larger slack in the economy requires a lower policy rate, and $\phi_{\Delta y}$ to be positive. The constant term includes the steady-state level of the interest rate, and the time-invariant target levels of inflation and output growth.

Before I estimate the equation above with quarterly data, and given that there are typically eight FOMC meetings per year, I follow Coibion and Gorodnichenko (2012) and select the meeting dates closest to the middle of the quarter so as to have forecasts from the Greenbook on a quarterly basis. I also follow Coibion and Gorodnichenko (2012) and take the average forecast for inflation over *t+1* and *t+2* as the relevant horizons ($h_\pi = 1, 2$), while for the output gap and GDP growth I take the contemporaneous forecast ($h_x = h_{\Delta y} = 0$). I estimate the Taylor rule in Eq. 1 for the US aggregate on quarterly data over 1984q1-2007q4, with Newey-West corrected standard errors. I stop the estimation at the end of 2007, thus excluding the ZLB period around and after the Great Recession as it has arguably distorted the relationship between conventional monetary policy and the real economy:

$$\hat{i}_t = \underset{(0.14)}{-0.76^{***}} + \underset{(0.06)}{0.29^{***}} E_{t-}\pi_{t+1,t+2} + \underset{(0.02)}{0.08^{***}} E_{t-}x_t + \underset{(0.02)}{0.22^{***}} E_{t-}\Delta y_t + \underset{(0.04)}{0.89^{***}} i_{t-1} + \epsilon_t \tag{2}$$

All the coefficients are estimated with high precision, and are fully in line with those in Coibion and Gorodnichenko (2012), who estimate Taylor rules with Greenbook forecasts over 1987q4-2006q4. The long-term coefficient on inflation is estimated to be 2.54, thus respecting the Taylor principle, whereby the central bank responds more than one-to-one to changes in expected inflation.[5] The Fed also adjusts the policy rate in a highly statistically significant way to the expected contemporaneous output gap and GDP growth, with the long-term coefficients estimated to be respectively 0.73 and 1.89. In addition, the lagged term on the dependent variable lies in the region of 0.8-0.9 typically found in the literature (Coibion and Gorodnichenko 2011, 2012, Orphanides 2003).

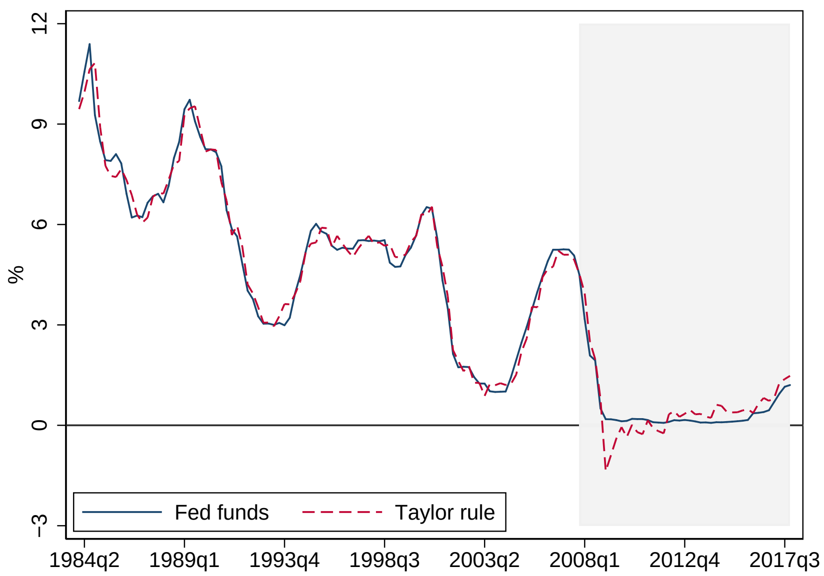
This type of Taylor rule with interest-rate smoothing, estimated on real-time forecasts from the Fed staff Greenbook, can account for most of the policy changes over the last two and a

[4]In Section 6 I show that the main results remain robust when I use the unemployment gap as the slack measure. In addition, I get qualitatively the same results when I estimate the aggregate Taylor rule with Fed forecasts for different inflation measures: (i) the Personal Consumption Expenditure (PCE) deflator, the official Fed's target, (ii) core CPI, or (iii) the GDP deflator. Results available upon request.

[5]The long-term coefficients result from dividing the short-run coefficients by one minus the coefficient on the lagged dependent variable (1-0.89).

half decades until the Great Recession, as evidenced by the high R-squared of 98%. The same information can be illustrated by plotting the fitted values from the regression above against the Fed funds rate (Figure 4). The high degree of policy inertia can also be seen by using the estimated coefficients to extend the Taylor rule over 2008-17: the out-of-sample fitted values continue to track rather closely the actual Fed funds rate.[6] Given the 5-year publication lag in the Greenbook forecasts, I use real-time median expectations from the Survey of Professional Forecasters (SPF) to compute the fitted values from 2012 onwards.[7,8] Although there is evidence that the Greenbook forecasts tend to perform better than the SPF (Romer and Romer 2000), the argument to complement the Greenbook with the SPF forecasts over 2012-17 is based on more recent research that has found that the gap in the (inflation) forecasting performance between the Greenbook and private sector forecasts has been narrowing considerably since the mid-1980s, and especially after 1994 (Gamber and Smith 2009).

Figure 4: The Fed funds rate vs monetary policy rules



Notes: The dashed red line refers to the fitted values of the Taylor rule estimated over 1984q1-2007q4 from Eq. 2. The grey shaded area represents out-of-sample values since 2008q1.

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 1999q4-2017q2, using the estimated coefficients from Eq. (2). To be clear, I do not re-estimate Taylor rules for each state given that I assume the same reaction

[6] 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 show in Section 6 that the main findings remain robust to using a concept of a shadow rate – measuring the effective policy rate during ZLB periods – from Wu and Xia (2016).

[7] The Survey of Professional Forecasters is a quarterly survey of US macroeconomic forecasts made by a large number of private sector agents, including financial and non-financial. The survey is published around the second week of the second month of a given quarter. It started in 1968, and it is currently maintained, since 1990, by the Federal Reserve Bank of Philadelphia.

[8] I use potential output from the Congressional Budget Office (CBO) to compute the output gap for the SPF, as the survey participants are not asked to forecast potential output; the closest variable they report is the forecast of annual average growth over the following ten years.

function for the central bank. Differences in prescribed policy rates across states come from inflation, output gap and GDP growth differentials, not from the coefficients themselves.

I should make a few additional remarks about the Taylor rules with state-level data. Firstly, in contrast to the central bank's real-time expectations data used before for the US aggregate, I use actual data on output and inflation for the US states given the lack of available forecasts at this level of disaggregation. In particular, I use average inflation values over the following two quarters, and the contemporaneous output gap and GDP growth. In a robustness check in Section 6, I show, however, that the main results and findings remain relatively similar when I estimate a Taylor rule with actual data, to be consistent with the state-level variables.

Secondly, I estimate the output gap for each state by filtering out the real GDP series from its transitory component with the new method developed by Hamilton (2018). His approach overcomes the typical issues associated with the Hodrick-Prescott (HP) filter, particularly that the latter produces spurious dynamic relations with no basis in the underlying data generating process, and the well-known end-of-sample issue. Hamilton's new method essentially translates into regressing a given non-stationary variable at $t{+}h$ on a constant and on the four most recent values of the dependent variable available at time t. Hamilton (2018) suggests to set the forecasting horizon at h=8 quarters.

Finally, my sample starts in 1999q4 as a result of data availability on real GDP. Although GDP data are available since 1997, I lose the first 11 quarterly observations in the dataset given that the Hamilton method requires lags 8, 9, 10, and 11 when estimating the cyclical component of real GDP for h=8.

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 4-quarter moving average of the interquartile range, has indeed been non-negligible, particularly in the run-up to the 2008/09 crisis (Figure 5). The rise in the cross-state heterogeneity over that period indicates that the divergence in economic performance across US states also called for different interest rates. At the trough of the last recession in early-2009, the prescribed interest rate ranged from around -2.0% to +0.4%, at a time when the estimated Taylor rule for the US aggregate was at -1.4%, while the Fed funds rate was practically at zero. After a decline in the dispersion in the aftermath of the Great Recession, there have been some signs more recently showing again an increase in the dispersion across states.

3.3 Monetary Policy Stance Gap

In a next step, I 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

Figure 5: Dispersion of Taylor rules across US states

Notes: The figure shows the 4-quarter moving average of the interquartile range of the Taylor rules for 30 US states.

