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by Soyoung Kim and Aaron Mehrotra

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Examining macroprudential policy and its macroeconomic effects – some new evidence[1]

Soyoung Kim[2] and Aaron Mehrotra[3]

Abstract

In this paper, we provide empirical evidence about the broader macroeconomic effects of macroprudential policies and the underlying transmission mechanism, as well as the response of macroprudential policy to financial risks. To this end, we use structural panel vector autoregressions and a dataset covering 32 advanced and emerging economies. We show that macroprudential policy shocks have effects on real GDP, the price level and credit that are very similar to those of monetary policy shocks, but the detailed transmission of the two policies is different. Whereas macroprudential policy shocks mostly affect residential investment and household credit, monetary policy shocks have more widespread effects on the economy. Moreover, while positive credit shocks are generally met with tighter macroprudential policy, macro-financial country characteristics such as the exchange rate regime and the level of financial development affect the policy response.

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2 Seoul National University. Email address: soyoungkim@snu.ac.kr

3 Bank for International Settlements. Email address: aaron.mehrotra@bis.org

1. Introduction

Recent years have seen an increasing use of macroprudential policies to mitigate systemic risk. This has inspired a growing number of papers that examine the effectiveness of macroprudential policies, especially in terms of curtailing credit and house price growth (eg Kuttner and Shim (2016); Vandenbussche et al (2015); Cerutti et al (2017a)).[4] Similarly, there is an increasing number of theoretical studies that analyse macroprudential policy, often together with monetary policy (eg Alpanda and Zubairy (2017); Angelini et al (2014); Bailliu et al (2015)).

However, some relevant issues have received only limited attention in previous research. One concerns the broader macroeconomic effects of macroprudential policy. In addition to affecting systemic risk and financial conditions, macroprudential policy may affect aggregate economic activity through its impact on the availability of credit or the cost of borrowing. For example, in the theoretical model of Alpanda and Zubairy (2017), a decrease in loan-to-value (LTV) ratios reduces both residential investment and consumption. In the two-period model of housing demand of Kuttner and Shim (2016), tighter LTV and debt-service-to-income ratios lead households to either reduce their housing demand or consumption. Accordingly, a few papers, including Kim and Mehrotra (2018), Richter et al (2019) and Alam et al (2019), have recently provided empirical evidence about the macroeconomic effects of macroprudential policy for panels of countries; Ayyagari et al (2018) have done so using firm-level data.

Yet, empirical evidence on the macroeconomic effects remains sparse, in particular in a framework that would incorporate both monetary and macroprudential policy. Modelling both policies jointly is important, as they share similar objectives and often interact with each other. Indeed, Kim and Mehrotra (2018) have shown empirically, using data for four inflation targeting Asia-Pacific economies, that the effects of macroprudential and monetary policy shocks on output, prices and credit bear close resemblance and there is dynamic interaction between the two policies. But similar evidence for a larger panel of countries is limited. Moreover, to our knowledge, no study has documented and compared the transmission of the two policies to the real economy in a uniform empirical framework, in terms of their effects on different components of aggregate demand and credit.

Another area with limited empirical evidence concerns the response of macroprudential policy to financial risks. The policy response to developments in credit may be particularly relevant, given that many macroprudential instruments have been used to curb excessive credit growth and asset price booms (FSB-IMF-BIS (2011)). The policy response need not be similar across countries. In addition to varying by the intensity of financial risks, it may depend on various macro-financial characteristics of the economy, including its degree of financial openness, the level of financial development, or the exchange rate regime. Indeed, such factors have been previously shown to matter for the effectiveness of macroprudential policy in curbing credit growth (eg Cerutti et al (2017a)). The macroprudential policy response may also depend on the interest rate policy response to credit developments, again underscoring the importance of interaction between the two policies.

4 See also the survey by Galati and Moessner (2018)

In this paper, we analyse the use of macroprudential policy in a cross-country panel covering 32 advanced and emerging economies. We estimate structural panel vector autoregressive (VAR) models that incorporate both monetary and macroprudential policies, similarly to Kim and Mehrotra (2018), but expand the sample substantially. We analyse the underlying transmission mechanism of macroprudential policy on economic activity, and compare it with monetary policy – to our knowledge this has not been done in previous empirical studies. The macroprudential measures we consider in our analysis include changes in capital buffers, interbank exposure limits, concentration limits, loan-to-value ratios and reserve requirements, drawing on a recent dataset by Cerutti et al (2017b).

Our paper further exploits the flexibility of the empirical framework that allows us to analyse not only the macroeconomic effects of macroprudential policy but also the macroprudential policy response to credit shocks. The macroprudential policy response is obtained as the systematic reaction of macroprudential measures to credit shocks in the VAR, controlling for monetary policy, given the relevant role of credit for financial stress in the past (eg Borio and Lowe (2002); Borio and Drehmann (2009); Kaminsky and Reinhart (1999); Jorda et al (2011); Schularick and Taylor (2012)). Finally, we analyse how the effects and the response of macroprudential policy to credit shocks depend on the macro-financial characteristics of the economies.

We report several novel findings. First, the effects of contractionary macroprudential policy shocks on macroeconomic variables are similar to those of monetary policy: output, the price level and credit all decline. Thus, our results confirm the findings of Kim and Mehrotra (2018), but for a much larger panel of economies.

Second, delving deeper into the underlying transmission mechanism, we find that macroprudential policy shocks mostly affect investment, in particular residential investment, and household credit. This likely reflects the tendency of macroprudential actions to be targeted at the housing market, affecting investment in housing and the demand and availability of mortgage credit. Notably, this general pattern holds also when we divide the macroprudential instruments into three groups based on whether they mainly work on financial institutions' assets, liabilities or capital. By contrast, we find that monetary policy shocks have more widespread effect on the economy, affecting both consumption and investment, and credit to firms as well as credit to households.

Third, we find that, in most country groups considered, positive credit shocks are met with a contractionary macroprudential policy response. This credit-stabilising response of macroprudential policy to credit shocks is consistent with some theoretical papers that postulate a reaction function for the macroprudential authority (eg Angelini et al (2014); Bailliu et al (2015)). Yet, the analysis unveils differences in the policy response across countries. Perhaps most prominently, the response of macroprudential policy to credit shocks is larger in financially less developed economies, and it is also stronger in countries with less flexible exchange rates.

