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Transmission of monetary policy in times of high household debt☆

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ABSTRACT

This paper explores whether the degree of household indebtedness can affect the effectiveness of monetary policy. We take an interacted panel VAR approach, using a panel of 23 countries, thereby obtaining several interesting findings, such as the responses of consumption and investment to monetary shocks are stronger in high levels of household debt. Furthermore, such responses become larger in a contractionary monetary policy stance rather than in an expansionary one, which suggests that monetary policy shocks have asymmetric effects. We have also found that monetary policy has a relatively larger impact in countries with higher share of adjustable-rate loans. Finally, we have found that when a country is in a high-debt state and in a contractionary policy stance, monetary policy is more powerful in countries with a higher share of adjustable-rate loans. We conjecture that these findings support the presence of a cash-flow channel with respect to the transmission of monetary policy in a high household debt state.

1. Introduction

We investigate whether household indebtedness affects the effectiveness of monetary policy, using a panel of 23 countries and covering the period from 1984:Q1 to 2015:Q4. To this end, we estimate the asymmetric effect of monetary policy dependent on the direction of policy stance, and the level of household indebtedness, thereby departing from the existing related literature, most of which focuses on the average effect of monetary shocks with opposite signs. In addition, we further examine the cash-flow channel in the transmission of monetary policy shocks, analyzing the cross-country differences in the predominant types of interest rate contracts that apply to household debts. If a country is dominated by fixed-rate mortgages (FRMs), one would expect the cash-flow channel to be relatively muted. However, in economies with mostly adjustable-rate mortgages (ARMs), the cash-flow channel may be more important for the transmission of monetary policy.

There are some channels through which higher levels of household debt may amplify the effects of monetary policy shocks on overall economic activity. According to the supposed cash-flow channels, monetary policy can have a direct impact on aggregate household spending via the transfer of income between household borrowers and lenders. For example, a decline in interest rates will reduce lenders interest income, while also reducing interest payments on indebted households, resulting in income transfers between the two groups. It has been widely acknowledged that changes in cash flows may affect consumption, particularly for households that are more financially constrained. This implies that the aggregate effects of this transfer may not be muted if borrowing households are financially constrained. Since households in a high-debt state are more likely to be financially constrained, they should have higher

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propensities to consume than the lenders. In a high household debt state, the same change in the policy rate, therefore, could have an arguably much larger effect on household spending through a cash-flow channel than otherwise.[1] The dominant type of interest rate contracts fixed versus floating interest rates that apply to household debt could also affect the responsiveness to monetary shocks of aggregate output in the economy.

Recent studies provide evidence that monetary policy may be less effective when households have high levels of debt, as seen in the recent US recession. Mian and Sufi (2014, 2015) argue that the precautionary savings motive, induced by the heightened risk to future employment income and low-equity mortgages, renders high-leveraged households less responsive to monetary stimulus during the balance sheet recession associated with the crisis. From a theoretical perspective, Alpanda and Zubairy (2016), presenting a partial equilibrium model in which households are financially constrained, argue that the cash-flow channel of monetary policy is stronger in a high-debt state, but new borrowing through home equity loans (i.e., a home-equity loan channel) works only when debt levels are relatively low and borrowers hold an adequate level of home equity.[2] They argue that expansionary monetary policy may have a weaker effect under high levels of debt, when the effect of the home equity channel dominates that of the cash-flow channel. Also, Bhutta and Keys (2016) show that low home equity levels make it more difficult for households to tap into their home equity lines of credit. In a similar vein, Chen et al. (2013) and Beraja et al. (2015) present evidence that households with low home equity levels have difficulties in refinancing at a lower mortgage rate.

In our empirical analyses, we use an interacted Panel Vector Auto Regression (IPVAR), first proposed by Towbin and Weber (2013) and Sá et al. (2014), as a framework to test whether household indebtedness affects the effectiveness of monetary policy. IPVAR allows VAR coefficients to vary as a deterministic function of observable economic characteristics, thereby enabling us to examine the impact of economic characteristics on the transmission mechanism of an economic shock of interest. We estimate a PVAR and augment it with an interaction term that allows the estimated coefficients to vary with the level of household indebtedness. With this approach, we can investigate how the macroeconomic variables impulse response to a monetary shock varies with the level of household indebtedness. In addition to the strength of monetary policy that is dependent upon household indebtedness, monetary policy may have an asymmetric effect based on its stance: expansionary or contractionary. To test for the possible asymmetric effect of monetary policy, we extend the interaction term to allow the effect of monetary policy to depend on both the direction of monetary policy and household indebtedness. In this framework, we test the asymmetric effect of monetary policy across the state of household indebtedness. Lastly, we split the sample countries into two groups by the predominant type of interest rate that applies to household debt floating versus fixed-interest rate contracts to study the robustness of the monetary policys cash-flow channel. Then, we estimate the Panel VAR with the extended interaction term for each group, and compare the impulse responses to monetary policy stance.

Our first findings suggest that monetary policy has a stronger average effect on real economic activities, particularly on consumption and investment, when households are highly indebted. This result does not discriminate between an expansionary and a contractionary monetary policy stance. We disentangle the effect of monetary policy on output and prices by the policy stance in a high-debt state, finding that monetary policy has a stronger effect on consumption and investment in a contractionary monetary policy stance than in an expansionary one. Finally, we investigate whether the effect of monetary policy can vary by the type of interest rate contracts and find that when a country is in a high debt state and in a contractionary monetary policy stance, monetary policy is more powerful in countries with a higher share of adjustable-rate loans. This finding is in line with what the cash-flow channel implies: monetary policy is more powerful when households are highly indebted and have adjustable-rate contracts. However, our results imply that the cash-flow channel may be more important in a contractionary monetary policy stance.

The remainder of this paper is organized as follows. Section 2 discusses the related literature. Section 3 describes the data and presents the empirical methodology. In Section 4, baseline estimates of impulse responses with several extensions are reported, along with the results from various robustness checks. Section 5 concludes.

2. Related literature

This paper relates to several strands of literature. First, our study contributes to the literature on the state dependence of effectiveness of monetary policy[3] and, specifically, to the literature on the relation between the level of household indebtedness and the effectiveness of monetary policy. There is little existing empirical literature on how the impact of monetary policy varies with household indebtedness. Alpanda and Zubairy (2016) show that the effect of US monetary policy is less powerful in a state where the level of household debt is relatively high. They attribute a decline in monetary policy effectiveness to the weakening of the home equity loan channel, due to the deleveraging of household debt in a high-debt state. Beraja et al. (2015) cite US loan-level data to show that expansionary monetary policy following a crisis reveals a weaker impact when home equity levels are low.

Second, our work is related to the literature on the asymmetric effect of monetary policy in terms of the direction of monetary

[1] Other possible channels, such as the financial accelerator mechanism (Kiyotaki and Moore, 1997; Bernanke et al., 1999) and the debt-deflation channel (Fisher, 1993), could reinforce the transmission of monetary policy in a high household debt state (Alpanda and Zubairy, 2016).

[2] In their model, households first use rising housing equity values induced by expansionary monetary policy to reduce leverage in the high-debt state, by letting the debt-to-equity ratio fall, before they start to borrow again.

[3] Previous research focuses on how the effect of monetary policy varies with the business cycle. They had somewhat mixed results. Lo et al. (2005), Garcia and Schaller (2002), Weise and Charles (1999) found that US monetary policy has a greater impact on output during recessions. However, more recently, Tenreyro and Thwaites (2016) found that the effect of US monetary policy is less powerful in recessions. Also see Smets and Peersman (2001) and (Thoma, 1994).

policy shocks. Tenreyro and Thwaites (2016), Angrist et al. (2013), and Cover (1992) present evidence to show that contractionary monetary shocks are more powerful than expansionary shocks to output and prices.[4] Barnichon and Matthes (2016) adopt a Gaussian Mixture approximation approach to estimate whether monetary policy shocks generate asymmetric responses upon the direction of shocks and the state of economy. They conclude that expansionary monetary policy has a weaker effect on unemployment than contractionary policy. In addition, they suggest that the effect of expansionary policy rests on the state of unemployment: expansionary monetary policy has a greater impact on unemployment in a period of high unemployment. Santoro et al. (2014) present a dynamic general equilibrium model in which a households utility depends on consumption deviations from a reference level, below which loss aversion is displayed. Thus, they reproduce an empirically relevant asymmetry in the reaction of output to monetary policy shocks with opposite signs: contractionary monetary policy shocks have greater effects on output, compared to expansionary shocks. More recently, Jorda et al. (2019), using local projection with instrumental variables (LP-IV) find evidence supporting asymmetric macroeconomic responses to monetary intervention. They also note that monetary interventions have larger restrictive effects when the economy is in a credit boom, which is consistent with our results.

Third, our findings complement evidence from an increasing body of literature on the relation between household debts and the transmission mechanisms of monetary policy, particularly the cash-flow channel. For instance, using the registry-based data on Swedish households, Flodén et al. (2016) argue that monetary policy will have a stronger effect on real economic activities when households are highly indebted with adjustable-rate mortgages. Cloyne et al. (2018) examined the responses to and income from monetary policy in the UK and the US. They note that the dollar change in mortgage payments following a temporary rate cut of 25 bp is three times as large in the UK, where most mortgages have an adjustable rate (in contrast to the US). However, they argue that the general equilibrium effect of the rate cut on income is quantitatively more important than the direct effect of cash-flows. Calza et al. (2013) show that the transmission mechanism of monetary shocks to consumption is stronger in countries with a higher debt-to-GDP ratio and a higher share of adjustable-rate mortgages. Rubio (2011) employs a model with housing market and collateral-constrained households, extending the framework in Iacoviello (2005) by allowing for both adjustable and fixed-rate mortgages. Monetary policy has a stronger effect when a larger share of mortgages has adjustable rates. However, in general equilibrium, the partial equilibrium effects are muted by the redistribution between borrowers and savers, and by labor supply responses. Garriga et al. (2017) conclude that monetary policy shocks have a larger real effect under ARMs than FRMs because an increase in interest rates reduces consumption growth not only by reducing new borrowings but also by increasing mortgage payments.

3. Data and methodology

3.1. Model specification

Our model is based on the interacted panel VAR methodology pioneered by Towbin and Weber (2013) and et al. (2014). Our model allows for the interaction between endogenous variables and exogenous terms, thereby exploring dynamics varying with exogenous circumstances. That is, we investigate the effectiveness of monetary policy on varying degrees of household indebtedness. Furthermore, we test for asymmetry in the cyclical response to a monetary policy shock by plugging additional interaction terms, dummy variables for identifying a monetary policy stance. Lastly, we split the sample into the two country groups, using the predominant type of interest rate that applies to household debts for each country to empirically test the hypothesis that a higher share of adjustable interest loans may amplify the impact of monetary policy on the financial sector and real activities.

We begin by estimating the transmission of monetary policy, using a simple PVAR model without interactive terms. The PVAR model is given by:

$$J_{i,t}y_{i,t} = A_{i,0} + \sum_{p=1}^{L} A_{i,p}y_{i,t-p} + \varepsilon_{i,t} \tag{1}$$

$$\left.\begin{array}{ll} J_{i,t}(\omega, K) = J_i(\omega, K) + J(\omega, K)X_{i,t} & for\ k < \omega \\ J_{i,t}(\omega, K) = 0 & for\ K > \omega \\ J_{i,t}(\omega, K) = 1 & for\ K = \omega \end{array}\right\} \tag{2}$$

where $y_{i,t}$ is a $K \times 1$ vector containing endogenous variables, and $t = 1, \cdots, T$ and $i = 1, \cdots, N$ denote time and sample country, respectively. The $K \times K$ matrix $A_{i,p}$, where $p = 0, 1, \cdots, L$ contains contemporaneous and autoregressive relationships between all endogenous variables, respectively. $A_{i,0}$ is a country-specific intercept, which corresponds to the fixed effect in the panel regression. The $K \times 1$ vector of structural residuals $\varepsilon_{i,t}$ is normally distributed with a mean of zero and with a diagonal $K \times K$ covariance matrix Σ.