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, output gap, GDP growth and the equivalent variables at the aggregate level (the weights are the parameter estimates from Eq. 2):

$$MPSG_{i,t} = \phi_{\pi}(\pi_{i,t+1,t+2} - \pi^{US}_{t+1,t+2}) + \phi_x(x_{i,t} - x^{US}_t) + \phi_{\Delta y}(\Delta y_{i,t} - \Delta y^{US}_t), \quad i = 1, ..., 30; \quad (3)$$

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 higher inflation, a more positive or less negative output gap, stronger GDP growth, or a combination of the three, 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.

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.12 in Appendix B). For instance, states such as Florida and California, which have undergone a pronounced housing market boom-bust cycle, are among the states with the loosest monetary policy stance before the crisis – taking the average MPSG over that period – 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).[9]

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

The LP approach also offers important advantages in modelling non-linearities over alternative methods, such as Markov-switching (MSVAR) or threshold VAR models (TVAR).[10] The main advantage of the LP method over these two alternative techniques is that it neither requires us to take a stance on the duration of a given state nor on the transition dynamics between states (i.e., between high and low debt states). For instance, Ramey and Zubairy (2018) stress that in the presence of non-linearities the LP method delivers more realistic estimates of the fiscal multiplier, and more consistent with the data generating process; Tenreyro and Thwaites (2016) make similar points on monetary policy. In the LP method, the impulse responses of a given dependent variable at $t+h$ is a forecast of how that variable will change at that horizon when another variable changes (MPSG in this paper) at t. The estimated coefficients in the LP framework thus measure the average effect of the MPSG on the dependent variable, as a function of the state dependencies – different debt states or recessions versus expansions – when the MPSG changes at time t. If the average effect of the MPSG is likely to affect the state-dependencies in the forecasting horizon – say, moving from high to low debt state – this will be reflected in the impulse response estimate. The other transitions between regimes that are independent of the MPSG are captured by the state-dependent control variables.[11] In MSVARs

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

[10] In a TVAR model, the coefficients are allowed to evolve from one regime/state to another, conditional on a pre-specified threshold value, similarly to the LP method in which state-dependencies are defined and imposed *a priori*. When the transition between regimes is allowed to be gradual, we call it smooth-transition VAR (STVAR). In turn, in a MSVAR, the regimes are determined endogenously according to a discrete Markov process, whereby probabilities to the different regimes or states are assigned at each point in time.

[11] For a more detailed explanation, seeRamey and Zubairy (2018).

or STVAR, however, the impulse responses assume that there is no change in the state of the economy, which may therefore bias the state-dependent impulse responses.

Moreover, the LP method models non-linearities in a more parsimonious way, compared to the highly-parameterised and computationally intensive MSVAR or TVAR models, especially in a panel data context. For instance, the LP method does not require us to estimate or calibrate transition probability functions as in STVARs or MSVARs. Third, LP make use of the full sample to estimate the non-linearities, while in TVARs the state-dependencies/regimes are estimated in separate models, which might complicate the estimation in the presence of a large set of parameters. Along the same lines, the estimation of MSVAR models may be unreliable and sometimes become infeasible for large models. In addition, if a regime does not appear very often in the sample, especially relevant when I combine the debt states with the state of the economy (Section 5.3), the lack of enough degrees of freedom in TVAR models makes it challenging to estimate precisely the responses conditional on the debt states.

Before I present the state-dependent (non-linear) effects of the MPSG, I estimate a linear version of the model. Specifically, for each horizon h=1,2...,20 I estimate the following model with Fixed Effects over 1999q4-2017q2:

$$\Delta_h Y_{i,t+1+h} = \alpha^h + \beta^h MPSG^h_{i,t} + \lambda^h \Delta \log(X^h_{i,t-1}) + \eta^h_i + \zeta_t + \epsilon_{i,t+1+h} \tag{4}$$

The dependent variables are computed as cumulative changes from quarter *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, $X_{i,t-1}$ the lagged dependent variables and lagged MPSG used as controls, 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.[12] 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 (2018), housing wealth is as follows, where HPI is the FHFA House Price Index (all variables available at the state level):

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

I deal with the issue of endogeneity and 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 quarter *t+1* to *t+1+h*, and estimating the model starting only

[12] I have run alternative specifications by: (i) adding several state-specific macro and financial variables as controls, which include income per capita, 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 GDP and the DTI to account for income effects and reversion to the mean. The main results remain broadly insensitive to these alternative specifications. Results available upon request.

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.

In addition, I carry out an exercise to show further that the method above of assuming that the MPSG cannot affect the dependent variables contemporaneously is able to yield impulse responses that are likely not biased by endogeneity and reverse causality. Specifically, I purge the MPSG from state-specific macro and financial variables, by resorting to the method of Bassett et al. (2014), who propose a procedure to purge banks' lending standards from influences of key macro and bank-specific factors. I apply their method by regressing for each state the MPSG on state-specific inflation, GDP growth, debt-to-income and house price growth. I take the residuals of this regression as the new MPSG measure purged from state-specific macro and financial variables. I show in the next section that the resulting impulse responses are broadly in line with the baseline results.

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.

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

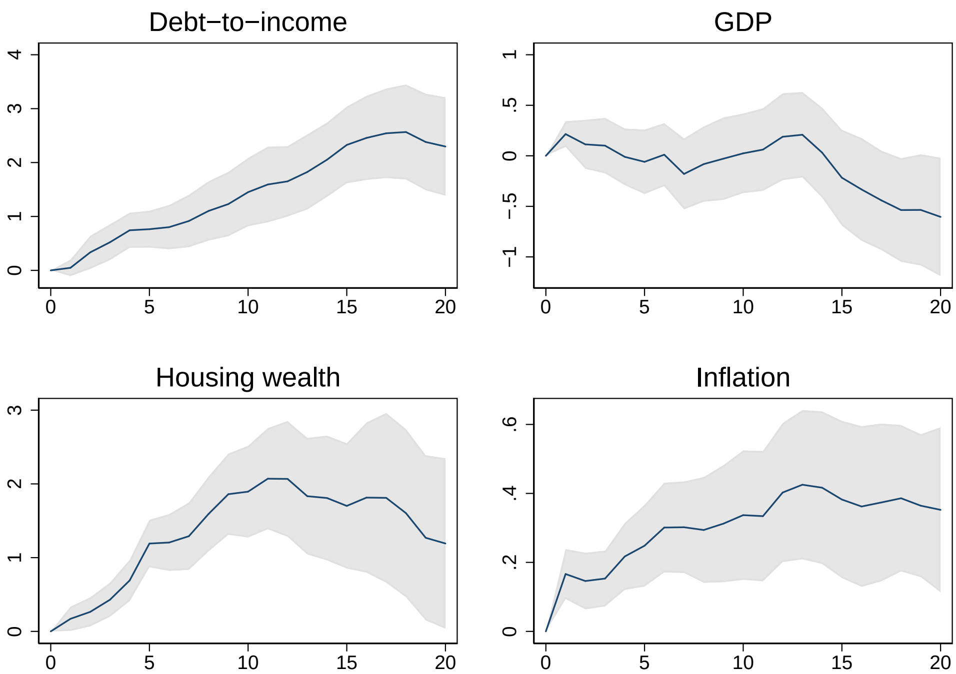
When estimating Eq. (4), and to better assess the economic relevance of the results, I calibrate the estimates to show the impulse responses to a one-standard deviation increase in the MPSG (0.5 p.p.). I find that an increase in the MPSG (looser monetary policy conditions in a specific state relative to the US aggregate) induces more household debt in a persistent and highly statistically significant way over the whole horizon (Figure 6).[13] The DTI is higher by roughly 0.8 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 2.5 p.p. after four years. At the same time, house prices also rise when state-specific monetary conditions become less restrictive, reflected in the hump-shaped profile of housing wealth that reaches a peak of 2.1% after two to three years.

[13] I get qualitatively similar impulse responses when I purge the MPSG from state-specific economic and financial variables, as illustrated in Figure B.13 of Appendix B, suggesting that my estimates are likely not plagued by reverse causality and endogeneity issues.

The rise in household debt and housing wealth after an increase in the MPSG is in line with the expected macro 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 by Bhutta and Keys (2016).

The response of real GDP displays a hump-shaped profile, with an increase in the very short run of 0.2%, before steadily converging to the baseline. The LP method, however, yields point estimates for the GDP response that are a bit erratic, and associated with large standard errors. Moreover, looser monetary policy also lifts consumer prices, which remain statistically above the baseline for the whole projection horizon.

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. (4)). The grey area refers to the 90% confidence bands.

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 some tentative evidence for this mechanism when I use household consumption and its main components as dependent variables in Eq. (4). Although it tends to remain flat over the short run, consumption rises over the medium term when monetary policy conditions become looser (Figure B.14 in Appendix B). The responses are stronger in durable goods, followed by services, while the response of non-durables is more muted. 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.[14] The estimated responses, however, are surrounded by significant uncertainty, probably related to the statistical noise from interpolating the original annual PCE data into quarterly.