Fourth, our results show that there is important interaction between monetary and macroprudential policy. One such finding is that macroprudential policy is loosened over time endogenously as a response to contractionary monetary policy shocks, which can again be interpreted as a policy action aimed at stabilising credit. This arises even if there is close-to-zero unconditional (contemporaneous) correlation between changes in monetary and macroprudential policy in the data. A second related finding is that there is complementarity in the response of macroprudential and monetary policy to credit shocks.

The study is related to various different strands of literature. In addition to papers mentioned above, it is related to other studies that analyse the effectiveness of macroprudential policy (eg Akinci and Olmstead-Rumsey (2018); Claessens et al (2013); Zhang and Zoli (2016)); and to theoretical studies that postulate a reaction function for macroprudential policy (eg Gelain and Ilbas (2017); Kannan et al (2012); Rubio and Carrasco-Gallego (2014)). The paper also ties in with research showing that, historically, some quantitative monetary and credit policy tools have had macroeconomic effects (eg Aikman et al (2016); Monnet (2014); Sonoda and Sudo (2015)), while Meeks (2017) provides evidence about the macroeconomic effects of changes in microprudential bank capital requirements. The research also relates to the scant empirical literature that has considered the response of macroprudential policy to financial risks (eg Boar et al (2017); Lim et al (2013)).

This paper is structured as follows. After a discussion of related literature in Section 2, we present the empirical methodology and the data in Section 3. We discuss the main empirical results and extensions to the baseline model in Section 4. Section 5 concludes.

2. Some related literature

Theoretical papers suggest various channels through which macroprudential policies can affect aggregate economic activity, beyond their more direct impact on systemic financial risk.

One channel works through reducing the credit available to borrowers and thus, through the assets of financial institutions. In the model of Alpanda and Zubairy (2017), tighter LTV ratios lower household credit and housing demand and, as a consequence, reduce both house prices and residential investment. As housing and consumption are substitutable and wages fall, consumption by borrower households declines as well. In Alpanda et al (2018), when LTV ratios tighten, the resulting decrease in consumption and residential investment also brings down business investment, although the latter declines by much less than residential investment. Similarly, while credit to businesses also declines, it does so by less than household credit. In the two-period model of housing demand of Kuttner and Shim (2016), when LTV or debt-service-to-income ratios are tightened, households reduce either their housing demand or consumption.

Another channel works through the capital of financial institutions. In the framework of Alpanda et al (2018), if bank capital requirements are raised, banks will lack sufficient net worth relative to regulatory requirements. As banks' funding costs increase, they increase the interest rate for lending to the private sector. This curtails credit to households and businesses and reduces output, as both consumption and investment decline. Similarly, Cecchetti and Kohler (2014) show that capital adequacy requirements and interest rates can act as substitutes. Under certain conditions, higher capital requirements reduce loan supply, raise lending rates, and reduce the demand for goods, output and inflation.

Some macroprudential measures, such as reserve requirements, work mainly through the liabilities of financial institutions. Reinhart and Reinhart (1999) show that when banks face a competitive deposit market but have market power in the loan market, higher reserve requirements can act as a tax on banks. As the higher costs are passed on to borrowers, credit in the economy falls.[5] Similarly, in the small open-economy model by Glocker and Towbin (2012), when the central bank follows an interest rate rule and reserve requirements are increased, the rise in the lending rate to borrowers leads to a decline in credit and investment in the economy. At the same time, however, as the deposit rate falls, consumption rises and exports are stimulated through exchange rate depreciation.

Some empirical papers confirm that macroprudential policies indeed have macroeconomic effects. Kim and Mehrotra (2018) perform a panel VAR analysis for four inflation targeting economies in the Asia-Pacific region. They show that contractionary macroprudential policy shocks lead to declines in real GDP, the price level and credit, similarly to monetary policy shocks. In a related contribution, Kim and Mehrotra (2017) show that the similar effects of macroprudential and monetary policy at times can at times give rise to policy trade-offs in the short run, eg macroprudential policy actions pushing inflation away from target. Richter et al (2019) use a narrative approach to identify exogenous changes to LTV ratios in a panel of advanced and emerging economies. The authors find that exogenous tightenings in LTV ratios lead to declines in GDP (and consumption) but not in inflation. Alam et al (2019) use a novel database covering over 100 economies and find that a tightening of macroprudential policy affects household credit but also consumption. And, Ayyagari et al (2018) use micro data on 900,000 firms from 48 countries and show that the use of macroprudential policies is associated with lower investment and sales growth.[6]

Most other existing empirical studies examine historical experiences. For example, Monnet (2014) analyses quantitative controls on money and credit in France during 1948-73. He shows that the effects on output and prices of monetary policy shocks derived from quantitative measures are similar to those found in other VAR studies for different economies and time periods. Aikman et al (2016) examine credit controls in the United Kingdom in the 1960s, 70s and early 80s. They show that contractionary credit policy shocks lead to declines in manufacturing output and credit, although consumer prices actually rise. Sonoda and Sudo (2015) find that quantitative restrictions to curb bank lending to real estate lending activities in Japan from the 1970s to 1990s had broader effects on the macroeconomy, as both consumption and investment fell.

Moving on to studies that feature macroprudential reaction functions, theoretical papers tend to feature policy reaction functions where credit plays an important role. For example, in the framework of Angelini et al (2014), the macroprudential authority sets a time-varying capital requirement in response to movements in the loans-to-output ratio, while in Kannan et al (2012) and Rubio and Carrasco-Gallego (2014), macroprudential policy responds to credit growth. Similarly, in Bailliu et al (2015), macroprudential policy responds to the deviation of credit growth from the steady

5 Reserve requirements have also been used as a monetary policy instrument, in particular in some EMEs, or as a complement to interest rate policy (see eg Montoro and Moreno (2011) for a discussion).