Specifically, we allow for heterogeneous slope parameters $A_{i,p}$ across countries and country-specific intercepts $A_{i,0}$, which is in line with Sá et al. (2014).[5] $J_{i,t}$is a $K \times K$ matrix of lower triangular with a vector of ones on the main diagonal which captures a

[4] Tenreyro and Thwaites (2016) also claim that the effect of monetary policy is less powerful in recessions, insisting that asymmetric effects of monetary policy shocks with opposite signs cannot be the source of asymmetry across the business cycle, given that contractionary and expansionary monetary shocks are equally common in both booms and recessions.

[5] Pesaran and Smith (1995) show that assuming homogeneity in slope parameters across countries can have negative consequences: for large T and N, imposing only heterogeneity in intercepts may result in inconsistency.

Table 1
Data sources and descriptive statistics.

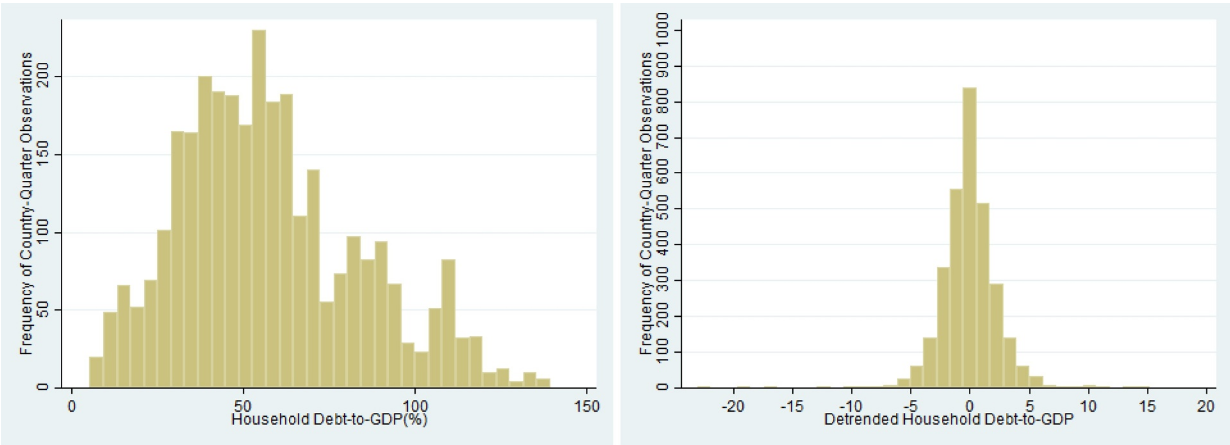
	Mean	SD	Median	Min	Max	Sources
Short-term Interest	6.015	4.953	4.725	−0.795	45.664	IMF IFS
Long-term Interest	6.866	4.072	5.700	−0.207	25.401	IMF IFS
Log(RGDP)	12.290	1.866	12.302	8.643	18.678	IMF IFS
Log(RCON)	11.432	1.439	11.511	7.680	16.336	IMF IFS
Log(RINV)	10.822	2.134	10.665	6.555	18.770	IMF IFS
CA/GDP	1.858	6.843	0.793	−20.335	40.037	IMF IFS
Log(CPI)	4.237	0.610	4.380	−3.414	4.726	IMF IFS
Log(RSHARE)	5.245	1.643	4.746	1.762	9.839	Haver
Log(REER)	4.587	0.141	4.588	3.955	5.197	BIS Database
Log(CREDIT)	9.021	2.476	8.516	3.599	15.400	BIS Database
Log(RHP)	5.023	0.400	4.961	4.097	6.087	BIS, Haver
HD/GDP	57.737	26.484	54.100	5.500	139.500	BIS Database

Notes: Short-term interest rates are three-month nominal money market rates or the rates on similar financial instruments. Long-term interest rates are the nominal yields on ten-year government bonds. Components of GDP and CPI are seasonally adjusted using X-13 ARIMA.

Table 2
Predominant types of interest rate contracts.

	Adjustable	Fixed
Country	Australia, Finland, Italy, Portugal, South Korea, Spain	Belgium, Germany, Netherlands, Switzerland, United States

Source: Badarinza et al. (2018), Cerutti et al. (2015)



(a) Household Debt-to-GDP (b) Detrended Household Debt-to-GDP

Fig. 1. Frequencies of household debt-to-GDP ratio.

contemporaneous effect. When it comes to the interactive terms, $X_{i,t}$ is a matrix of country characteristics that are expected to affect the response of macroeconomic variables to monetary policy shocks. The scalars $J_{i,t}(\omega, K)$ is the (ω, K) scalar element of $J_{i,t}$ and represent contemporaneous effect of the qth-ordered variable on the ω th-ordered variable. The scalars $J_i(\omega, K)$ and $J(\omega, K)$ are coefficients that represent the marginal effect of a change in the respective interaction term on $J_{i,t}(\omega, K)$.

The panel VAR is now augmented with interactive terms between endogenous variables by combining Eqs. (1) and (2). The structural interacted Panel VAR is given by:

$$J_{i,t} y_{i,t} = A_{i,0} + \sum_{p=1}^{L} A_{i,p} y_{i,t-p} + B_0 X_{i,t} + \sum_{p=1}^{L} B_p X_{i,t} y_{i,t-p} + \varepsilon_{i,t} \tag{3}$$

where B_0 and B_p are intercepts and a $K \times K$ matrix of autoregressive coefficients up to lag L, which represent the states of household debt, respectively. We now divide both sides of the Eq. (3) with $J_{i,t}$, thereby obtaining the reduced-form equation as:

$$y_{i,t} = \widetilde{A}_{i,0} + \sum_{p=1}^{L} \widetilde{A}_{i,p} y_{i,t-p} + \widetilde{B}_0 X_{i,t} + \sum_{p=1}^{L} \widetilde{B}_p X_{i,t} y_{i,t-p} + \tilde{\varepsilon}_{i,t} \tag{4}$$

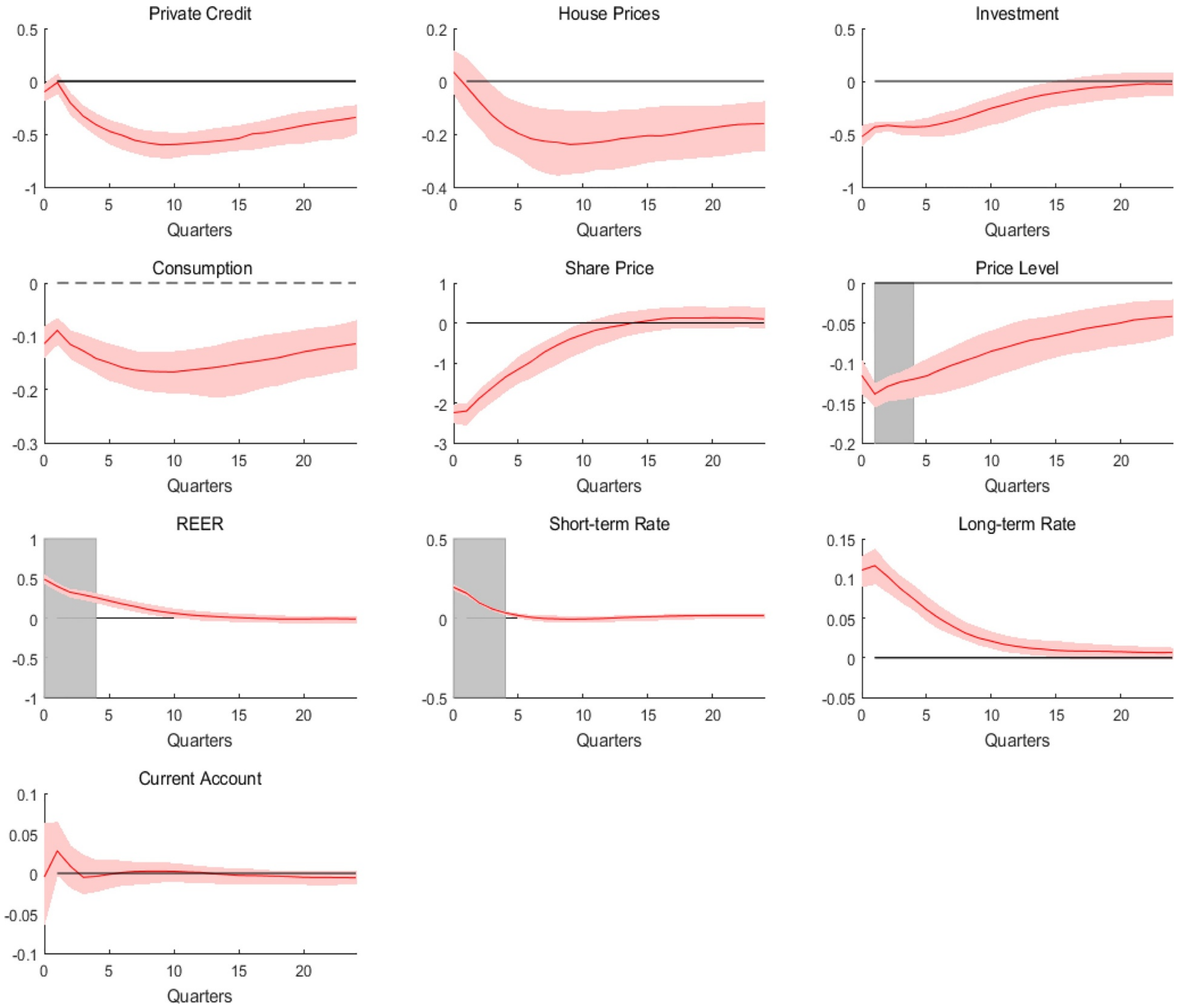


Fig. 2. Baseline impulse responses to a monetary policy shock. Note: The gray shaded area depicts the variables and the horizon on which sign restrictions are imposed. The standard error bands that account for parameter uncertainty are the 16th and 84th percentiles of the set of accepted impulse response functions for all draws.

where the reduced form coefficient matrices are defined as $\widetilde{A}_{i,0} = J_{i,t}^{-1}A_{i,0}$, $\widetilde{A}_{i,p} = J_{i,t}^{-1}A_{i,p}$, $\widetilde{B}_0 = J_{i,t}^{-1}B_0$, $\widetilde{B}_p = J_{i,t}^{-1}B_p$, and $\tilde{\varepsilon}_{i,t} = J_{i,t}^{-1}\varepsilon_{i,t}$. $\tilde{\varepsilon}_{i,t}$ has normal distribution with mean zero and covariance matrix $\Sigma_{i,t}$.

To test for the implication of the level of household debt on the effectiveness of monetary policy, it is necessary to set up an alternative specification of the PVAR model. To control for potentially related variables, this alternative specification should explicitly allow for the time-varying level of household debt as an exogenous factor acting on the response of real sector variables and prices to a monetary policy shock. To this end, we propose that the autoregressive coefficients of endogenous variables are the functions of the cross-time-varying level of household debt-to-GDP ratio. Such frameworks were first proposed by Loayza and Raddatz (2007) and Towbin and Weber (2013) and allow evaluations of whether the macroeconomic response to policy shocks varies with exogenous structural characteristics.