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 choice of household debt to study the state-dependent effects of monetary policy is underscored by the considerable cross-state heterogeneity in household debt levels over the last 20 years, coupled with a significant divergence in economic performance between states with high and low household debt. Furthermore, while recent research has found that excessive borrowing is detrimental to future economic growth (Albuquerque and Krustev 2018, 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.

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 (2018) 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 over the last 20 years was far from being uniform across states.[15] Is a common monetary policy

[14] 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.

[15] 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

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), who 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. First, I compute the debt-to-income gap for each US state, which I define as the deviation of the debt ratio from its trend derived with the Hamilton (2018) method described in Section 3.2. Second, and in contrast with Alpanda and Zubairy (2017), I define three debt periods instead of just two, in order to also allow monetary policy conditions to transmit differently to states with debt gaps at moderate levels. Specifically, I extend Eq. (4) with $\Phi^H_{i,t-1}$, a pre-determined time-varying dummy where 1 refers to states with a high debt gap, more specifically those belonging to the top quintile of their debt-to-income gap distribution, and with $\Theta^L_{i,t-1}$ that takes the value of 1 for states with a low debt gap, those in the first quintile. The remainder states with a moderate debt gap belong to the quintiles in between. The subscripts *M*, *H*, and *L* indicate the coefficients for moderate, high and low debt states:

$$\begin{aligned}\Delta_h Y_{i,t+1+h} =& \alpha^h_M + \beta^h_M MPSG^h_{i,t} + \lambda^h_M \Delta \log(X^h_{i,t-1}) \\ &+ \Phi^H_{i,t-1}\left[\alpha^h_H + \beta^h_H MPSG^h_{i,t} + \lambda^h_H \Delta \log(X^h_{i,t-1})\right] \\ &+ \Theta^L_{i,t-1}\left[\alpha^h_L + \beta^h_L MPSG^h_{i,t} + \lambda^h_L \Delta \log(X^h_{i,t-1})\right] \\ &+ \eta^h_i + \zeta_t + \epsilon_{i,t+1+h}\end{aligned} \tag{5}$$

By computing the debt gap individually for each state, I allow the US states to have household debt deviating from their trend at different points in time, which means that, in a given quarter, state A can transition from a high debt state relative to its trend to a moderate or low debt state in subsequent quarters. In other words, by exploring state-specific debt periods, I do not impose that all US states should have been in a high debt state in the run-up to, and during, the Great Recession, as suggested by aggregate data, such as in Alpanda and Zubairy (2017). According to my approach, the cross-state dispersion in the debt gaps are indeed considerable over the last 20 years, giving support to defining the debt gaps at the state level rather than defining common periods from aggregate data: around 20% of the states had high debt in the years preceding the Great Recession, which then rose to an average of 50-60% during the crisis period. More recently, the substantial household deleveraging has allowed most of the states to transition from a high debt state to either a moderate or low debt states.

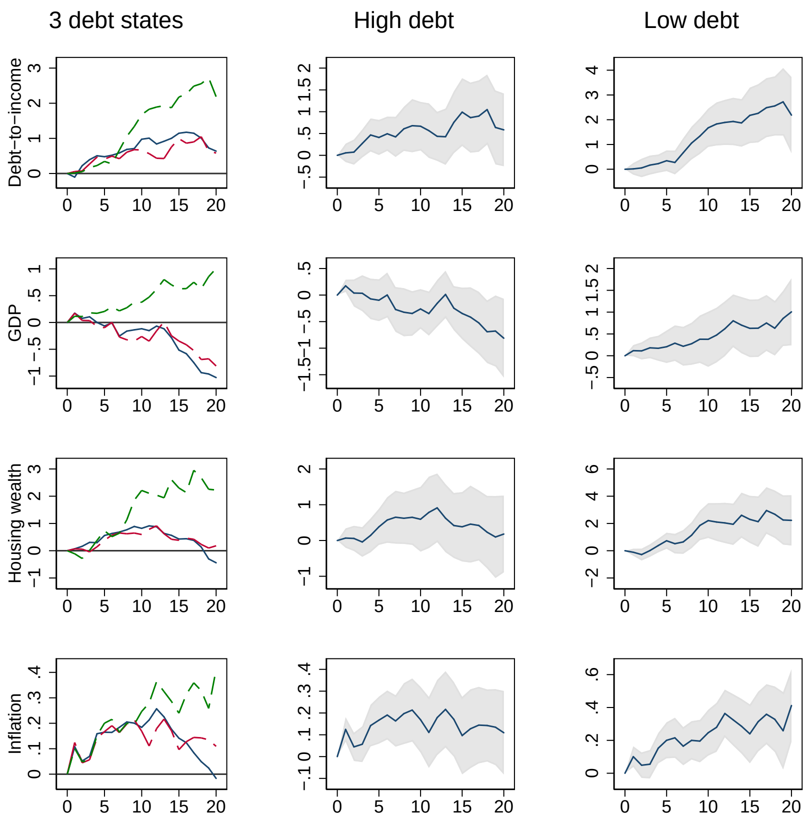
The new estimates of a one-standard deviation increase in the MPSG show that the initial increase in household debt in moderate, high and low debt states is similar (Figure 7). But while loose monetary policy is supportive of household debt in low debt states for the whole horizon, there is an indication that the boost from monetary policy to household debt in high debt states is short-lived; the DTI stays relatively flat after one year, and in non-cumulative

left real house prices at the end of 2017 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.

terms it starts declining after four years, when households likely start adjusting downwards their level of indebtedness relative to income. There is, however, a denominator effect at play in high debt states that masks the extent of the 'true' decline in household debt over the medium term: lower income (or GDP) attenuates the decline in the debt ratio, as the fall in nominal debt in high debt states is more marked, and starts early (roughly after one year), than the one the debt ratio is portraying.

Against this background, the short-lived increase in household debt in states that had already high debt relative to their estimated trend may translate into lower economic activity: after a muted initial response during the first quarters, real GDP starts contracting in high debt states. 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 1.8 p.p. lower than in low debt states after five years.

Figure 7: 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.

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 in the short run may place debt at even higher levels relative to income. This 'excessive' credit may 'force' households to deleverage and cut back on consumption (Figure B.15 in Appendix B).[16] At the same time, house prices, and consequently housing wealth, do not increase in high debt states in a statistically significant way, which prevents households from extracting more equity from their homes. The fact that a loosening in monetary policy conditions is not able to stimulate house prices may be related to the household debt dynamics described above: when the level of debt is already high, loose monetary policy may lead eventually to deleveraging over the medium run, which weighs on housing demand and prices, despite supportive monetary policy conditions. Although the reduced-form model prevents me from testing these mechanisms more formally, my 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).

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. Along the same lines, Beraja et al. (2017) find 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.

As regards low debt states, I find that housing wealth increases consistently over the whole horizon, which contrasts sharply with the responses in high debt states. My estimates show that this increase in housing wealth is driven by higher house prices that accumulate as housing equity (intensive margin) rather than by higher homeownership rate (extensive margin) – Figure B.16 in Appendix B. In addition, I find some evidence that the homeownership rate may actually decline in the short term after a loosening in state monetary conditions, adding further signs that the expansion in household debt may be more the result of existing homeowners taking advantage of the home equity channel when house prices go up, in line with Bhutta and Keys (2016), rather than as a result of potential new homeowners taking on new mortgages.

Although there is a difference in the timing of deleveraging in high debt states, which starts after four years, and the contraction in real GDP growth, which takes place a few quarters earlier, it should be noted that this apparent puzzle has already been observed in the data at the national level in the run-up to the last crisis. In fact, around the Great Recession, the US debt-to-income ratio only started to decline in 2009q1, with the crisis well under way, while real GDP had reached the trough a few quarters earlier (Figure B.17 in Appendix B). In addition, real house prices had been on a downward trend for already two years before the debt ratio started to decline. This difference in timing – which can also be rationalised in the context

[16] A tightening in credit supply standards might also be playing a role in explaining the weaker dynamics in borrowing in high debt states relative to low debt states. For instance, the banks and the regulator may consider debt to be excessive relative to some lending criteria, or when it surpasses some pre-specified threshold values of standard macro prudential indicators, such as the loan-to-value ratio or the debt-to-income.

of a strong rigidity of debt – suggests that it is not only deleveraging *per se* that may affect economic growth, but the on-going debt build-ups, when judged to be excessive, can also exert a toll on economic activity, even before the debt bubble bursts.