6 Relatedly, Meeks (2017) shows that changes in microprudential capital requirements in the United Kingdom during 1990-2008 affected aggregate expenditure. See also the evidence in Conti et al (2018) for Italy and Eickmeier et al (2018) for the United States.

state. In Gelain and Ilbas (2017), the macroprudential policy rule consists of a lump-sum levy/subsidy on bank capital that is set as a function of credit growth and output growth. And, in Rubio and Yao (2019), the macroprudential regulator sets the LTV ratio as a function of the deviations of credit and output from steady state.

However, empirical counterparts to such macroprudential reaction functions are notably sparse. An exception is Boar et al (2017) who estimate a panel equation where macroprudential policy responds to credit growth, capital inflows and output growth. They find a positive (tightening) response to increases in all three variables. Another study is Lim et al (2013) that estimates the response time of macroprudential policy to changes in the credit cycle during 2008-11. It considers eight different macroprudential instruments for 39 economies, and both upswings and downswings in the credit cycle. However, in contrast to our study that focuses on macro-financial country characteristics, the focus of Lim et al (2013) is on how the involvement of the central bank in the macroprudential framework affects the response of macroprudential policy to changes in the credit cycle.

3. Estimation framework and data

Following Kim and Mehrotra (2018), the analysis is based on estimating panel structural vector autoregressive (SVAR) models.

Let us assume that an economy i (i=1,2,…,N) is described by the following structural form equation:

$$G(L)y_t^i = d^i + C(L)x_t + e_t^i \qquad (1)$$

where $G(L)$ and $C(L)$ are matrix polynomials in the lag operator L, y_t^i is an $M\times1$ data vector of endogenous variables for country i at time t, x_t is an $K\times1$ data vector of exogenous or world variables, d^i is a $M\times1$ constant matrix, M and K are the numbers of endogenous and exogenous variables in the model, respectively, and e_t^i is a vector of structural disturbances. By assuming that structural disturbances are mutually uncorrelated, $\mathrm{var}(e_t^i)$ can be denoted as Λ, which is a diagonal matrix where the diagonal elements are the variances of structural disturbances. The individual fixed effect, d^i, is introduced to control for country-specific factors that are not considered in the model.

We estimate the following reduced form panel VAR with the individual fixed effects:

$$y_t^i = c^i + B(L)y_{t-1}^i + D(L)x_t + u_t^i, \qquad (2)$$

where c^i is an $M\times1$ constant vector, $B(L)$ and $D(L)$ are matrix polynomials in the lag operator L, u^i is an $M\times1$ vector of reduced form residuals, and $\mathrm{var}(u_t^i) = \Sigma$.

The parameters of the structural form equation can be recovered from the estimated parameters of the reduced form equation in several ways. The identification schemes under consideration impose recursive zero restrictions on contemporaneous structural parameters by applying Cholesky decomposition to the variance-covariance matrix of reduced form residuals, Σ, as in Sims (1980).

In the empirical model, the vector of endogenous variables, y^i, is written as $[RGDP^i, CPI^i, CRD^i, PP^i, R^i]'$. We include two policy instruments: the policy interest rate (R) for monetary policy, and an index of macroprudential policies (PP) based on Cerutti et al (2017b) as the macroprudential policy instrument (see below). We also include two policy target variables: the consumer price index (CPI) for monetary policy, and, consistent with the theoretical models mentioned in the previous section, the stock of real credit to the private sector (CRD) as the target for macroprudential policy.[7] Real GDP ($RGDP$) is included as a measure of overall economic activity. A logarithmic transformation is applied for real GDP, CPI and real credit, and then multiplied by 100.

The focus on credit as the target for macroprudential policy is justified by the empirical regularity that strong credit growth has typically preceded crises (eg Kaminsky and Reinhart (1999); Jorda et al (2011); Schularick and Taylor (2012)). In addition, an important aim of macroprudential tools has been to address threats from excessive credit expansion (FSB-IMF-BIS (2011)). Our baseline measure is total credit to the private sector, which comprises bank credit from domestic sources, but also cross-border credit as well as debt securities issuance. Thus, this measure internalises some of the substitution effects from domestic bank credit to non-bank credit and foreign borrowing that may arise when macroprudential measures are set on domestic bank credit (see Cizel et al (2016); Reinhardt and Sowerbutts (2015)). Moreover, Drehmann (2013) reports that the early warning indicator properties of total credit are superior to bank credit. However, we also estimate separate models for corporate and household credit, respectively. Mian et al (2017) have recently highlighted the adverse impact of household debt accumulation on economic activity in the medium run. Moreover, as many macroprudential measures have been directed at the housing market, they may have important effects on mortgages and thus household credit.

The vector of exogenous variables, x_t, is written as $[USRGDP, FFR]'$ where $USRGDP$ and FFR are real GDP and the Federal Funds rate of the United States. This is motivated by the potential impact of monetary policy and real activity of the United States on economic activity, financial conditions and monetary policy of other countries (eg Rey (2013)).

For identification, the three macro variables ($RGDP$, CPI, CRD) are assumed to be contemporaneously exogenous to the two policy instruments (PP, R). These assumptions allow the policy stance to be set after observing the current economic condition as reflected by the macro variables. Then, policy shocks are identified as residuals of the equations where policy instruments are allowed to endogenously respond to the state of the economy in such a way. Our model structure may be

7 Real credit is obtained by deflating nominal credit by the consumer price index.

regarded as an extension of the model by Christiano et al (1999) that identifies monetary policy shocks.

Our identification assumptions imply that in addition to contemporaneous values of output and price that are the traditional objectives of monetary policy, the monetary authority is allowed to consider contemporaneous developments in credit, in line with the increased relevance of financial stability objectives. The structure is similar to the augmented interest rate rule considered in Bailliu et al (2015). Macroprudential policy, in turn, is set by considering current credit conditions (eg Angelini et al (2014); Kannan et al (2012); Quint and Rabanal (2014); Rubio and Carrasco-Gallego (2014)). However, the macroprudential policy rule also allows a response to output, as in the theoretical models of Angelini et al (2014), Gelain and Ilbas (2017) and Rubio and Yao (2019). Gelain and Ilbas (2017) argue that the presence of output in a macroprudential loss function reflects the concern to stabilise indirect effects to the real economy from disruptions to financial variables. In similar vein, we cannot exclude the possibility that macroprudential policy takes into account contemporaneous developments in the price level, especially when the central bank is the authority in charge of macroprudential policy.