Specifically, as noted above, we use household debt in the form of a percentage of GDP of the previous four-quarter moving average, as the main interaction variable in the baseline estimation as follows:

$$X_{i,t} = MA_4\left[HP_{cc}\left(\frac{HD}{GDP}\right)_{i,t-1}\right] \tag{5}$$

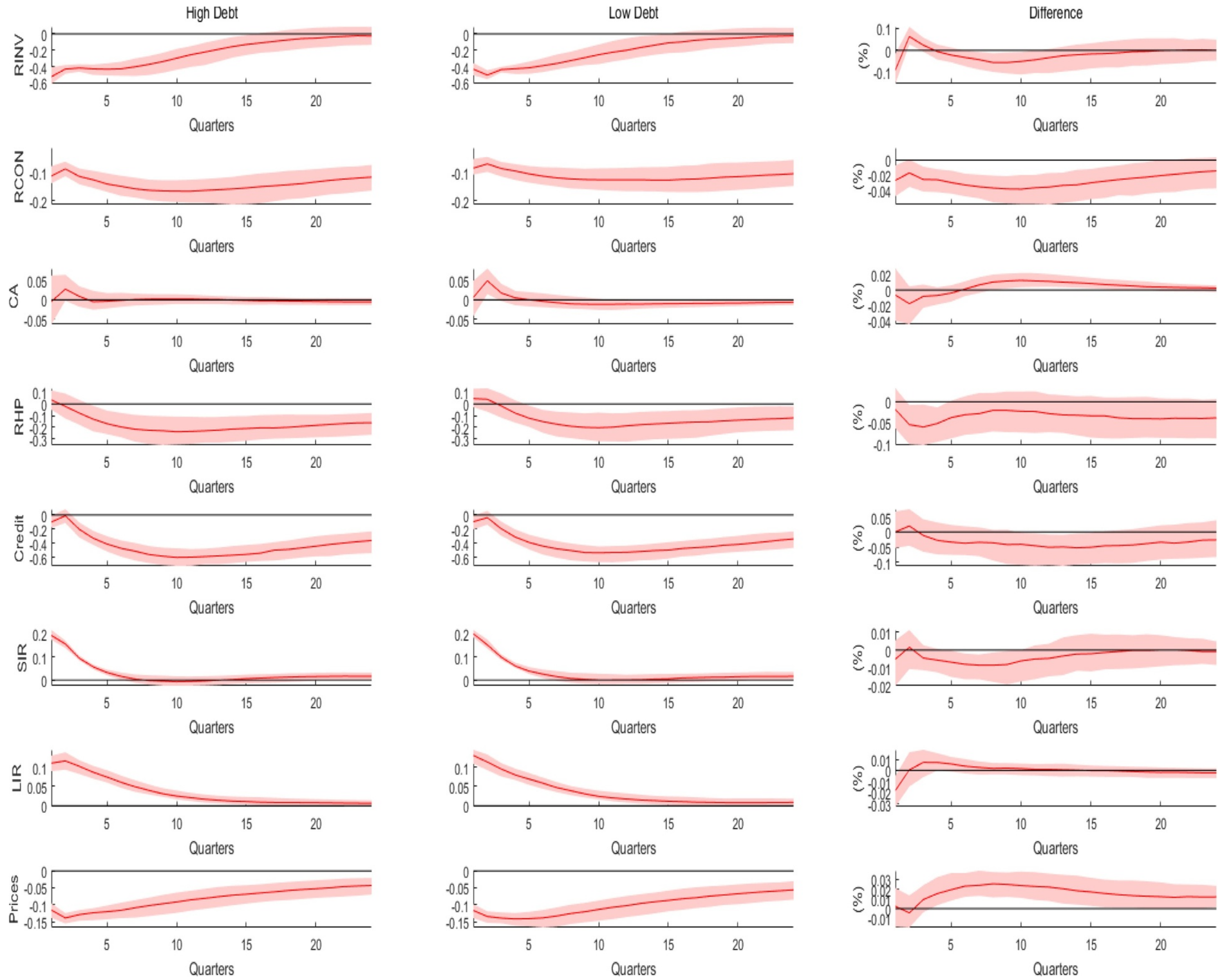


Fig. 3. Differences in impulse responses to a monetary policy shock by the degree of household indebtedness. Note: The gray shaded area depicts the variables and the horizon on which sign restrictions are imposed. The standard error bands that account for parameter uncertainty are the 16th and 84th percentiles of the set of accepted impulse response functions for all draws. We report impulse responses evaluated at 80% and 20% of the gap ratios of household indebtedness.

where $t = 1, \cdots, T$ and $i = 1, \cdots, N$. $MA_4\left[HP_{cc}\left(\frac{HD}{GDP}\right)_{i,t-1}\right]$ denotes a q-quarter moving average of lagged household debt-to-GDP ratio detrended through Hodrick-Prescott Filtering methodology. This indicates that all contemporaneous and lagged parameters may change deterministically with the degree of household indebtedness. We evaluate the impact of monetary policy upon the degree of household debts by comparing impulse response functions measured at the 20th and 80th percentiles of the respective distributions. This approach will help to clearly capture how much output and inflation react to monetary policy shocks. In the next step, the interaction term is extended to allow for a vector of dummy variable-capturing asymmetries in the transmission of monetary policy across differential monetary policy regimes. The extended interaction term can thus be expressed as:

$$X_{i,t} = \alpha_0 MA_4\left[HP_{cc}\left(\frac{HD}{GDP}\right)_{i,t-1}\right] + \alpha_1 D_{i,t} + \alpha_2 D_{i,t} MA_4\left[HP_{cc}\left(\frac{HD}{GDP}\right)_{i,t-1}\right] \quad (6)$$

$D_{i,t}$ denotes a vector of three indicators, $D_{i,t} = [D_{i,t}^{\exp}, D_{i,t}^{con}, D_{i,t}^{neu}]$ where $D_{i,t}^{\exp}$, $D_{i,t}^{con}$, and $D_{i,t}^{neu}$ are the stances of expansionary, contractionary, and neutral monetary policy, respectively, and assigns a value of one when it corresponds to the stance (otherwise, zero). We then compare the magnitude of transmission between expansionary and contractionary stances. If we confirm the presence of asymmetry in the monetary policy transmission across policy regimes, we can further conduct an additional estimation, accordingly, investigating the background behind the regime-dependent impulse responses. We split the sample into the three groups, based on

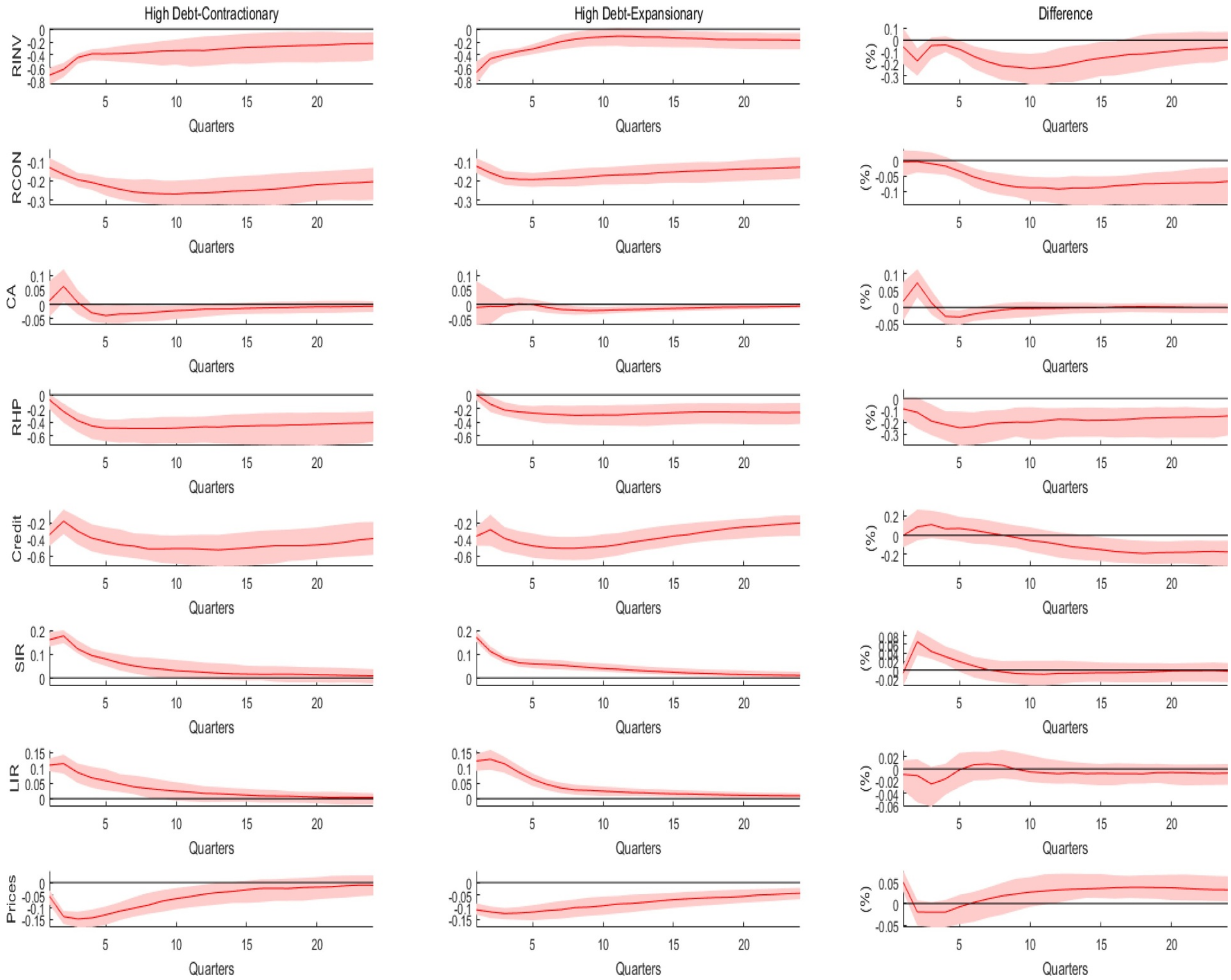


Fig. 4. Differences in impulse responses to a monetary policy shock by monetary policy stance at a high degree of household indebtedness. Note: The standard error bands that account for parameter uncertainty are the 16th and 84th percentiles of the set of accepted impulse response functions for all draws. We report impulse responses evaluated at 80% and 20% of the gap ratios of household indebtedness. We also identify the exogenous monetary policy shock using the baseline specification and then construct a monetary policy stance measure by subtracting its 6-quarter moving average from the identified policy shock. We then assign contractionary stance $D_{i,t}^{con}$ to the upper 40 percentile; expansionary stance $D_{i,t}^{\exp}$ to the lower 40 percentile; and neutral stance $D_{i,t}^{neu}$ to 20 percentile around the median. To allow for a respective policy stance, we construct a vector of three indicators, $D_{i,t} = [D_{i,t}^{\exp}, D_{i,t}^{con}, D_{i,t}^{neu}]$ and assign a value of one when it corresponds to the stance.

the predominant types of interest rates (i.e., floating, mixed, or fixed) that apply to household debts. We then compare the differences in the transmission between floating and fixed types. Indeed, the share of variable-rate loans in total loan outstanding is, if available, a good indicator, considering its time-variant nature. It could, however, be problematic to the extent that it is likely to be endogenous to the phase of business cycle or policy stance. In particular, the predominant interest type shows little difference across the sample period as we examine the trend of the index constructed by the IMF since the 1980s. In this context, we use the time-invariant index, since it is robust to endogeneity.

This approach has been sensitive to criticism in a recent work by Ramey and Zubairy (2018) that non-linear VARs constructing the impulse response functions over longer horizons may lead to biased result of the effects of policy shocks in that some states might not last on average for longer than 20 quarters. Nevertheless, given that it is challenging to compare our baseline approach with their proposed approaches, we will leave it for future studies to check for robustness of our specification to alternative ones.