The results presented in this section suggest that over the medium to long term monetary policy might create a gap, or amplify it, in the economic performance between states with low and high debt gaps. In a scenario where states with a high debt gap tend to be associated with stronger economic fundamentals, such as higher GDP growth and higher house price growth, monetary policy would in effect be beneficial to reducing regional asymmetries, in that it would allow states with low debt to catch up. This line of reasoning, however, is not backed up by the data; over the last 20 years, states with high debt gaps have actually grown by less than states with low debt gaps, and have also recorded lower house price increases (Table 1). The differences in economic performance conditional on the debt gaps is more marked in the last half of the sample, in a context where a stronger collapse in house prices in areas with higher debt levels started to take a toll on aggregate demand. Against this background, monetary policy may accentuate the pre-existing economic differences between the states.

Table 1: Descriptive statistics for high vs low debt states

	Full sample		1999q1-2007q4		2008q1-2017q2	
	High	Low	High	Low	High	Low
Debt-to-income ratio	94.35	80.01	92.49	71.28	96.43	82.94
Debt gap	7.48	-7.13	7.56	-7.20	7.36	-7.09
ΔDebt-to-income ratio (p.p.)	0.91	-0.72	1.71	0.51	-0.06	-1.13
ΔDebt gap (p.p.)	2.06	-1.76	2.63	-2.62	1.35	-1.52
ΔReal GDP (%)	0.23	0.47	0.50	0.49	-0.09	0.46
ΔReal housing wealth (%)	0.12	0.12	0.90	1.76	-0.81	-0.43
ΔReal house prices (%)	-0.15	0.13	0.61	1.40	-1.08	-0.30
CPI (% yoy)	2.32	1.78	2.86	2.31	1.65	1.61

Notes: High (low) debt states refer to states with a high (low) debt gap, defined as those states belonging to the top (first) quintile of their debt-to-income gap distribution.

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 define state-specific recessions as those periods with the weakest real GDP growth for each state, specifically 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. I expand Eq. (5) 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:[17]

$$
\begin{aligned}
\Delta_h Y_{i,t+1+h} =& \alpha^h_M + \beta^h_M MPSG^h_{i,t} + \lambda^h_M \Delta \log(X^h_{i,t-1}) \\
&+ \Omega^R_{j,t-1}\left[\alpha^h_{MR} + \beta^h_{MR} MPSG^h_{i,t} + \lambda^h_{MR}\Delta\log(X^h_{i,t-1})\right] \\
&+ \Phi^H_{i,t-1}\left[\alpha^h_{H} + \beta^h_{H} MPSG^h_{i,t} + \lambda^h_{H}\Delta\log(X^h_{i,t-1})\right] \\
&+ \Phi^H_{i,t-1} * \Omega^R_{j,t-1}\left[\alpha^h_{HR} + \beta^h_{HR} MPSG^h_{i,t} + \lambda^h_{HR}\Delta\log(X^h_{i,t-1})\right] \\
&+ \Theta^L_{i,t-1}\left[\alpha^h_{L} + \beta^h_{L} MPSG^h_{i,t} + \lambda^h_{L}\Delta\log(X^h_{i,t-1})\right] \\
&+ \Theta^L_{i,t-1} * \Omega^R_{j,t-1}\left[\alpha^h_{LR} + \beta^h_{LR} MPSG^h_{i,t} + \lambda^h_{LR}\Delta\log(X^h_{i,t-1})\right] \\
&+ \eta^h_i + \zeta_t + \epsilon_{i,t+1+h}
\end{aligned} \tag{6}
$$

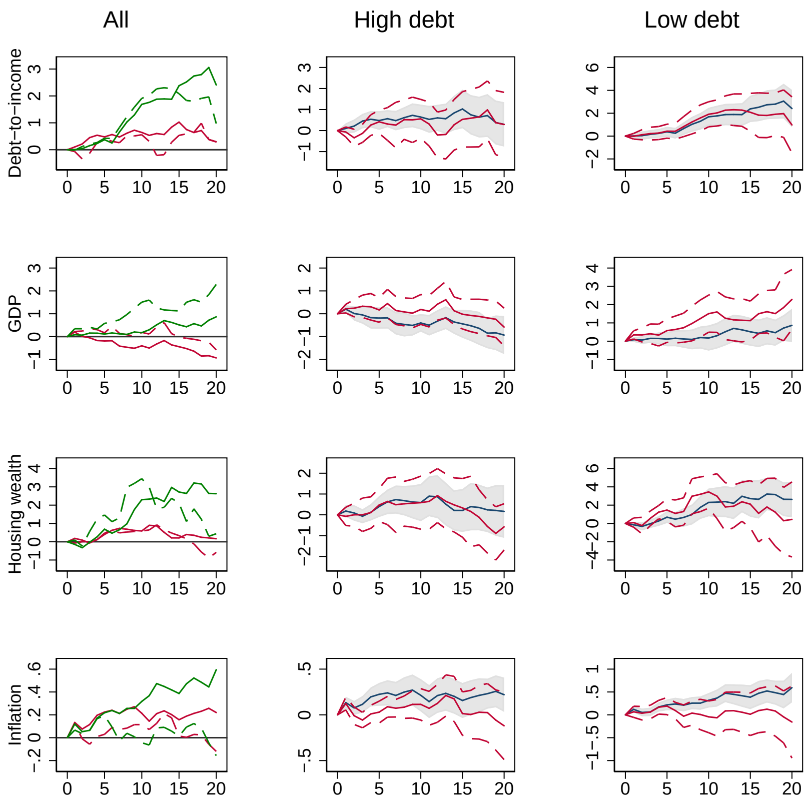
I focus on high versus low debt states during recessions and expansions. Following an expansion in the relative monetary stance, I find that households in high debt states increase their borrowing in the short run but only during expansions, as debt declines during recessions (Figure 8). One of the possible explanations for the different debt dynamics in the short run 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). Over the medium term,

[17] 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 $\beta^h_M + \beta^h_{MR}$.

however, I do not find statistical evidence that the response of household debt in high debt states is conditional on the state of the business cycle. In addition, the decline in GDP in high debt states is more muted during recessions, although the impulse responses are not estimated with a high degree of precision, given the loss of degrees of freedom when estimating several state-dependencies simultaneously.

As for low debt states, a looser monetary policy stance stimulates household debt and economic activity in both periods. In addition, economic growth also rises in both recessions and expansions, although the economic magnitude of these increases appears to be somewhat stronger during recessions. Finally, the increase in housing wealth is more short-lived during recessions.

Figure 8: 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.

Overall, I find that the business cycle appears not to matter materially to uncover asymmetries in the responses to a loosening in monetary conditions between high and low debt states. In other words, I have shown that, apart from some minor differences, the main results of Figure 7 from the previous section are generally independent of the state of the economy. Accordingly, my findings point to the distinction between high and low debt states, rather than recessions versus expansions, as being more fundamentally important to uncover differences in the way monetary policy transmits to the economy.[18]

[18]For the sake of completeness, I also provide estimates that rely on a different definition of 'bad' versus 'good'

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

6.1.1 Shadow rate

The first 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 the Taylor rule in Eq. 1 using Wu and Xia (2016)'s shadow rate instead of the Fed funds rate as the dependent variable, and over 1984-2017 instead of ending the estimation in 2007. Since the Greenbook forecasts are only available until the end of 2011, I use the SPF forecasts to extend the dataset from that period and until the end of 2017.

6.1.2 Financial cycle

The second 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 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 (2017), 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

times: slack and non-slack periods. According to Ramey and Zubairy (2018), 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 output gap for each state is below zero, and otherwise as non-slack periods. The estimates in Figure B.18 of Appendix B suggest that monetary policy is more effective in stimulating debt, supporting economic growth and house prices for low debt states that coincide with periods of slack. In turn, the responses in high debt states are broadly in line with those obtained with the recessions/expansions in the baseline framework.

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 2018, Disyatat 2010, Juselius et al. 2017, 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 (Drehmann et al. 2011). The Fed staff do not forecast household debt in the Greenbook, let alone a concept of potential or equilibrium debt. In this context, I capture the dynamics of financial cycles with the debt-to-income gap, computed as the deviation of the debt ratio from its long-term trend derived with the Hamilton (2018) method. Differently from the computation of most macro variables, and taking into account that the deviation of debt from its long-term trend tends to last longer than for other macro variables, Hamilton (2018) suggests to set the forecasting horizon at h=20 quarters, instead of 8 − used before in Section 3.2 when computing the output gap − as long as the data are reasonably long.[19] In the case of the US aggregate, household debt data come from the Flow of Funds and go back as far as 1951q4.

Another approach to compute the debt gap is through the one-sided HP filter, typically done by the Bank of International Settlements. For instance, Drehmann et al. (2011) estimate the debt gap using a smoothing parameter λ of 400,000 over a longer sample starting in the late-50s. 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 than the two-sided, 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.