Regarding the ordering between the two policy instruments, in the baseline model, macroprudential measures (*PP*) are assumed to be contemporaneously exogenous to interest rates (*R*). However, as we show in Section 4.3, the results are similar when *R* is assumed to be contemporaneously exogenous to *PP*, as innovations in *PP* and innovations in *R* have a correlation close to zero.

At the same time, the model allows to infer the policy response to the variables of interest, in the presence of various shocks, based on impulse response functions. For example, we can infer how the macroprudential policy measure, *PP*, responds to fluctuations in the assumed target variable of macroprudential policy, *CRD*, in the presence of credit shocks. This can be observed from the impulse responses of *PP* and *CRD* to credit shocks.

In addition to using impulse responses directly, we formally derive the macroprudential policy response by combing the impulse responses of *PP* to credit shocks and the impulse responses of *CRD* to credit shocks. Suppose that the impulse responses of *PP* and *CRD* to credit shocks are $PP_t = a(L)\ e_{CRD}$ and $CRD_t = b(L)\ e_{CRD}$, respectively. Then, by combining these two responses, we obtain the response of *PP* to *CRD* in the presence of credit shocks. $a(L)\ b(L)^{-1}$ shows the size of *PP* tightening (net of loosening) for various horizons when credit increases by 1% in the presence of credit shocks, given that logarithm is taken for *CRD* and *PP* is an index for macroprudential policy actions as explained below. With a similar method, we can derive the monetary policy response to *CRD* in the presence of credit shocks. Suppose that the impulse responses of *R* and *CRD* to credit shocks are $R_t = c(L)\ e_{CRD}$ and $CRD_t = d(L)\ e_{CRD}$. Then, $c(L)\ d(L)^{-1}$ shows the percentage point increase in the policy interest rate for various horizons when *CRD* increases by 1% in the presence of credit shocks.[8]

[8] The nature of credit shocks can be different under an alternative ordering of the variables. In the model, we assume that *RGDP* and *CPI* are contemporaneously exogenous to *CRD* because output and the price level represent aggregate macroeconomic activity and aggregate prices that tend to be sluggish or sticky. By contrast, credit is a financial variable that tends to respond quickly to shocks to aggregate economic activity.

Our study considers nine different macroprudential instruments, based on the database of Cerutti et al (2017b). These are general capital requirements, the loan-to-value ratio, sector-specific capital buffers (for real estate loans, consumer loans, and others), concentration limits (limits on bank exposures to specific sectors), interbank exposure limits, and changes in reserve requirements on foreign and local currency denominated accounts, respectively. The data are obtained both from primary and secondary sources, including the IMF's Global Macroprudential Policy Instruments survey and national authorities' web pages and reports.

Macroprudential policy actions are included in the model as an index variable, where the changes in policies are accumulated over time. When macroprudential policy is tightened (loosened), regardless of the instrument used or its intensity, the level of the index rises (falls) by one unit. The new value of the index maintains until another macroprudential action is taken. Thus, the estimated effects of macroprudential policy shocks should be regarded as average impacts of shocks to the various prudential instruments. However, we also provide results where the index is constructed on the basis of selected individual macroprudential instruments only.

The modelling of macroprudential policies as an index is consistent with a number of studies (eg Akinci and Olmstead-Ramsey (2018); Bruno et al (2017); Cerutti et al (2017b); Kim and Mehrotra (2017, 2018)). As noted by Cerutti et al (2017b), the index can capture policy actions that may not be easily measured by a single numerical statistic. For example, authorities could tighten the LTV ratio only for second-home buyers, or they may increase reserve requirements only for the largest banks.

In order to examine the implications of measuring macroprudential policy in this way, Kim and Mehrotra (2018) conduct separate estimations in a panel SVAR framework using reserve requirements both in actual levels and as an index. They report that the estimated effects of macroprudential policy shocks are very similar regardless of whether the index or the actual level of reserve requirements is used. Cerutti et al (2017b) also show that for China, an index constructed on the basis of changes in reserve requirements traces closely the level of reserve requirements over time, even if the latter would not capture changes to various subcategories such as reserve requirements affecting different types of bank accounts.

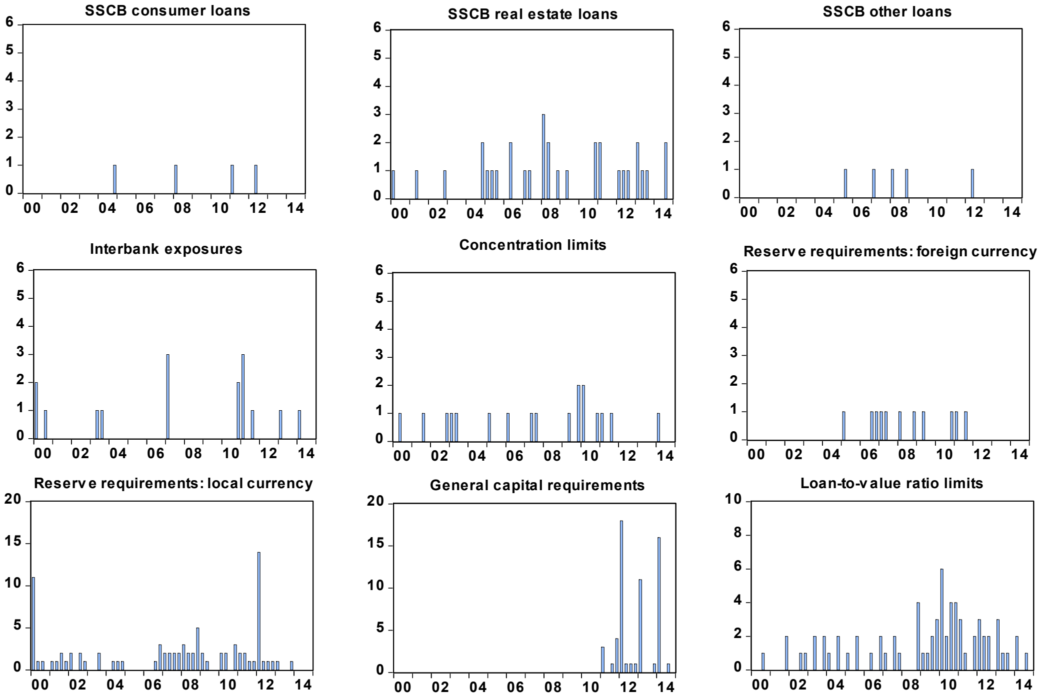
Our sample spans Q1:2000 to Q4:2014, based on the availability of the macroprudential measures in Cerutti et al (2017b). We use data for 32 economies: 19 advanced and 13 EMEs.[9]