3.2. Data

We use the quarterly data on the unbalanced panel of 23 countries, over the period 1985:Q1 2015:Q4.[6] Most of the variables used

[6] We set 1985 as a starting point for the purpose of excluding effects caused by the oil crisis. Meanwhile, we check whether our results are robust to the inclusion of the period of zero lower bounds. We assume that the monetary policy reaches the zero lower bound if the policy rate is lower than

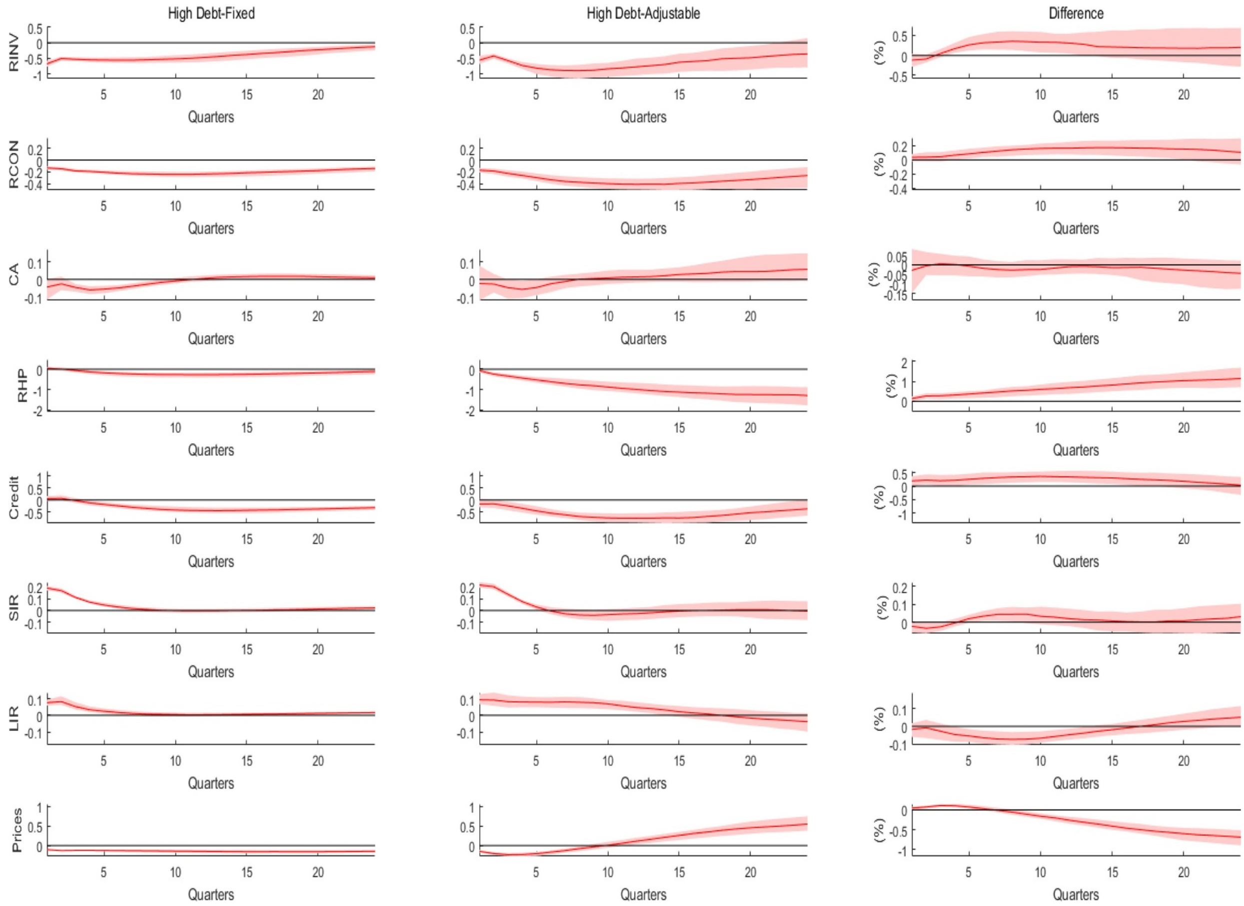


Fig. 5. Differences in impulse responses between predominant types of lending contracts at a high degree of household indebtedness. Note: The standard error bands that account for parameter uncertainty are the 16th and 84th percentiles of the set of accepted impulse response functions for all draws. We report differences in impulse responses between predominant lending contracts given upper 80 percentile of the gap ratios of household debt. We define ARM-dominated mortgage systems as market shares of adjustable rate mortgages higher than 70% while FRM-dominated systems as those lower than 30%, where the market shares of the adjustable rate mortgages through 2000 ~ 2013 are calculated by Badarinza et al. (2018).

in the analysis are from the IMFs International Financial Statistics (IFS), BIS database, and the HAVER database. We selected the sample countries in terms of data availability, geographical diversity, and financial market development, which is a prerequisite for implementing effective monetary policy. The countries chosen are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Korea, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom, and the United States.[7]

To evaluate the effectiveness of monetary policy, our baseline econometric specification includes the following variables: real investment (RINV), real private consumption (RCON), the current account as a share of GDP (CA), the consumer price index (CPI), the real house prices (HP), the real credit to private non-financial sector (CREDIT), nominal short-term interest rate (SIR), nominal long-term interest rate (LIR), real share prices (SP), and real effective exchange rates (REER). Components of the GDP and the CPI are seasonally adjusted using X-13 ARIMA. For short-term interest rates, we use three-month money market rates, or rates on similar financial instruments. Short-term rates are largely affected by a central banks policy stance. Long-term interest rates, in turn, refer to

(*footnote continued*)
or equal to 0.25%. We find qualitatively similar responses where we exclude 151 observations where monetary policy reaches the zero lower bound from our sample periods. The results will be provided upon request.

[7] We acknowledge that since the launch of Eurozone, individual member countries have not held any authority in independent monetary policy. Nevertheless, we include the Eurozone member countries in the sample for several reasons: (1) our study focuses on the effect in direction from monetary policy shocks to real economy; (2) exclusion of the Eurozone member countries would limit the number of the sample for panel analysis of transmission of monetary policy; and (3) the economic indicators of the sample countries (e.g., Germany, France, Italy, Spain etc.) have sterling impacts on the ECBs decision on key rates, given their dominant positions in the Eurozone economy. Moreover, we note that the recent literature (e.g., Jannsen et al. (2015); Sá et al. (2014) etc.) also includes Eurozone member countries.

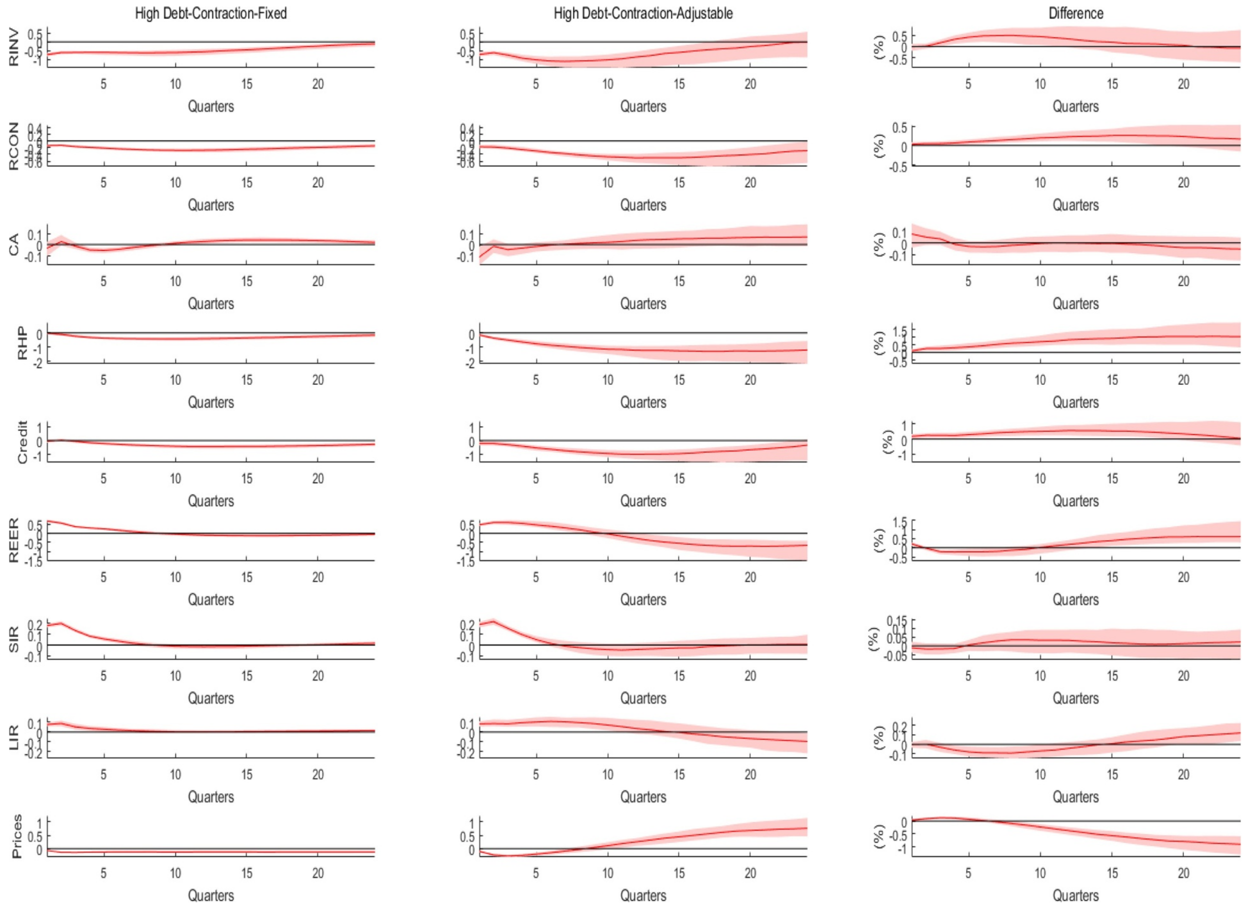


Fig. 6. Differences in impulse responses between predominant types of lending contracts at a high degree of household indebtedness and contractionary monetary policy stance. Note: The standard error bands that account for parameter uncertainty are the 16th and 84th percentiles of the set of accepted impulse response functions for all draws. We report differences in impulse responses between predominant lending contracts given upper 80 percentile of the gap ratios of household debt and contractionary stance $D_{i,t}^{con}$ to the upper 40 percentile. We define ARM-dominated mortgage systems as market shares of adjustable rate mortgages higher than 70% while FRM-dominated systems as those lower than 30%, where the market shares of the adjustable rate mortgages through 2000 ∼ 2013 are calculated by Badarinza et al. (2018).

ten-year government bonds. The real house prices, the real credit to private sector, and the real share prices are all constructed by deflating the nominal values by the consumer price level. We use the real effective exchange rates (REER) data obtained from the BIS database. All variables in the series, except for interest rates and the current account as a share of GDP, are expressed in natural logarithms. We also use all variables equally, following Christiano et al. (1999) among others (Table 1).

For interaction terms, we adopt two variables: household indebtedness as a share of GDP, and indicators of the central banks monetary policy stance. First, we need to define a state of high household indebtedness. In order to control for the effect of economic growth, financial deepening, and demographic factors, we detrend the household debt-to-GDP ratio, using the HP filter with a smoothing parameter, $\lambda = 10,000$ and construct cyclical debt gap ratios, following Drehmann and Tsatsaronis (2014), Bernardini and Peersman (2018), and Alpanda and Zubairy (2016).[8] The reason we choose deviation from a trend of debt-to-GDP rather than its trend is that the former is seen as reflecting households financial (or borrowing) constraint while the latter as reflecting financial deepening. Here, we focus more on examining the heterogeneous responses to monetary shocks by state of household debt in terms of its financial constraint. We also HP-filter the series from 1982Q1 to 2017Q4 and use debt gap data from 1984Q1 to 2015Q4 to address the end-point problem. The variable also enters the regression in the form of a previous four-quarter moving average to address potential problems arising from endogeneity. Fig. 1 shows that the detrended debt ratio is close to normal distribution, concentrating around 0, while debt ratios are widely scattered, ranging from 5% to 140%.[9]

[8] Adopting a higher smoothing parameter in constructing the deviation of the debt-to-GDP ratio from a smooth trend is useful in capturing the longer duration of credit cycles. We assume that credit cycles are twice as long as real business cycles.

[9] After conducting an estimation with the household debt-to-GDP ratio not detrended, we obtained results that are consistent with those of

In addition, we identify the exogenous monetary policy shock using the baseline sign-restriction specification above, thereby decomposing the policy stance into three phases: the periods of expansionary, contractionary, and neutral monetary policy stances.[10] To allow for a respective policy stance, we construct a vector of three indicators, $D_{i,t} = [D_{i,t}^{\exp}, D_{i,t}^{con}, D_{i,t}^{neu}]$ and assign a value of one when it corresponds to the stance (otherwise, zero).