Figure B.19 in Appendix B shows that the debt gap for the US economy was considerably larger in the run-up to the Great Recession with the Hamilton method than with the HP filter. The cyclical component of household debt with the Hamilton method is also more in line with the debt gap estimates by Albuquerque et al. (2015), who compute a measure of equilibrium household debt for the US states determined by economic fundamentals. The differences between the Hamilton method and the HP filter dissipate to a large extent during the aftermath of the last crisis, a period when substantial deleveraging by households led debt to fall below its trend. More recently, the pick-up in economic activity that has stimulated debt led to a convergence of debt towards its long-run trend, as estimated by the Hamilton method, while the HP filter is still suggesting debt to be considerably below its trend.

I estimate the following extended Taylor rule with the debt gap obtained with the Hamilton

[19] I get qualitatively similar results with the mortgage debt gap or real house prices gap as alternative proxies for capturing the financial cycle.

method over 1984-2017:

$$i_t = c + \phi_\pi E_{t-}\pi_{t+1,t+2} + \phi_x E_{t-}x_t + \phi_{\Delta y} E_{t-}\Delta y_t + \phi_d E_{t-}d_t + \rho i_{t-1} + \epsilon_t \tag{7}$$

The Taylor rule is estimated until 2017 to account for the leverage and subsequent substantial deleveraging in household debt over the last 20 years. Similarly to the previous specification, I use the shadow rate for the ZLB period, and SPF forecasts over 2012-17.

6.1.3 Unemployment gap as the slack measure

In the baseline Taylor rule specification, I have used the output gap to measure the amount of slack in the economy. As a robustness check, I use instead the unemployment gap, which has also been used in the related literature on the estimation of Taylor rules, such as in Coibion and Goldstein (2012), Leduc and Sill (2013), and Rudebusch (2010).[20]

I compute the unemployment gap at the US aggregate level by subtracting the Greenbook forecast for the NAIRU from the forecast for the unemployment rate. Since the NAIRU forecast is available only since 1989, I update the Greenbook series with the CBO's NAIRU for the preceding five years, 1984q1-1988q4. I estimate the new Taylor rule over 1984q1-2007q4, as in the baseline. As regards the state-level data, I compute the unemployment gap for each state by filtering out the unemployment rate, similarly to what I have done for the state-level output gap in the baseline specification.[21]

6.1.4 Actual data

The fourth and final specification estimates a Taylor rule on actual (final) data, more in the spirit of the classical Taylor rules (Taylor 1993, 1999). Although this Taylor rule is more prone to endogeneity issues – the dynamics in inflation and economic activity might be affected by interest rate decisions by the monetary authority – it may nonetheless be useful to compare the resulting impulse responses to all the other specifications that use real-time expectations.

More specifically, I estimate the original Taylor rule in Eq. 1 over 1984-2007, using actual data on inflation and the unemployment gap, but leaving the GDP growth term out of the equation, as it typically does not feature in classical Taylor rules. I use the unemployment gap given that data on the unemployment rate are less revised compared to GDP growth, therefore minimising the risk of having a large discrepancy between the first estimate of the data and the final data.

[20] More accurately, Coibion and Goldstein (2012), and Leduc and Sill (2013), use the unemployment rate.

[21] An alternative way to compute the NAIRU is to assume that the natural rate of unemployment for each state corresponds to the average of the unemployment rate over the 1990s. Justiniano et al. (2015) consider this period for their model's steady state for the US economy given the relative economic stability, and because the subsequent decade is distorted by the swings in debt and house prices. My main results are broadly robust to using the average unemployment rate over the 90s as the natural rate of unemployment; the only noticeable difference is the GDP response of low debt states being more muted.

6.2 Robustness of the impulse responses

The estimated coefficients of the alternative Taylor rule specifications are roughly in line with those of the baseline Taylor rule (Table 2). The long-term coefficients on inflation respect the Taylor principle, although there is some dispersion, with the coefficients ranging from 1.5 in the Taylor rule that uses actual data instead of real-time expectations (*Actual*) to 2.9 in the specification that employs the shadow rate (*Wu-Xia*). It is worth noting that the debt gap is highly statistically significant in the Taylor rule of Column (3), implying that the Fed increases interest rates when household debt goes above its long-term trend. Finally, according to the estimates in Column (4), where I use forecasts for the unemployment gap (*Ugap*), it seems that the Fed responds more strongly to changes in the unemployment gap than to the output gap, even after taking into account an Okun's law coefficient of two to translate changes in unemployment to output.

Table 2: Taylor rule regressions

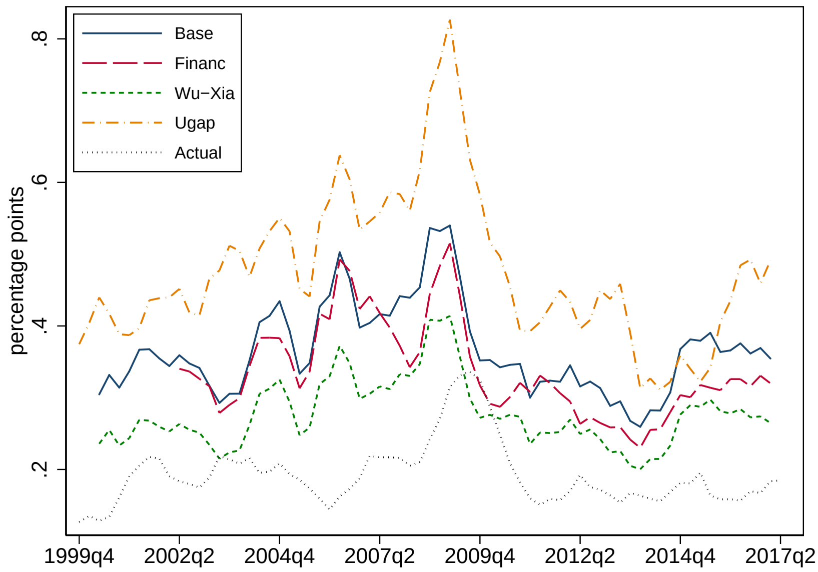
	(1) Base	(2) Wu-Xia	(3) Financ	(4) Ugap	(5) Actual
ϕ_π	0.289***	0.213***	0.286***	0.308***	0.113**
	(0.065)	(0.053)	(0.054)	(0.065)	(0.070)
ϕ_x	0.083***	0.050***	0.048***	-0.262***	-0.166**
	(0.023)	(0.016)	(0.015)	(0.057)	(0.090)
$\phi_{\Delta y}$	0.216***	0.170***	0.167***	0.211***	
	(0.024)	(0.046)	(0.044)	(0.026)	
ϕ_d			0.014***		
			(0.004)		
ρ	0.886***	0.926***	0.900***	0.864***	0.925***
	(0.035)	(0.023)	(0.021)	(0.038)	(0.032)
Constant	-0.762***	-0.687***	-0.823***	-0.710***	0.054
	(0.137)	(0.164)	(0.152)	(0.149)	(0.234)
Period	1984q1-2007q4	1984q1-2017q4		1984q1-2007q4	
Observations	96	136	136	96	96
Adj. R-squared	0.979	0.987	0.988	0.981	0.956

Notes: Regression estimates of Eq. 1, with exception of column (3) that refers to Eq. 7. The coefficient ϕ_x in Columns (4) and (5) refers to the unemployment gap. Newey-West corrected standard errors in parentheses. Asterisks, *, **, and ***, denote statistical significance at the 10, 5, and 1% levels.

The dispersion of the alternative Taylor rules, as measured by the 4-quarter moving average of the interquartile range, follows the same dynamics over time as the baseline: a steady increase in the dispersion in the run-up to the 2008/09 crisis, followed by a decline in the aftermath of the Great Recession (Figure 9). There are, however, some differences in the level of the dispersion across specifications, with that of the baseline Taylor rule being generally somewhat higher with respect to the alternative specifications, apart from the one that uses the unemployment gap as the slack measure. In particular, the lower dispersion of the extended Taylor rule with the 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.

The second observation is that the dispersion of the specification estimated on actual data 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 coefficient on inflation declines substantially.