There are differences in the frequency with which the various macroprudential instruments have been used. Figure 1 shows the number of measures, summing up both tightenings and loosenings, across all economies, for each quarter in the sample. Changes in the loan-to-value ratio and reserve requirements in local currency have been applied more frequently than other measures over the entire sample, while general capital requirements have been increased in the post-crisis period.

9 The advanced economies are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom. The EMEs are China, the Czech Republic, Hong Kong SAR, Hungary, Indonesia, Korea, Malaysia, Mexico, India, Poland, Singapore, South Africa and Thailand.

Number of macroprudential measures in 32 economies

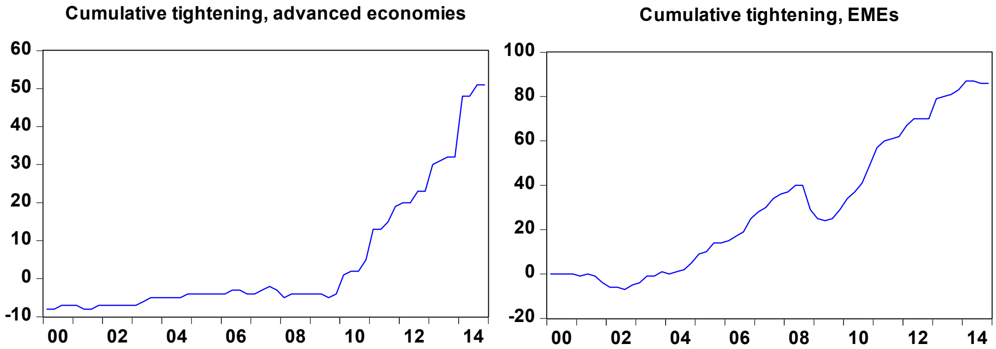
Figure 1



Notes: SSCB denotes a sector-specific capital buffer. The figure shows the number of measures, including both tightenings and loosenings, undertaken in each quarter, computed across all economies in the sample. Note the different scaling in the third row compared to the first and second rows.

Cumulative tightening in macroprudential instruments, advanced economies and EMEs

Figure 2



Note: The index shown incorporates changes in all nine macroprudential instruments: Sector-specific capital buffers for real estate loans, consumer loans and other loans, concentration limits, interbank exposures, reserve requirements in foreign and local currency, loan-to-value ratio and general capital requirements.

Over time, not surprisingly, macroprudential policies have been tightened more in EMEs than in advanced economies. Figure 2 shows the cumulative tightening for both advanced economies and EMEs, computed over all the macroprudential instruments in the dataset. On average, over time and per country, the (net) cumulative tightening amounted to 0.44 measures per year in the group of EMEs and to 0.18 in advanced economies. While advanced economies tightened macroprudential policies mainly after the Great Financial Crisis, EMEs have a longer history of applying macroprudential tools, and actually loosened policies in the immediate aftermath of the crisis.

Regarding estimation, all series are included in the system in levels. The VAR includes a constant and 2 lags. A dummy variable for individual countries is used to account for the most intense period of the Great Financial Crisis (Q3 2008-Q2 2009; see Section 4.3 for the results when other crises periods are controlled for). We follow Bayesian inference, in the form of the Monte-Carlo integration method (see RATS (2013)), to construct posterior probability bands for the impulse responses.

4. Estimation results

4.1. Macroeconomic effects of macroprudential policy

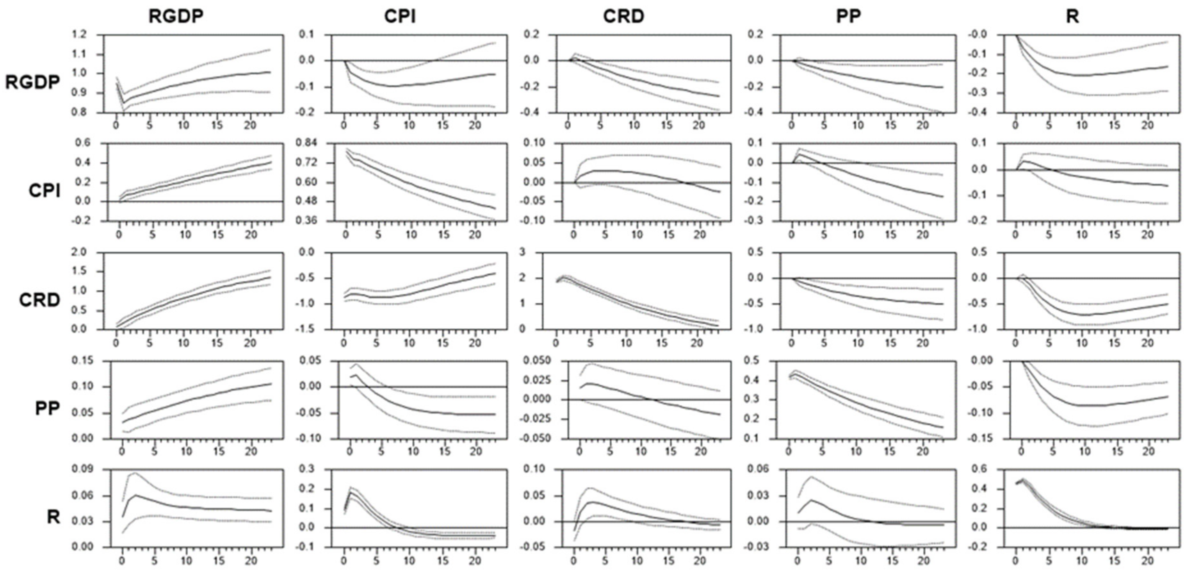
We first consider the estimated macroeconomic effects of macroprudential policy shocks. In the baseline results, all 32 sample economies are included in the panel VAR and the various macroprudential instruments are considered jointly in the accumulated index.