Lastly, ARM-dominated mortgage system is defined as market shares of adjustable rate mortgages higher than 70% while FRM-dominated system as those lower than 30%, where the market shares of the ARM through 2000 2013 are calculated by Badarinza et al. (2018).[11] Adjustable types of interest rates are predominant in six economies, while the fixed-rate types of loans are predominant in five countries (Table 2).

3.3. Estimation and inference

Our estimation employs a Bayesian methodology, building on Sá et al. (2014). We first estimate the recursive form of an interacted PVAR model, using the Ordinary Least Squares. We then choose two lags in the baseline specification by the Akaike information criterion.[12] We update the estimates with prior information, using an uninformative Normal-Wishart prior. We draw all recursive-form parameters from the posterior, using Monte Carlo integration methods (Uhlig, 2005; Koop and Korobilis, 2010). In line with Cogley and Sargent (2005) and Sá et al. (2014), we also discard explosive draws according to prior conditions of non-explosive responses.

For the identification of monetary policy shocks, we employ the sign restriction approach proposed by Canova and De Nicolo (2002) and Uhlig (2005), and others. This approach has several advantages over the alternatives. First, it has been widely used to address challenges in analyzing the effect of monetary policy, such as the price puzzle and exchange rate puzzles. Impulse responses are also independent of the ordering of endogenous variables. The signs of impulse responses are, instead, determined in line with economic theory. Specifically, we follow the identification restrictions on monetary policy shocks, well-documented by Christiano et al. (1999). In our estimation, we impose restrictions in response to a restrictive monetary policy shock, short-term interest rates, and real effective exchange rate rise during the first to fourth quarters; and prices decrease from the second to fourth quarter, while remaining agnostic with respect to GDP and other variables.[13]

We also consider that the behaviors of economic variables may diverge from the theory in highly inflationary pressure or extremely recessionary periods. For a robustness check, therefore, we conduct the estimation excluding the post-GFC period.

In practice, we proceed in the following manner. We take a random draw from the posterior of reduced-form parameters and compute the lower-triangular Cholesky decomposition. We then consider 500 random draws of the rotation matrix and compute the set of implied structural impulse responses for each regime. If the draw satisfies sign restrictions, we store the value; otherwise, we discard it. After repeating this process 500 times, we thereby compute the 16th and 84th percentile of confidence bands, and the median.[14]

4. Results

In this section, we report the results of impulse response functions on the transmission of monetary shocks. We then conduct several robustness checks, based on the identification of interaction terms, as well as the re-sampling of the period.

4.1. Monetary policy transmission

Fig. 2 displays the results of the baseline estimation that is not augmented with any interaction term in Eq. (1). The solid red line represents the median impulse response, and the shaded red areas are the 16th and 84th percentiles of the respective posterior distribution.[15] The gray shaded area indicates variables and the horizon where sign restrictions are imposed.

We observe falls in financial variables and resulting decreases in consumption, investment, and prices, following a one-standard deviation contractionary adjustment to monetary policy. Specifically, in response to a contractionary monetary policy shock, we see contemporaneous drops in the prices of short- and long-term bonds, share prices, and house prices. Similarly, the reaction of credit to

(*footnote continued*)
baseline estimations. The estimation results will be provided upon request.

[10] Following Bernanke and Mihov (1998) and Fung and Yuan (2001), we construct a monetary policy stance measure by subtracting its 6-quarter moving average from the identified policy shock. We then assign contractionary stance $D_{i,t}^{con}$ to the upper 40 percentile; expansionary stance $D_{i,t}^{\exp}$ to the lower 40 percentile; and neutral stance $D_{i,t}^{neu}$ to 20 percentile around the median.

[11] Although South Korea and Switzerland are not presented in Badarinza et al. (2018), they are included in the sample, following Lea (2010) and Cerutti et al. (2017), respectively.

[12] Similar previous literature by Sá et al. (2014) and Jannsen et al. (2015) also selects two quarter lags.

[13] We have examined if there is any substantial change in the impulse responses when altering the restriction on the horizons and find any significant difference in the responses. The estimation results will be provided upon request.

[14] We also identify the impulse responses to the monetary shock with two standard error bands to preclude the over-estimation of the difference between the two states. Consequently, we find that our main results are robust to the choice of standard error bands.

[15] We check for two standard error bands. Consequently, we obtain the results which are broadly consistent with those displaying two standard error bands.

the non-financial private sector is negative on impact and gradually returns to its origin after bottoming out at around the 10th quarter. In the case of real variables, the responses of demand variables appear to be negative and persistent over considerable horizons. Consumption reaches bottom at around 0.2%, five quarters after impact, and rebounds very gradually over time. Investment declines on impact by about 0.5% and then hovers at a similar level until the fifth quarter. By contrast, the current account turns to deficits after temporary improvement in the impact, which supports the presence of a so-called J-curve effect.

We now present the differences in the transmission of a monetary shock by the degree of household indebtedness. Fig. 3 displays the impulse responses of each variable of interest to a contractionary monetary shock. We note that the responses of investment and consumption are significantly larger with high debts. In particular, the difference in the response of consumption is remarkably huge from the impact. We also find significantly larger deficits in the high-debt state. In contrast, there appears to be no significant difference in the response of prices. This finding supports the notion that the impact of a monetary policy shock should be sizeable in a high-debt state.

Furthermore, we examine the backdrop behind larger responses in state of high-debt. To investigate if there is an asymmetry of the responses by the monetary policy regime, first, we augment the baseline debt-dependent estimation model with the interaction term of monetary policy stance. Estimation results presented in Fig. 4 show that the impulse responses of consumption and investment are significantly larger in a contractionary monetary policy stance. That is, the responses of investment and consumption become significantly larger 3 ∼ 4 quarters after impact in the contractionary stance, and the differences last over considerably long horizons.
[16]

Then, we test for the supposition that the effect of a monetary shock on the economy largely depends on the predominant type of interest rate that applies to household debts. Specifically, we conduct additional estimations, splitting the sample into three groups by the predominant types of interest rate: fixed, mixed, and adjustable in the manner which is described above. As a result, we find that there is a nontrivial difference in the response of consumption and investment on shock while the difference in the current account is muted. This result indicates that the higher the share of adjustable-rate loans, the greater impact a monetary shock has on the real sectors.

Lastly, we combine the states in which the monetary policy shocks turn out to have differential impacts above household debt, monetary policy stance, and the predominant type of interest rate, thus, testing for state-dependence of the response to the monetary policy shock. Fig. 6 compares the impulse responses to monetary policy shock in state of high household debt and contractionary monetary policy stance across the economies that manage predominantly adjustable and fixed-rate loans. The results indicate that the higher the share of adjustable-rate loans, the greater impact a contractionary monetary shock has on the real sectors. In particular, it seems that growing and persistent divergence in the responses of consumption and investment arises from the fact that adjustable-rate loans comprise the loan contract in which rates can be readjusted after a delay of one or three years.

4.2. Robustness check

In this section, we consider several robustness checks on our baseline estimation. This is to confirm that the results of our baseline estimation are robust to the definitions of the interaction term variable, standard error bands, and endogenous variables.

4.2.1. Alternative interaction-term variable

In our baseline estimation, we employ a detrended household debt-to-GDP ratio, using the HP filter with a smoothing parameter of 10^4 as our interaction term variable. To test for robustness of the baseline estimation, we substitute the logarithm of the household debt detrended in the same manner above for the ratio.

Consequently, we obtain results similar to those of the baseline estimation. Fig. A.1 in the Appendix displays the impulse response to a contractionary monetary shock by the degree of household debt. Indeed, differences in the responses of investment and consumption are, if anything, of a smaller magnitude than those of the baseline estimation. The response of investment is larger by 0.1 percentage points for high debts than for low debts in this definition, while being larger by around 0.2 percentage points in the baseline identification. The difference in the response of consumption is as small as 0.04 percentage points, compared to approximately 0.1 percentage points in the baseline identification. Nevertheless, we note that the differences are still statistically significant and persistent.

With high debts, the responses of investment and consumption turn out to be larger in a contractionary monetary stance than in an expansionary stance. Moreover, the differences in the responses of consumption and investment are of a similar magnitude to those of the baseline model. As noted above, the difference in consumption response becomes larger over time, which is supposed to arise from the staggered adjustment of variable interest rates. Meanwhile, in contrast to the result of the baseline estimation, the current account does not show a significant difference between the two regimes, although it still exhibits the J-curve effect. The prices display a homogeneous behavior, bottoming out at -0.15% and returning to a trend moderately.

[16] We test for state dependence of responses to monetary shock by policy stance, not controlling for the debt state. We obtain the result which suggest that the responses to the contractionary shock are more powerful than those to the expansionary shock. It is consistent with Tenreyro and Thwaites (2016), Angrist et al. (2013), and Cover (1992). These estimation results will be provided upon request.

4.2.2. Substituting GDP for its components

Now, we examine whether our results are affected by the substitution of aggregate GDP for the components of GDP in our baseline model. Fig. A.3 shows the impulse response of GDP to a contractionary monetary shock by the degree of debt. We observe that GDP falls by 0.5% six quarters after impact in the high-debt state and by around 0.3% in the low-debt state. The impact on prices does not diverge across states. These observations are broadly consistent with our estimation results above.

We also obtain the same result when we check for asymmetry across the monetary policy regimes, as shown in Fig. B.1. However, we observe that the impact on prices is stronger in an expansionary monetary policy stance than in a contractionary stance, which conflicts with results from previous studies. Therefore, we find that the difference in the impact on prices needs to be interpreted with caution. Nevertheless, we find our results remain unchanged.

4.2.3. Adding some variables capturing global economic activities

To strengthen our identification of monetary shocks, we add more endogenous variables that can help capture the factors affected by the global economy. For this purpose, we construct a global GDP and global CPI index, using the data available in the IFS database. We then add these variables to the top of the vector of endogenous variables in the baseline estimation model. Fig. B.1 suggests that the response of consumption to monetary shocks is much larger in the high-debt state while that of prices is not significantly different between the two states; this finding is in line with the baseline estimation. Fig. B.3 is also consistent with the baseline estimation in that contractionary monetary shocks have a stronger transmission effect on the real sector than expansionary shocks.

5. Conclusion

We find, using a panel of 23 countries, that the effectiveness of monetary policy depends upon the degree of household indebtedness. Specifically, the magnitude of responses of key macroeconomic variables to a monetary policy shock is greater in a state of high household debts. Furthermore, we investigate the possible asymmetry in the transmission by monetary policy stance. As a result, we find evidence that monetary policy becomes more powerful in a contractionary policy stance than in an expansionary one, specifically in a high-debt state. We further find that monetary policy has a relatively larger impact in countries with higher share of adjustable-rate loans. Finally, the effect of the monetary policy shock, when a country is in a high-debt state and in a contractionary policy stance, is more prominent in countries with a higher share of adjustable-rate household loans. These empirical findings lend support for the presence of a cash-flow channel with respect to the transmission of a monetary policy, particularly a contractionary one.

Our study provides some interesting implications concerning the transmission of monetary policy. Our finding is broadly consistent with what the cash-flow channel implies: monetary policy is more powerful when households are highly indebted and have adjustable-rate contracts. Furthermore, this implies that the cash-flow channel may be more responsive in a contractionary policy stance. These results provide interesting and crucial implications: namely, policymakers need to consider as many factors as possible, in that a certain monetary policy action may have unexpected, differential consequences across states.

To our knowledge, this paper is the first attempt to investigate the dependence of the transmission of monetary policy on the level of household indebtedness, using cross-country data. This paper also departs from existing literature with our finding that the dependence itself may be affected by policy and market-structural factors such as monetary policy stance regime and share of floating interest rate loans. Our empirical work has left several important questions for future study. For example, the existence of asymmetric effects of monetary policy with opposite directions in a high-debt state but not in a low-debt state, needs to be explored. In a similar context, the reason that the presence of the cash-flow channel in a high-debt state is more prominent especially in a contractionary monetary stance, remains to be further understood.