Figure 9: Dispersion of alternative Taylor rules across US states

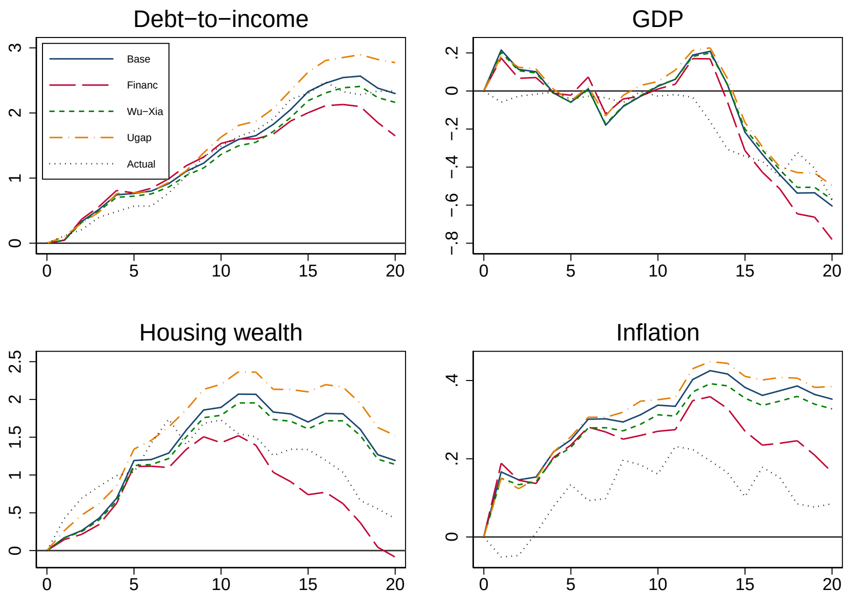


Notes: The figure plots the 4-quarter moving average of the interquartile range of alternative Taylor rules for 30 US states. *Base* is the baseline estimated Taylor rule, *Financ* is the extended rule with the debt-to-income ratio gap, *Wu-Xia* takes Wu and Xia (2016)'s shadow rate, *Ugap* employs forecasts of the unemployment gap as the slack measure, and *Actual* is a Taylor rule estimated on actual data.

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 on Eq. (4), and Figure 7 from Eq. (5). I find that following a one-standard deviation increase in the state-specific MPSG, the baseline results remain broadly robust to all alternative Taylor rule specifications, both for the linear case (Figure 10) and when considering non-linearities related to different debt gap levels across states and time (Figure 11).

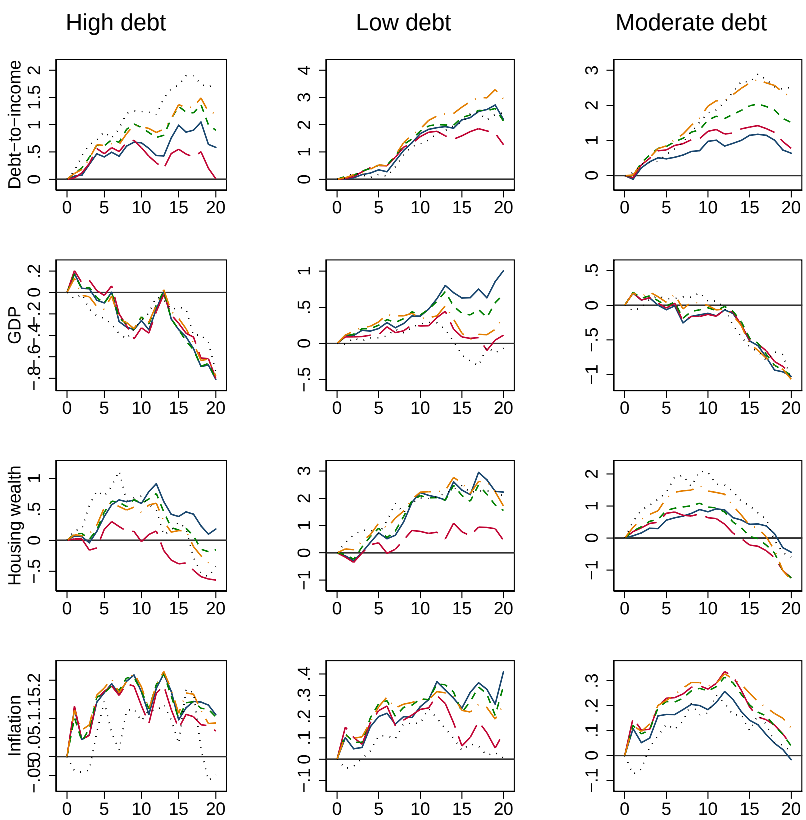
Having said this, there are nevertheless some differences across specifications worth mentioning. Although the dynamics in debt, GDP, housing wealth and inflation are broadly similar, housing wealth converges faster to the baseline for the extended Taylor rule that accounts for the financial cycle in the linear case in Figure 10. This result is driven mostly by the decline in housing wealth in high debt states, and by a muted response in low debt states (Figure 11). Accordingly, the debt deleveraging in high debt states is more pronounced, and starts earlier, than in the baseline, probably also related to the fact that housing wealth in these states actually declines over the medium run.

Figure 10: 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 Taylor rule, *Financ* is the extended rule with the debt-to-income ratio gap, *Wu-Xia* takes Wu and Xia (2016)'s shadow rate, *Ugap* employs forecasts of the unemployment gap as the slack measure, and *Actual* is a Taylor rule estimated on actual data.

Figure 11: 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 Taylor rule, the long-dashed red line the extended rule with the debt-to-income ratio gap, the short-dashed green line the rule with Wu and Xia (2016)'s shadow rate, the dashed-dotted orange line employs forecasts of the unemployment gap as the slack measure, and the dotted black line is a Taylor rule estimated on actual data.

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 may contribute 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 linked to household deleveraging from excessive credit growth. In addition, I find that house prices do not increase in high debt states, making it harder for households to take advantage of the home equity loan channel to extract more equity from their homes to finance consumption, or to refinance their mortgages. Although the reduced-form model prevents me from testing these mechanisms more formally, my findings go in the same direction as 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 (Jordà et al. 2013, 2015, Mian and Sufi 2010, 2011, Mian et al. 2017).

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 – 1999q1-2017q2

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 2017, 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: income from labour (wages and salaries), from owning a home or business, from the ownership of financial assets, and government transfers. Source: BEA.

Real GDP: Gross Domestic Product computed through the output or value-added approach. Annual data interpolated into quarterly from 1999 to 2004 with the Chow-Lin procedure, and using US real GDP as the indicator variable. Source: BEA.

Housing wealth: estimated total housing wealth owned by home owners, computed as: (Homeownership rate x Occupied housing units) x HPI x Median house price in 2000.

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 and Haver Analytics.

Occupied housing units: a house, apartment, mobile home or trailer, a group of rooms, or a single room that is occupied. Annual data have been interpolated into quarterly. 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. Data available until 2016. Source: BEA.

Unemployment rate: the unemployed aged 16 and over in percentage of total labour force, taken from the household survey. Source: BLS.

Table A.1: Descriptive statistics over 1999q1-2017q2

In levels

Variable	Obs	Mean	Std. Dev.	Min	Max
Monetary policy stance gap	2130	-0.2	0.5	-1.8	2.5
State-level CPI (% yoy)	2220	2.2	1.3	-3.8	5.7
Debt-to-income ratio	2220	82.4	20.0	40.9	153.3
Real GDP (log)	2220	12.4	1.0	10.5	14.7
Real housing wealth (log)	2220	23.3	1.0	21.0	26.0
Real house prices (log)	2220	5.1	0.3	4.6	6.3
Homeownership rate (%)	2220	67.6	7.3	37.6	82.4
Total real PCE (log)	2160	11.3	1.0	9.3	13.4
Real PCE: durables (log)	2160	9.2	1.0	7.1	11.2
Real PCE: non-durables (log)	2160	9.8	1.0	7.8	11.7
Real PCE: services (log)	2160	10.9	1.0	8.8	13.0
Unemployment rate (%)	2220	5.9	1.9	2.1	14.6

In first differences

Variable	Obs	Mean	Std. Dev.	Min	Max
ΔMonetary policy stance gap	2100	0.0	0.5	-4.2	3.1
ΔState-level CPI	2220	0.0	0.7	-4.8	3.7
ΔDebt-to-income ratio	2190	0.3	2.5	-13.0	17.6
ΔReal GDP (%)	2220	0.4	1.2	-6.4	11.6
ΔReal housing wealth (%)	2220	0.5	3.1	-11.3	12.3
ΔReal house prices (%)	2220	0.3	1.8	-10.5	9.4
ΔHomeownership rate	2220	0.0	1.6	-5.9	6.8
ΔTotal real PCE (%)	2160	0.5	0.7	-3.2	2.8
ΔReal PCE: durables (%)	2160	0.2	2.1	-9.5	9.2
ΔReal PCE: non-durables (%)	2160	0.4	1.3	-8.4	4.1
ΔReal PCE: services (%)	2160	0.6	0.7	-1.6	4.1
ΔUnemployment rate	2220	0.0	0.3	-0.9	2.6

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.12: Monetary policy stance gaps for US states