We show all impulse responses from the estimated panel VAR in Figure 3. Each column shows the impulse responses of the five endogenous variables to a different shock, from zero to 24 quarters after the shock. The column and row headings indicate the name of the shock and the name of the responding variable, respectively. Uncertainty in the results is captured by 90% probability bands, marked as dashed lines around the solid line of the median estimate.

The fourth column shows the responses of all endogenous variables to a contractionary macroprudential policy shock of one standard deviation. The response of the macroprudential policy index to a macroprudential policy shock, shown in the fourth row and fourth column, is temporary, although persistent, and the level of the macroprudential policy index gradually falls back toward zero. The contractionary macroprudential shock leads to a fall in the level of real GDP, the price level and real credit. All effects are significantly different from zero at 95% probability. Notably, the macroeconomic effects of macroprudential policy shocks are highly similar to those of monetary policy (interest rate) shocks – the latter are shown in the fifth column. Thus, our results confirm the findings in Kim and Mehrotra (2018), obtained for a smaller sample of economies in the Asia-Pacific region.

Impulse responses from the baseline model

Figure 3



Notes: The column headings denote the shocks and the row headings the response variables. RGDP = real GDP; CRD = total credit; CPI = consumer price index; PP = macroprudential policy measure; R = policy interest rate. For example, the impulse response in the first row, fifth column, shows the response of real GDP to an interest rate shock. The x-axes show the number of quarters that have passed from the shock.

We then compare the relative response of credit-to-output and credit-to-prices to the two policy shocks. The aim is to formally infer whether there are differences in the relative effectiveness of monetary and macroprudential policies in stabilising the target for financial stability and the more traditional macroeconomic targets of output and prices, respectively. In the first row of Table 1, we report the probability that the ratio of credit-to-price responses under monetary policy shocks is smaller than the ratio under macroprudential policy shocks at various horizons. If the probability is large, monetary policy would be relatively more effective in stabilising prices and macroprudential policy in stabilising credit. In the second row, we report a similar probability for the ratio of credit-to-output responses. Although the relative responses are not exactly the same under the two policy shocks, the probabilities range from 25% to 66%, which suggests that the difference is not significant at any conventional significance level.

Comparison of the relative credit, price and GDP responses under monetary and macroprudential shocks

Table 1

Horizons	1 year	2 year	3 year	4 year
CRD/CPI	61.6%	45.7%	33.2%	25.9%
CRD/RGDP	24.5%	56.7%	63.7%	65.8%

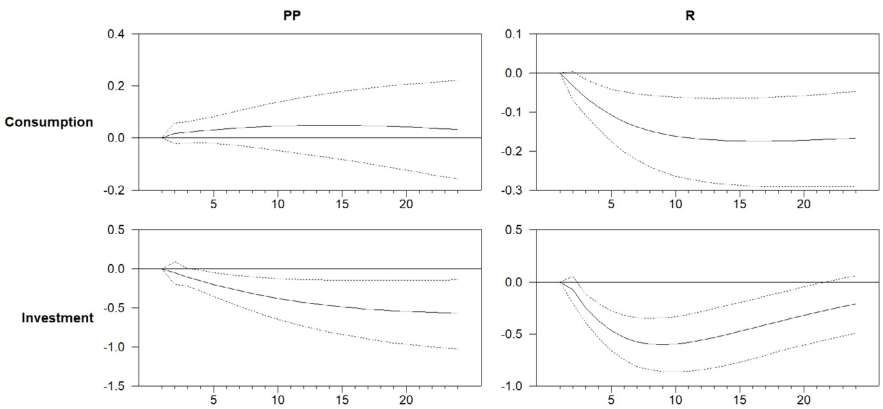
The table shows the probabilities that the ratio of credit-to-price and credit-to-GDP responses are smaller under monetary policy shocks than under macroprudential shocks.

Through what channels would macroprudential policy, principally intended to reduce systemic risk that originates in the financial system, have macroeconomic effects? To examine the channels, we consider extensions to the baseline model where we include real consumption and real investment, one by one, as additional endogenous variables in the system. In this extended model, these variables are assumed to be contemporaneously exogenous to the two policy variables, as the adjustment of aggregate real economic activity represented by these variables tends to be sluggish.[10]

The impulse responses in Figure 4 with the components of real GDP suggest that contractionary macroprudential shocks lead to declines in the level of investment but not in consumption. The impact on investment could arise, as a large share of macroprudential measures is directed at the housing market and may affect residential investment. Indeed, considering the impact on residential and business investment separately in Figure 5, we find that the effect of macroprudential policy shocks on residential investment is roughly twice the size of their effect on business investment. The negative effect of macroprudential policy shocks on business investment could also be partly related to the housing market, as housing serves as important collateral especially for smaller firms (see eg Banerjee and Blickle (2016)).[11]

By contrast, monetary policy shocks have statistically significant effects on both real consumption and real investment (Figure 4). Thus, it has a broader effect on aggregate expenditures than macroprudential policy. Moreover, and similarly to macroprudential policy shocks, monetary policy shocks are found to have larger effects on residential investment than on business investment. The latter finding is consistent with previous literature (eg Bernanke and Gertler (1995)).