Appendix A. Alternative Interaction Term Variable

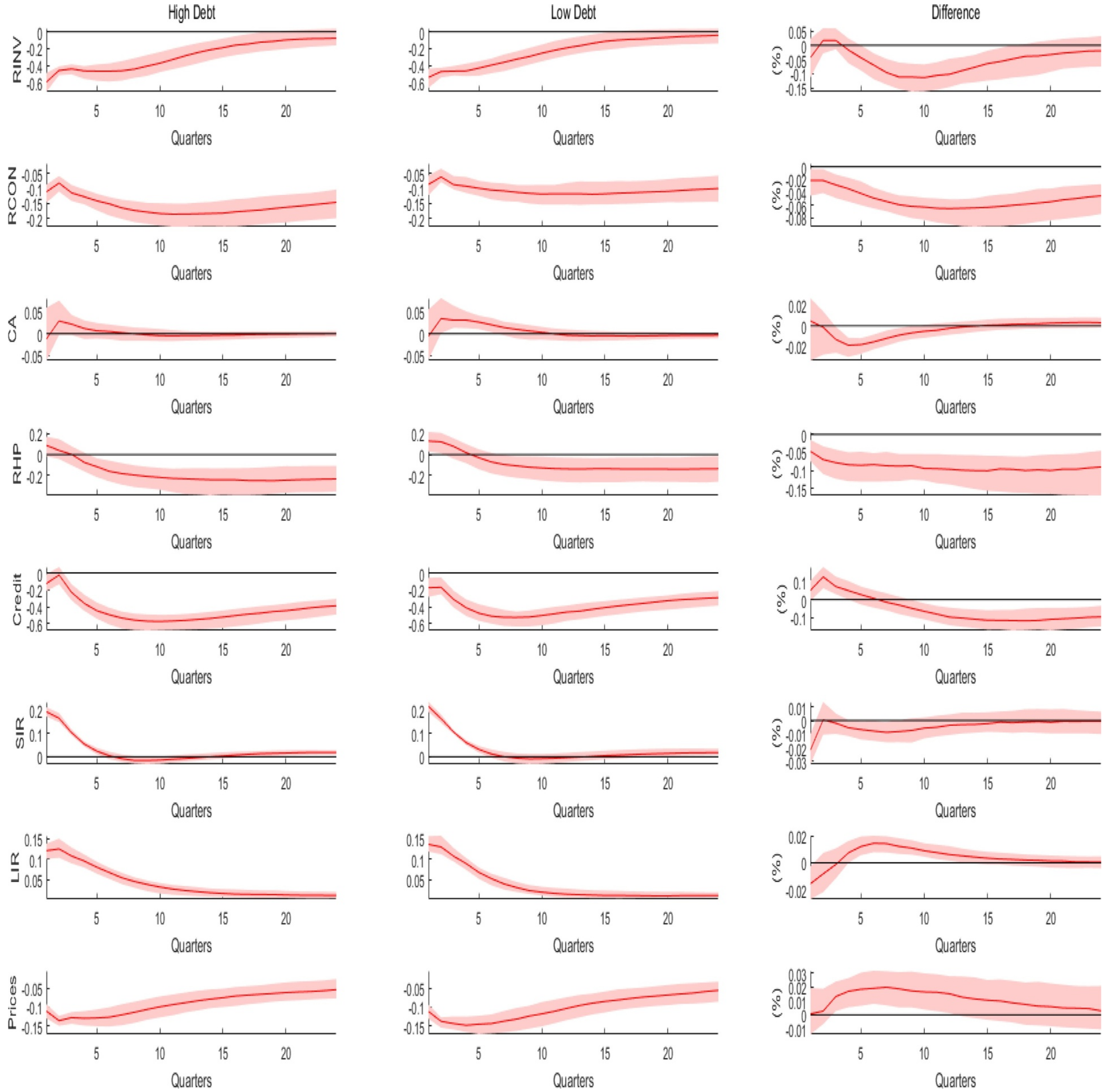


Fig. A.1. Differences in impulse responses to a monetary policy shock by degree of household indebtedness. Note: For the interaction term of the degree of household debt, we use a natural logarithm of household debt, which is detrended by the HP filter with $\lambda = 10^4$. The gray shaded area depicts the variables and the horizon on which sign restrictions are imposed. The standard error bands that account for parameter uncertainty are the 16th and 84th percentiles of the set of accepted impulse response functions for all draws. We report impulse responses evaluated at 80% and 20% of the gap ratios of household indebtedness.

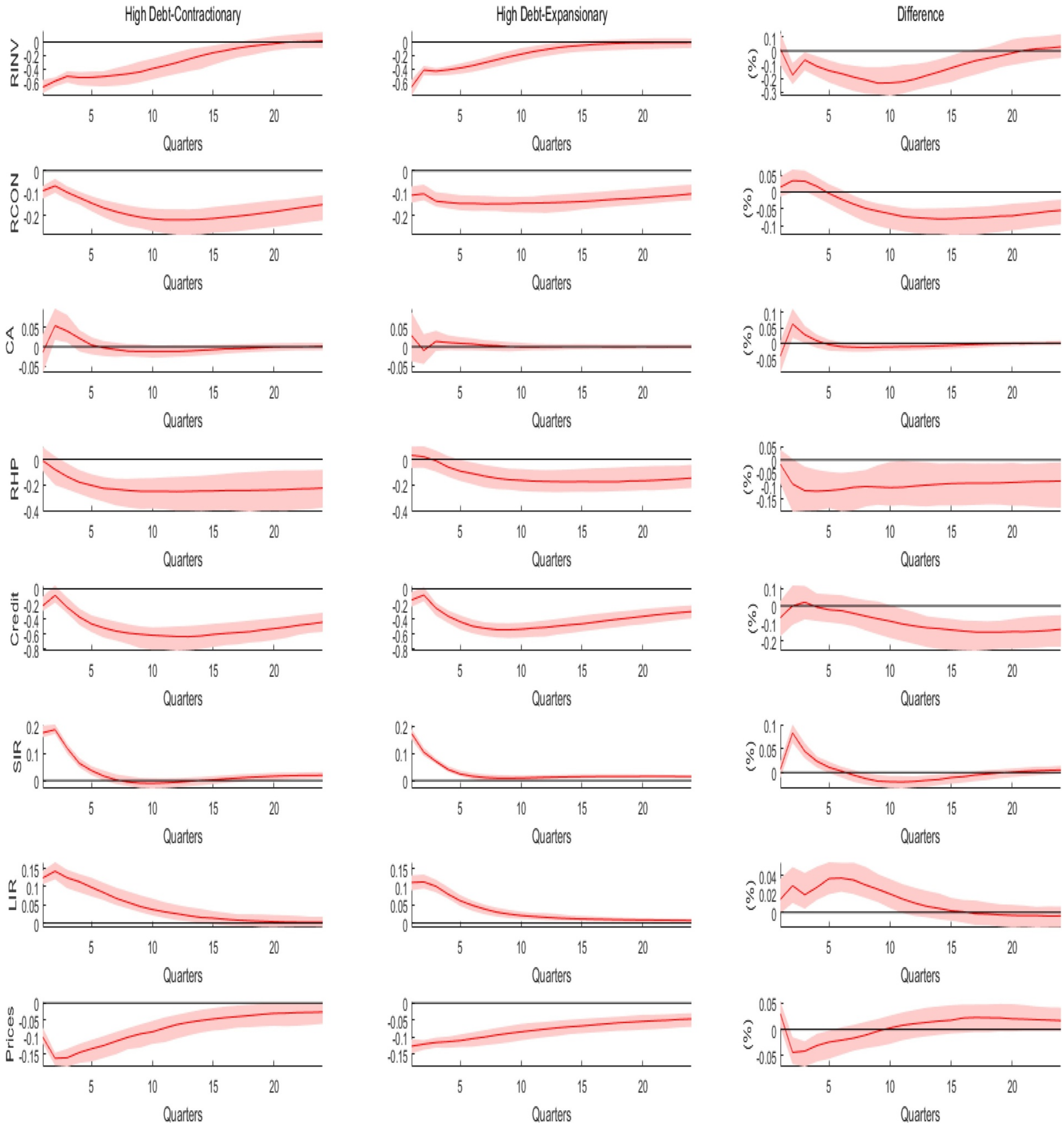


Fig. A.2. Differences in impulse responses to a monetary policy shock by monetary policy stance at a high degree of household indebtedness. Note: For the interaction term of the degree of household debt, we use a natural logarithm of household debt, which is detrended by the HP filter with $\lambda = 10^4$. To facilitate the comparison between the two regimes, we also present the impulse responses to contractionary shock in an expansionary monetary policy stance. The gray shaded area depicts the variables and the horizon on which sign restrictions are imposed. The standard error bands that account for parameter uncertainty are the 16th and 84th percentiles of the set of accepted impulse response functions for all draws.

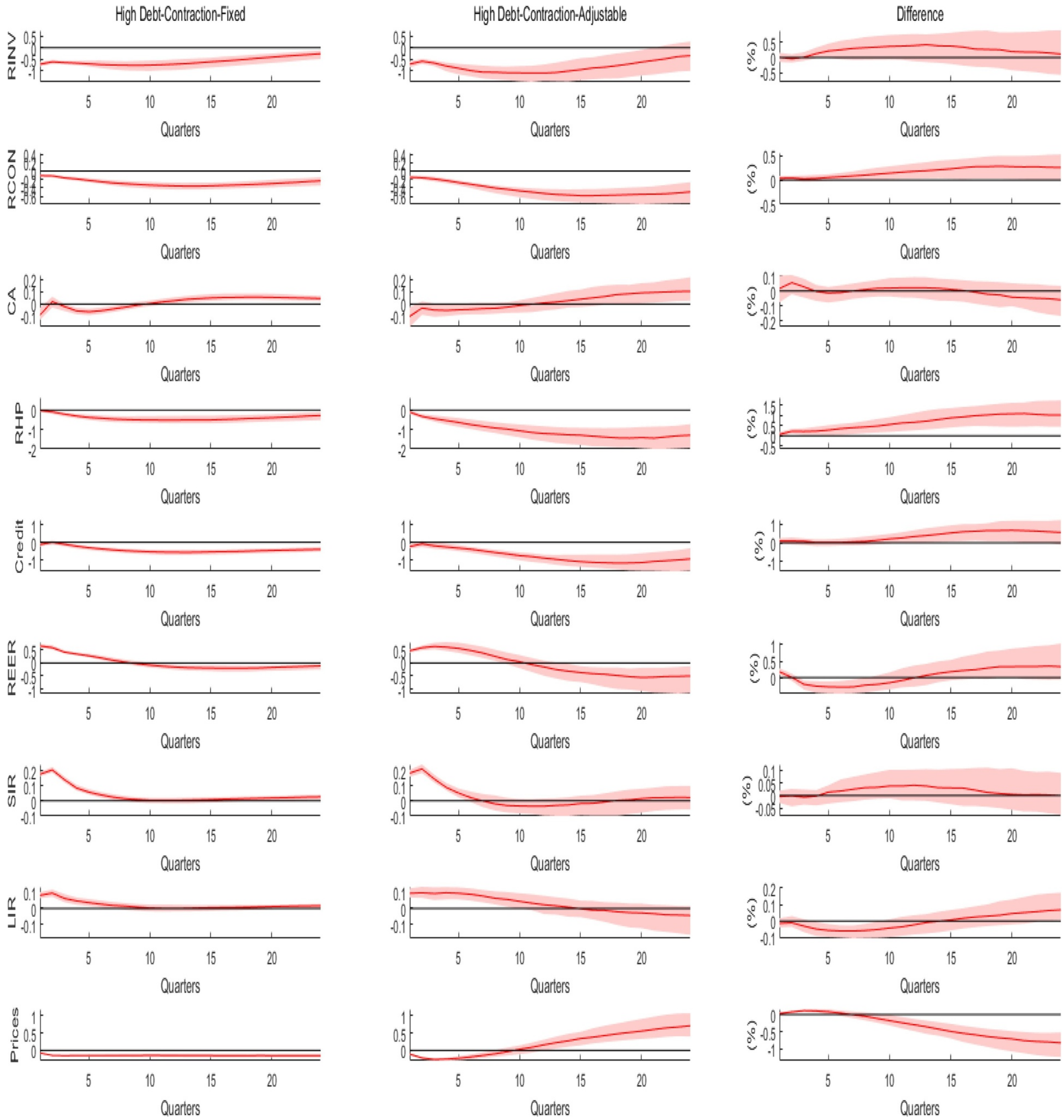


Fig. A.3. Differences in impulse responses to a monetary policy shock by predominant interest type at a high degree of household debt and a contractionary MP stance. Note: For the interaction term of the degree of household debt, we use a natural logarithm of household debt, which is detrended by the HP filter with $\lambda = 10^4$. The gray shaded area depicts the variables and the horizon on which sign restrictions are imposed. The standard error bands that account for parameter uncertainty are the 16th and 84th percentiles of the set of accepted impulse response functions for all draws.