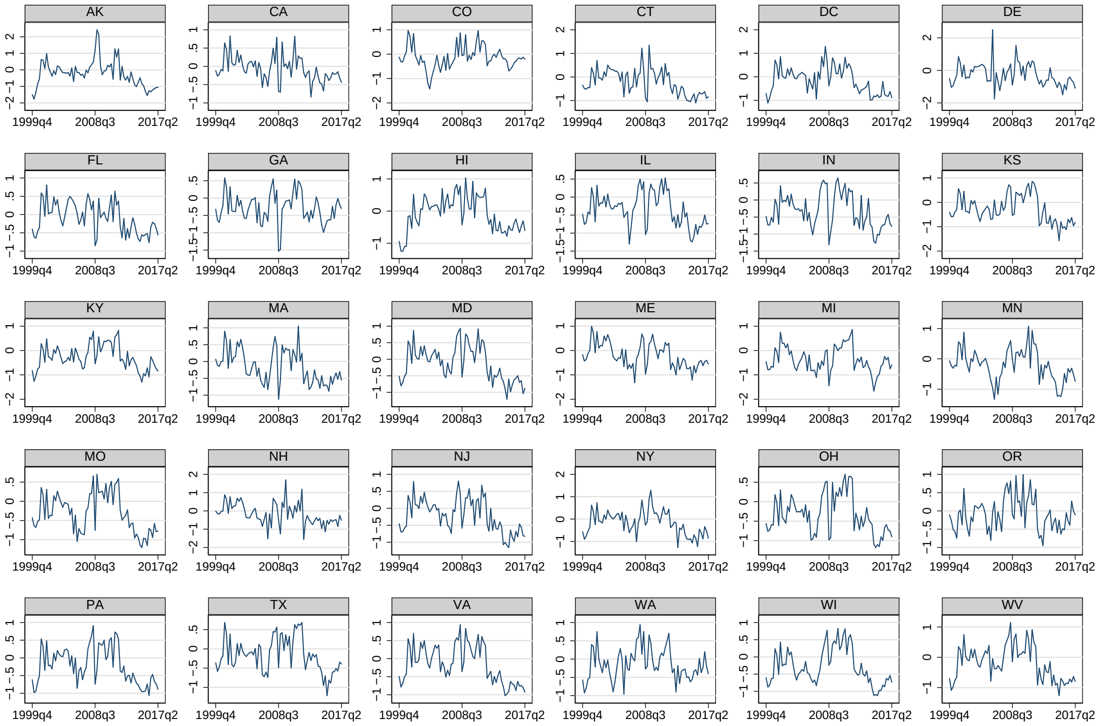
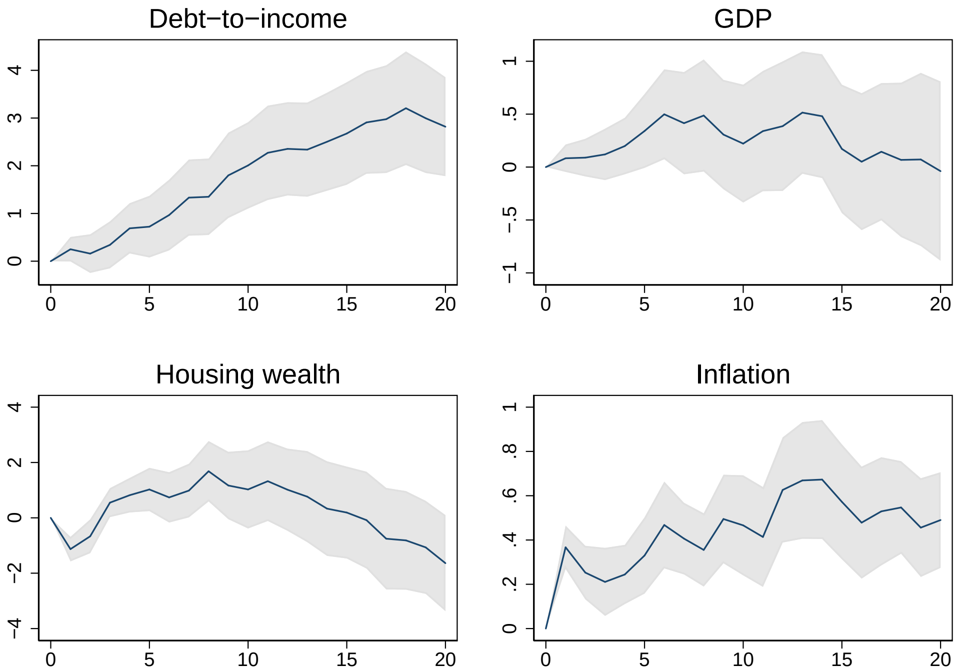
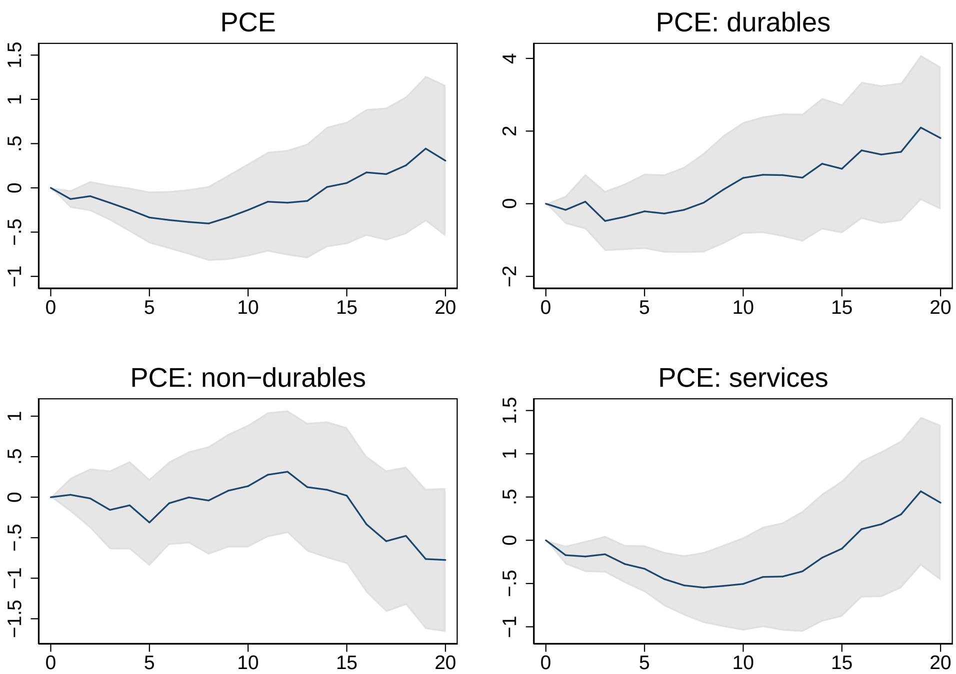


Figure B.13: Purged MPSG: IRF to an expansion in the monetary policy stance gap



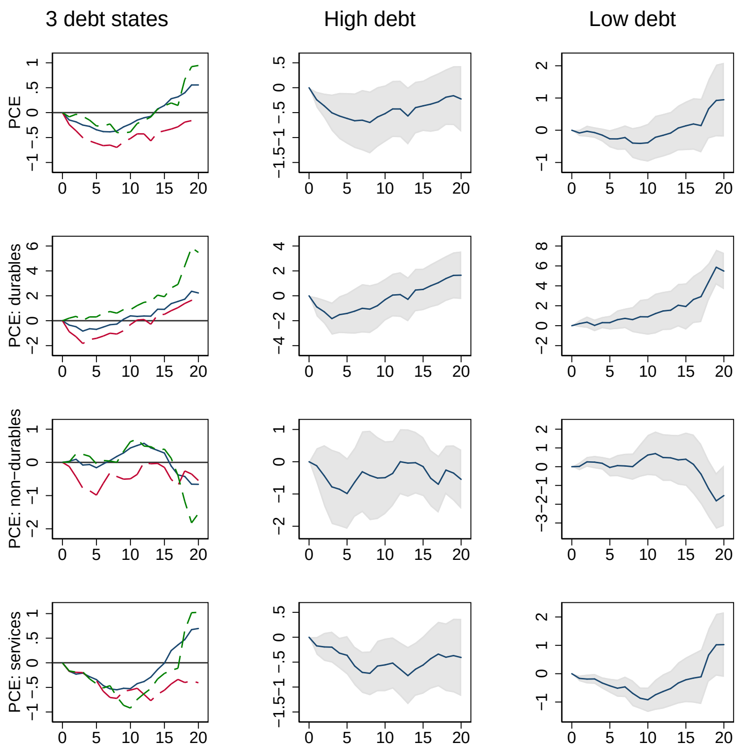
Notes: The solid blue line is the cumulative response of the change in the debt-to-income ratio, real GDP, real housing wealth, and CPI inflation, to a one-standard deviation increase in the purged MPSG for horizons 1 to 20 (β^h from Eq. (4)). The grey area refers to the 90% confidence bands. The MPSG has been purged from state-specific macro and financial variables. See the main text for details.