Impulse responses from models with consumption and investment — Figure 4



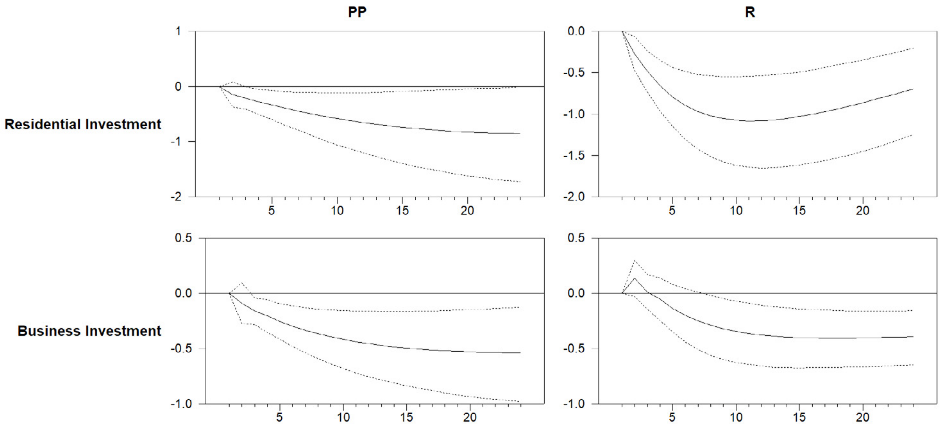
Notes: The column headings denote the shocks and the row headings the response variables. PP = macroprudential policy measure; R = policy interest rate. For example, the impulse response in the first row, second column, shows the response of real consumption to an interest rate shock. The x-axes show the number of quarters that have passed from the shock.

10 The results are similar when we assume that the two policy variables are contemporaneously exogenous to these variables.

11 Our result of a significant impact of macroprudential policy on business investment is also consistent with the results in Ayyagari et al (2018) for small and young firms.

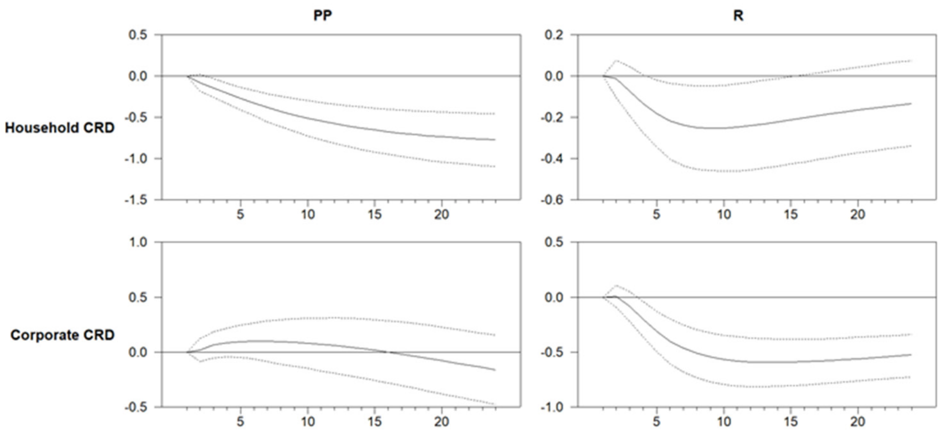
Analysing the effects on different types of debt gives further information about the channels behind the macroeconomic effects. Instead of total credit, we incorporate two different credit variables simultaneously in the estimated VAR: real credit to households and real credit to non-financial corporates. As in the baseline model, both credit measures are assumed to be contemporaneously exogenous to the two policy instruments. The impulse responses are shown in Figure 6.

Impulse responses from models with residential and business investment — Figure 5



Notes: The column headings denote the shocks and the row headings the response variables. PP = macroprudential policy measure; R = policy interest rate. For example, the impulse response in the first row, second column, shows the response of residential investment to an interest rate shock. The x-axes show the number of quarters that have passed from the shock.

Impulse responses from models with household and corporate credit — Figure 6



Notes: The column headings denote the shocks and the row headings the response variables. CRD = credit; PP = macroprudential policy measure; R = policy interest rate. For example, the impulse response in the first row, second column, shows the response of household credit to an interest rate shock. The x-axes show the number of quarters that have passed from the shock.

Figure 6 suggests that contractionary macroprudential policy shocks have negative effects on household credit, while the effect on corporate credit is not statistically different from zero. The result echoes the finding in Cerutti et al (2017a) that macroprudential policies have greater effects on household than corporate credit. One potential reason is that a major share of household credit is comprised of mortgage debt. Macroprudential actions aimed at corporate credit could also be subject to "leakage" effects, such as greater reliance on market-based or foreign funding if domestic bank credit dries up.[12] Given the different effects on household and corporate credit, we observe that the share of household credit in total credit declines, while that of corporate credit rises, when macroprudential policies are tightened.

In contrast to macroprudential policy, contractionary monetary policy shocks are found to dampen both household and corporate credit, as shown in the second column of Figure 6. The latter finding, together with the result that monetary policy affects both consumption and investment, is consistent with monetary policy having a more widespread impact on the economy, as it sets the price of leverage in a given currency and thus affects all financing in the economy (eg Borio and Drehmann (2011) and Stein (2013)). This also suggests that if the authorities' aim is to stimulate the economy as a whole, instead of a particular sector, then monetary policy rather than macroprudential policy would be better suited for the purpose.

Next, we divide the macroprudential instruments into three categories, based on the components of financial institutions' balance sheets that the measures are most closely connected with. In particular, we divide the measures into those that work through financial institutions' assets (LTV and concentration limit), capital (general and sector-specific capital requirements), and liabilities (reserve requirements in both local and foreign currency) (see Shin (2015)). We exclude interbank exposures here as they may work either through financial institutions' assets or liabilities. Moreover, in addition to the previous set of endogenous variables, we include the lending rate to the private sector as an additional interest rate in the VAR. All other variables are assumed to be contemporaneously exogenous to the lending rate in the system because a financial variable like the lending rate is likely to respond to any type of shock contemporaneously.

Figure 7 shows that macroprudential instruments in the three categories have qualitatively similar effects on the different expenditure components and types of credit. In particular, we observe negative effects on investment and on household credit in all of the three categories, even if the economic and statistical significance admittedly varies between the different instruments.

Our finding regarding the negative output effect of capital-based measures is in line with theoretical outcomes in Cecchetti and Kohler (2014) and Alpanda et al (2018) – the latter also shows a negative impact on investment. As for liability-based tools, the model by Glocker and Towbin (2012) similarly predicts a decline in investment as reserve requirements are tightened. And, in terms of asset-based measures, Alpanda et al (2018) show that a tightening of LTV ratios dampens housing investment.