Appendix B. Substituting GDP for its component

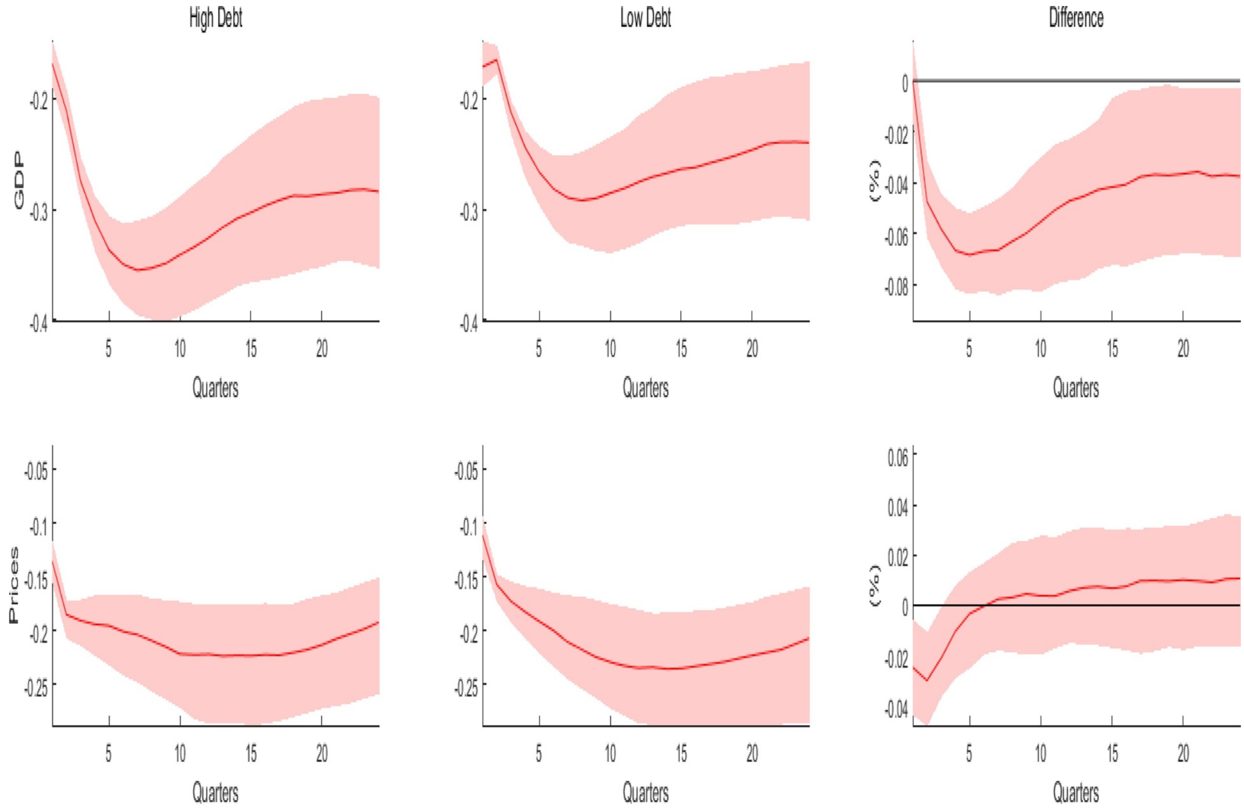


Fig. B.1. Differences in impulse responses to a monetary policy shock by degree of household indebtedness. Note: The standard error bands which account for parameter uncertainty are the 16th and 84th percentiles of the set of accepted impulse response functions for all draws. We report impulse responses evaluated at 80% and 20% of gap ratios of the household indebtedness.

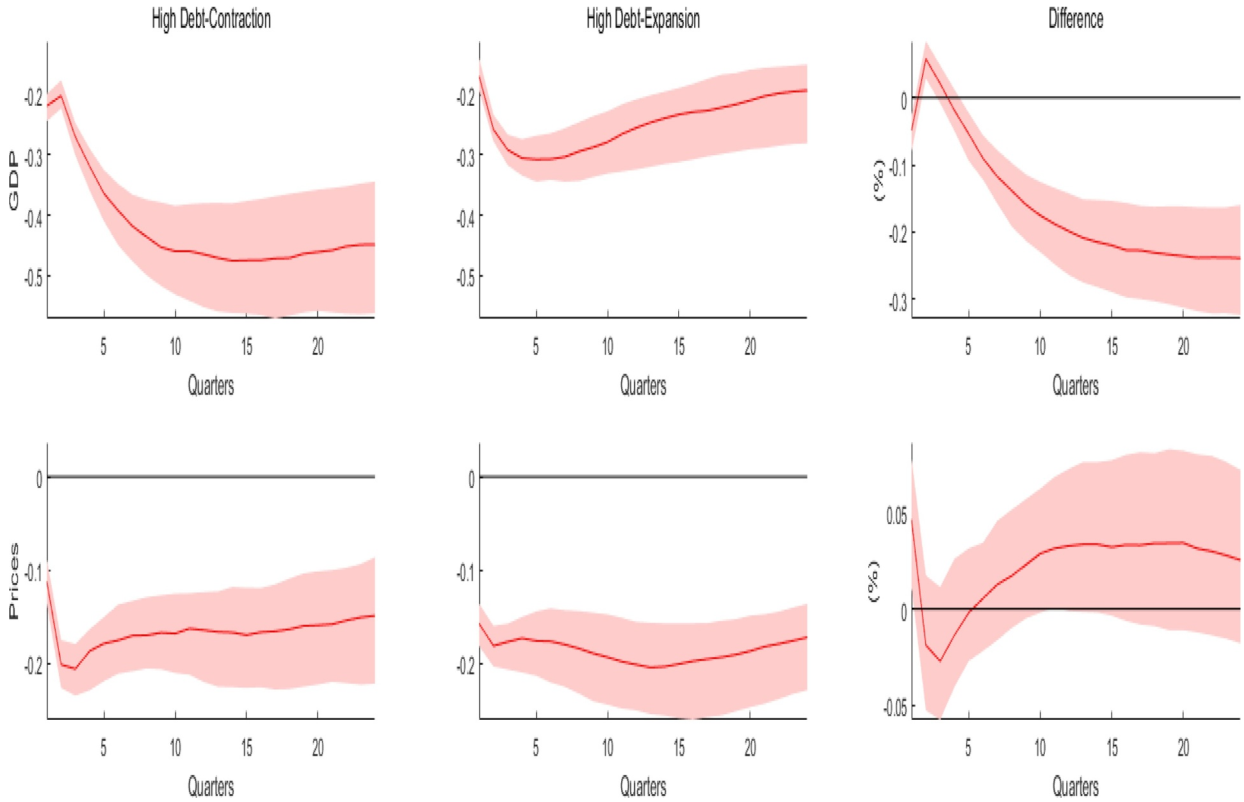


Fig. B.2. Differences in impulse responses to a monetary policy shock by monetary policy stance at a high degree of household indebtedness. Note: The standard error bands which account for parameter uncertainty are the 16th and 84th percentiles of the set of accepted impulse response functions for all draws. We report impulse responses evaluated at 80% and 20% of gap ratios of the household indebtedness.

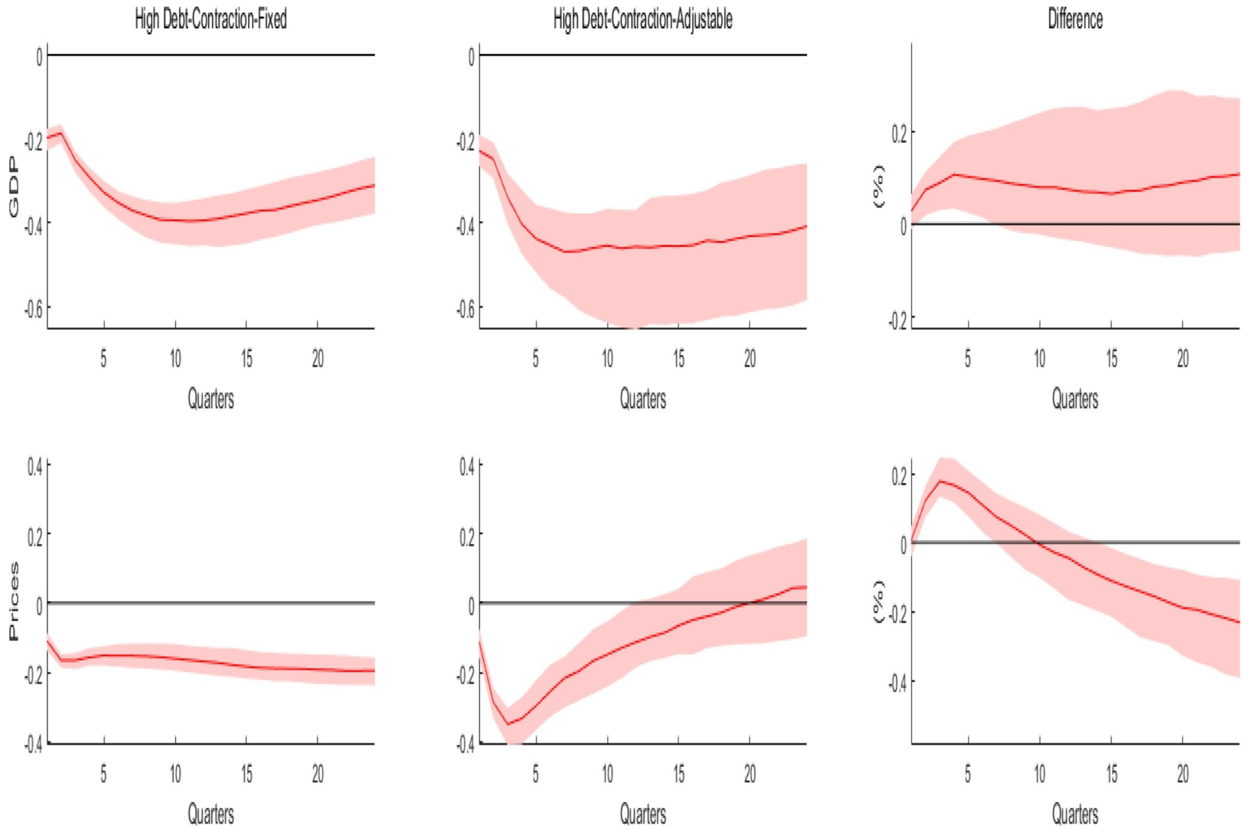


Fig. B.3. Differences in impulse responses to a monetary policy shock by predominant interest type at a high degree of household debt and a contractionary MP stance. Note: The standard error bands which account for parameter uncertainty are the 16th and 84th percentiles of the set of accepted impulse response functions for all draws. We report impulse responses evaluated at 80% and 20% of gap ratios of the household indebtedness.