Figure B.14: IRF of consumption to an expansion in the monetary policy stance gap



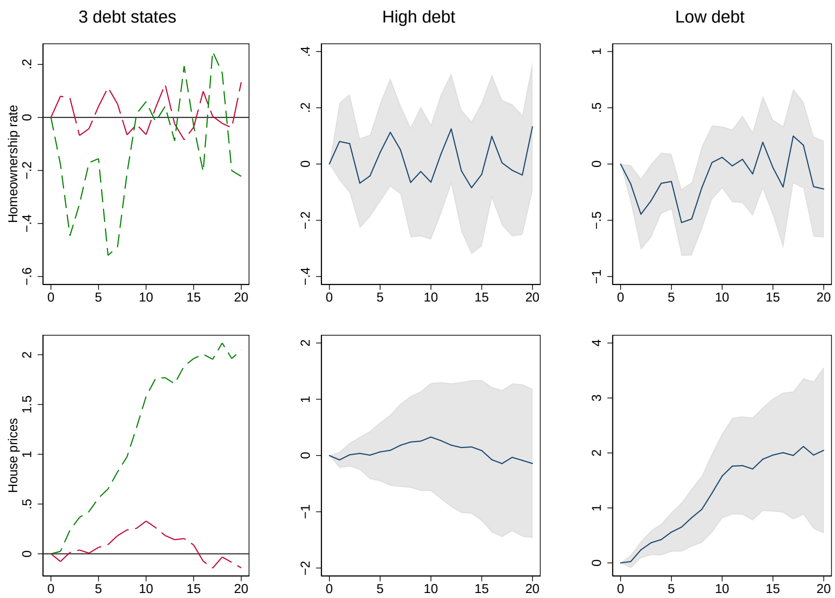
Notes: The solid blue line is the cumulative response of each variable to a one-standard deviation increase in the MPSG for horizons 1 to 20 (β^h from Eq. (4)). The grey area refers to the 90% confidence bands.

Figure B.15: Consumption: Household debt and state-specific monetary policy conditions



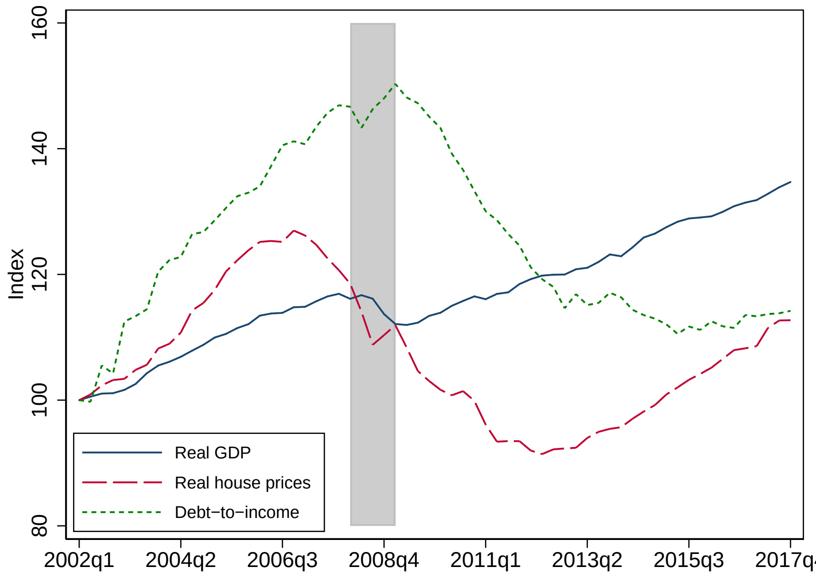
Notes: Cumulative response of each variable to a one-standard deviation increase in the MPSG for h=1 to 20. 1^{st} column: the long-dashed red line refers to states with high household debt; the short-dashed green line to states with low debt; the solid blue line to states with moderate debt. 2^{nd}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

Figure B.16: Extensive and intensive margins of the housing market



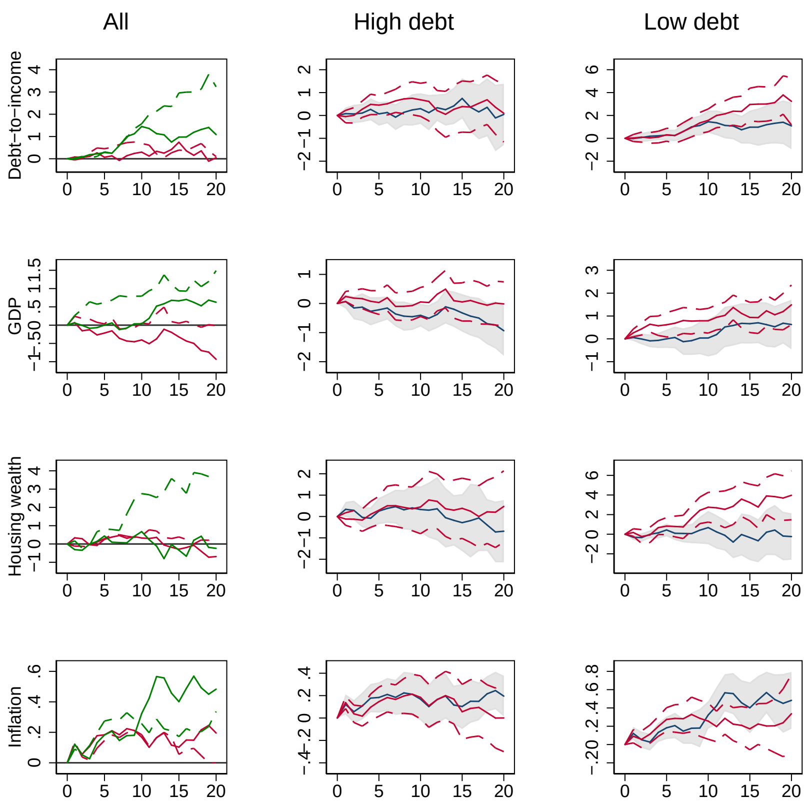
Notes: Cumulative response of each variable to a one-standard deviation increase in the MPSG for h=1 to 20. 1^{st} column: the long-dashed red line refers to states with high household debt, and the short-dashed green line to states with low debt. 2^{nd} and 3^{rd} columns show the point estimates for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

Figure B.17: Dynamics of economic growth, house prices and household debt at the national level



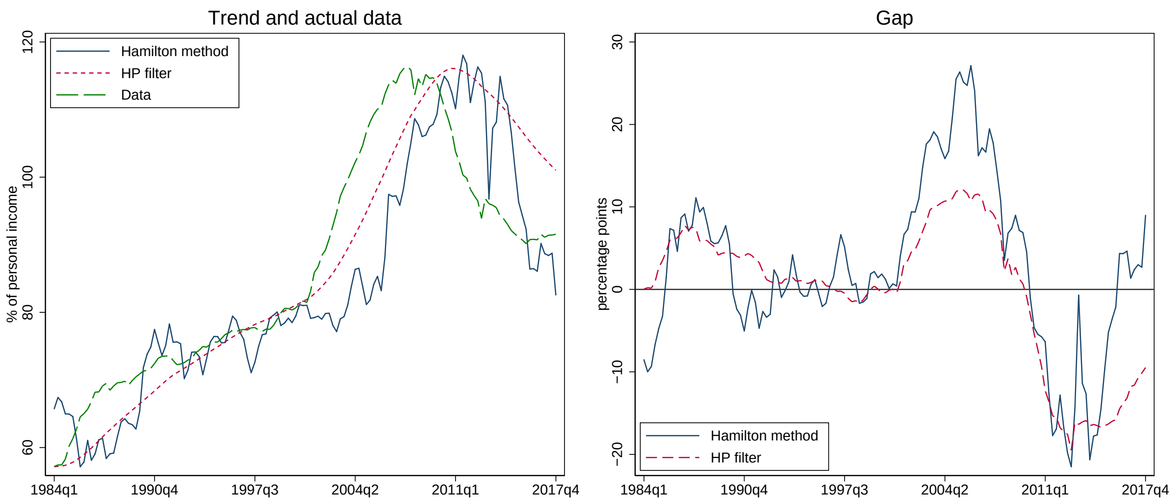
Notes: For the sake of comparison, the variables have been normalised to 2002q1=100. The grey shaded area refers to the official NBER recession over 2007q4-2009q2.

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.

Figure B.19: Household debt-to-income: trend and cyclical component



Notes: The left-hand chart shows actual data for the DTI at the aggregate level, plus its trend component based on the Hamilton (2018) method and on a one-sided HP filter with a smoothing parameter of 400,000. The right-hand chart plots the cyclical component, or gap, of the DTI.

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