Appendix C. Adding global variables

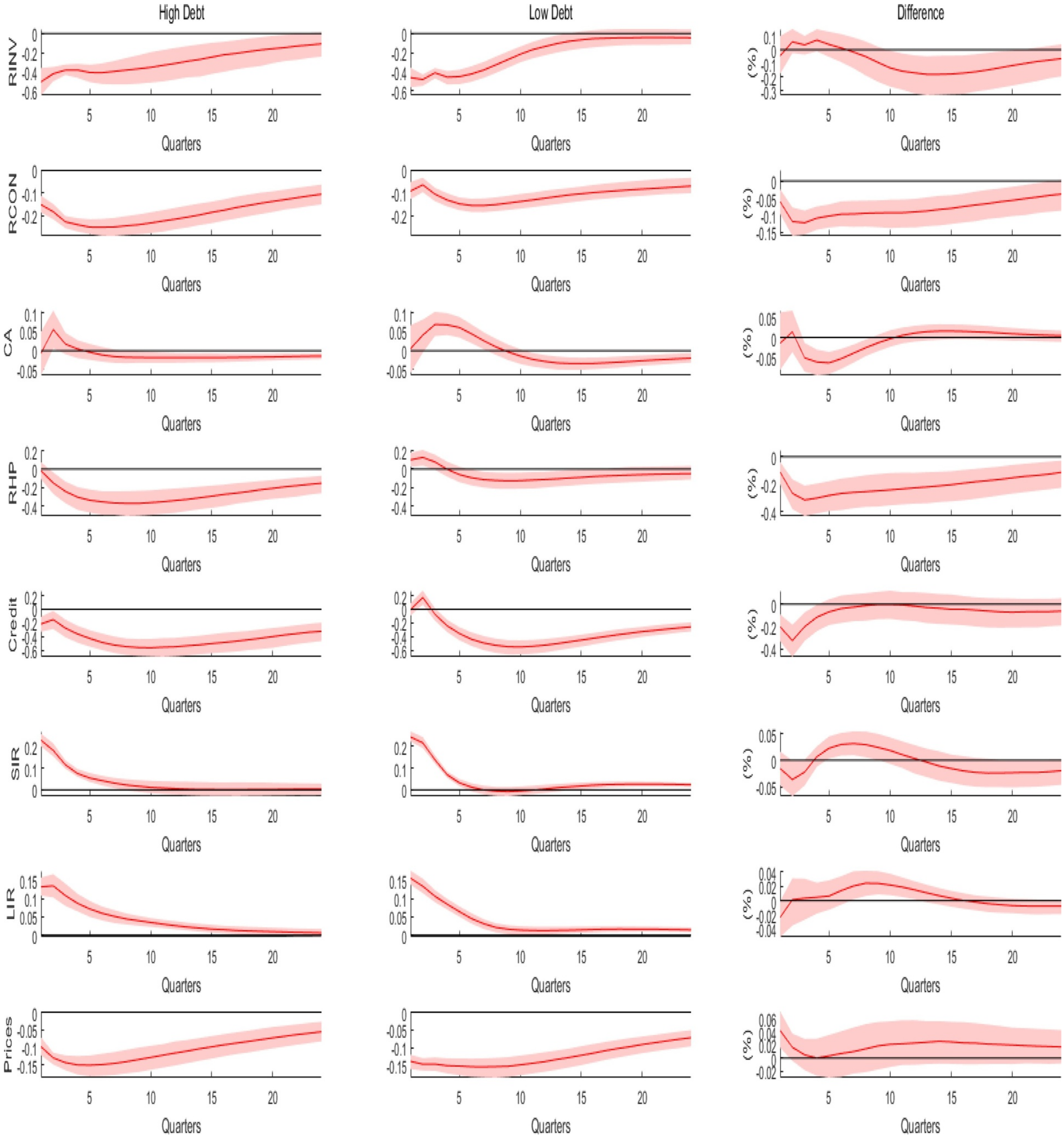


Fig. C.1. Differences in impulse responses to a monetary policy shock by degree of household indebtedness. Note: For the interaction term of the degree of household debt, we use a natural logarithm of household debt, which is detrended by the HP filter with $\lambda = 10^4$. The gray shaded area depicts the variables and the horizon on which sign restrictions are imposed. The standard error bands that account for parameter uncertainty are the 16th and 84th percentiles of the set of accepted impulse response functions for all draws. We report impulse responses evaluated at 80% and 20% of the gap ratios of household indebtedness.

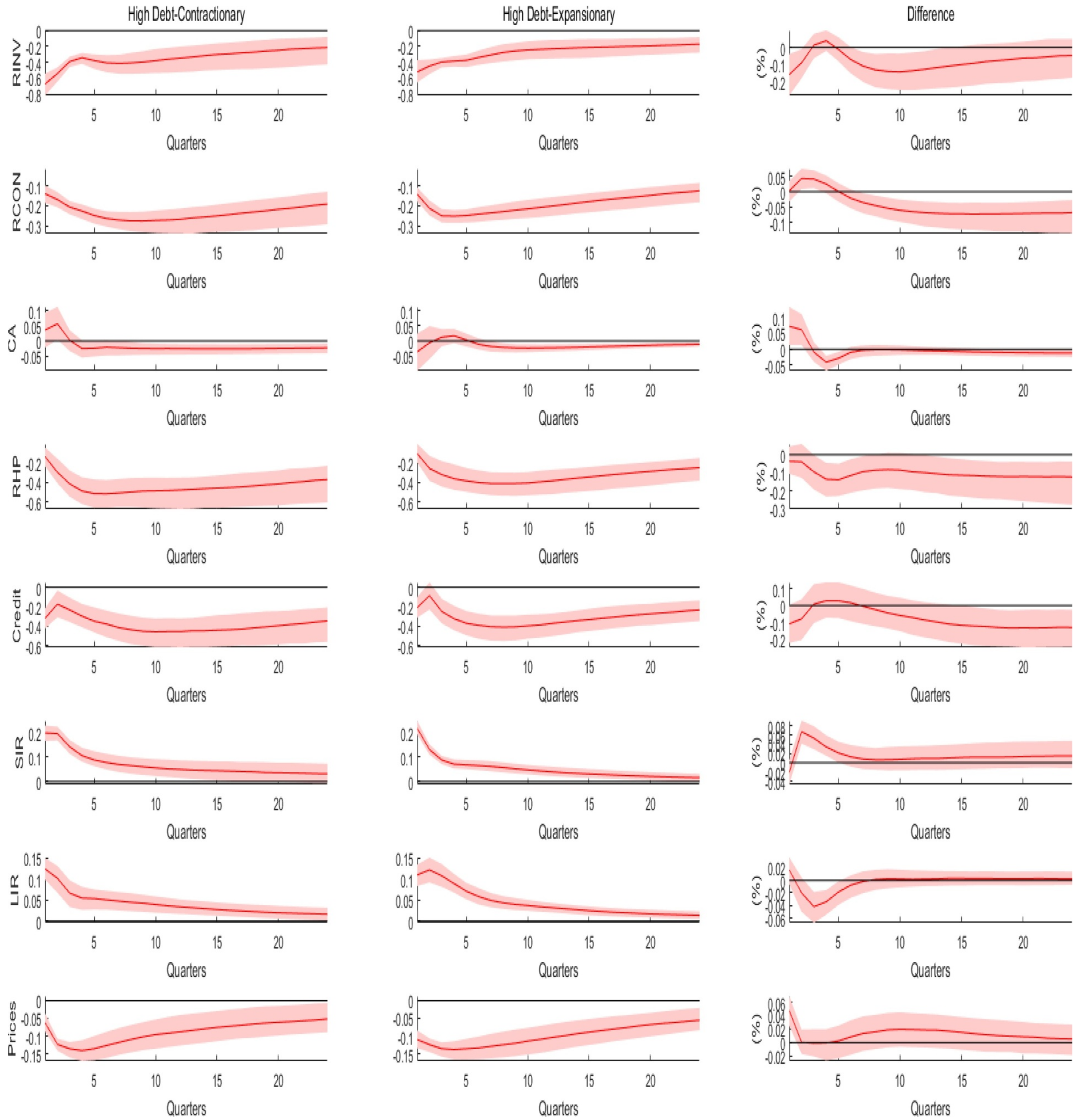


Fig. C.2. Differences in impulse responses to a monetary policy shock by monetary policy stance at a high degree of household indebtedness. Note: The standard error bands which account for parameter uncertainty are the 16th and 84th percentiles of the set of accepted impulse response functions for all draws.

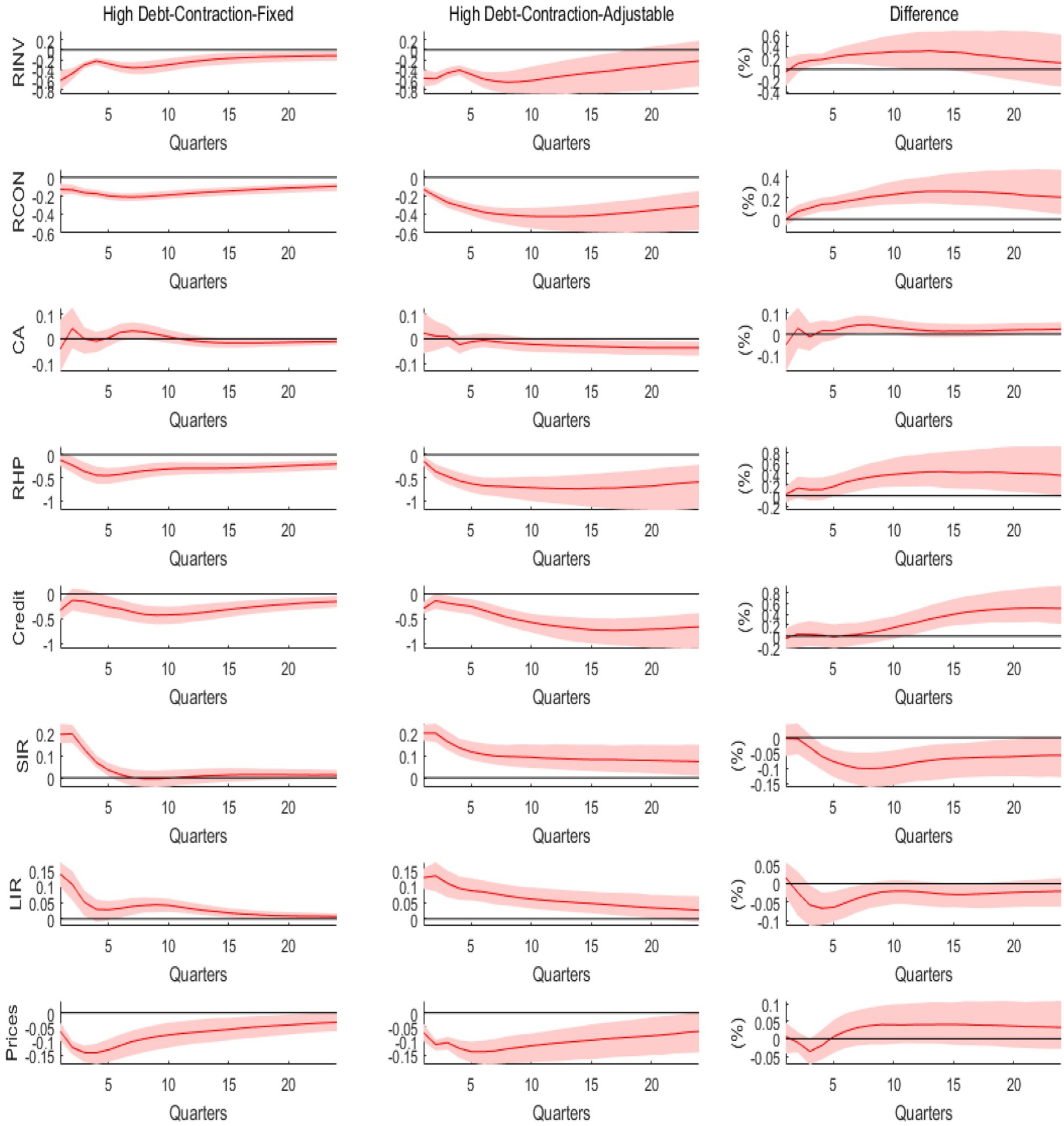


Fig. C.3. Differences in impulse responses to a monetary policy shock by predominant interest type at a high degree of household debt and a contractionary MP stance. Note: The standard error bands that account for parameter uncertainty are the 16th and 84th percentiles of the set of accepted impulse response functions for all draws.

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