At the same time, perhaps surprisingly, consumption does not appear to be negatively affected by tighter macroprudential policy. A negative consumption effect would be predicted for asset-based tools (in terms of LTV ratios) by the models of Alpanda and Zubairy (2017) and Kuttner and Shim (2016); and for capital-based

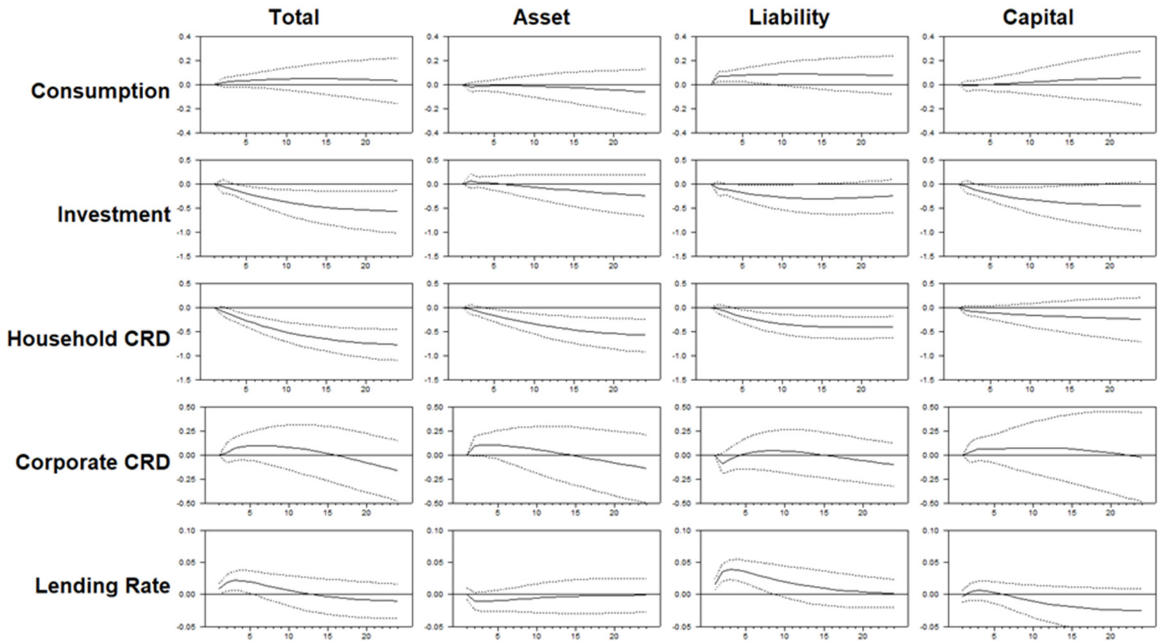
[12] Cizel et al (2016) find that macroprudential measures on bank credit lead to substitution effects towards non-bank credit. See also Aiyar et al (2014) for analysis on leakage effects of macroprudential policy between regulated and unregulated institutions.

measures by Alpanda et al (2018). Moreover, if contractionary macroprudential policy leads to declines in asset prices, including house prices, the resulting wealth effect could dampen consumption. However, for liability-based tools, the model by Glocker and Towbin (2012) shows that an increase in reserve requirements can raise consumption if banks lower deposit rates and this encourages consumption spending through the Euler equation. We indeed find that consumption tends to increase in response to shocks to liability-based tools.

Figure 7 also shows that contractionary macroprudential policy shocks lead to an increase in the lending rate, with the effects seemingly stemming from liability-based instruments. This is consistent with models where banks pass on increased costs from reserve requirements to borrowers (eg Glocker and Towbin (2012); Reinhart and Reinhart (1999)). However, and in contrast to the model of Alpanda et al (2018), the lending rate does not appear to rise when capital-based instruments are tightened, possibly reflecting the nature of the post-Great Financial Crisis period when capital requirements were raised but interest rates remained extraordinarily low.

Effects of contractionary macroprudential policy shocks, expenditure components and types of credit

Figure 7



Notes: The column headings denote the type of macroprudential instruments and the row headings the response variables. CRD = total credit. For example, the impulse response in the first row, second column, shows the response of consumption to a policy shock of asset-based macroprudential tools. The x-axes show the number of quarters that have passed from the shock.

The macroeconomic effects of macroprudential policies may vary between countries with different levels of financial development or other macro-financial characteristics. First, we consider the relevance of financial development. We split the sample of countries into two country groups of equal size, based on their mean level of financial development during the sample period (2000–14). Financial development is measured using the index by Svirydzenka (2016) that captures how developed financial institutions and markets are in terms of their depth, access and efficiency.

The results suggest that the macroeconomic effects of macroprudential policy shocks are somewhat stronger in economies with a lower level of financial development. In particular, as shown in the first two columns of Figure 8, the point estimates of the effects on the price level and credit are higher in absolute terms in countries with a lower level of development.[13] This result may stem from potential difficulties in enforcing macroprudential policies in more complex financial systems (see also Cerutti et al (2017a)).[14]

Next, we analyse whether the level of debt matters for the macroeconomic effects of macroprudential policy. We again split the sample into two country groups of equal size, based on the average ratio of total private non-financial sector debt to GDP over the sample, and examine the impulse responses in the third and fourth columns of Figure 8.

Macroprudential policy shocks appear to have stronger effects on credit in economies where the level of debt is low. This result suggests that it may be difficult to stabilise credit conditions once the level of debt reaches a high level.[15] At the same time, however, macroprudential shocks have greater effects on real GDP in economies where the stock of debt is higher, probably because higher levels of debt make the economy more sensitive to shocks. If households and firms' balance sheets are overextended, even small income shortfalls or increases in borrowing costs could lead to reduced investment and defaults (eg Drehmann and Juselius (2012)). Similarly, the point impact of macroprudential policy shocks on the price level is slightly higher in countries with a higher level of debt.

Third, we evaluate whether the macroeconomic effects of macroprudential policy depend on the degree of financial openness of the economy. The country groups are based on the average ratio of external assets and liabilities to GDP over the sample.

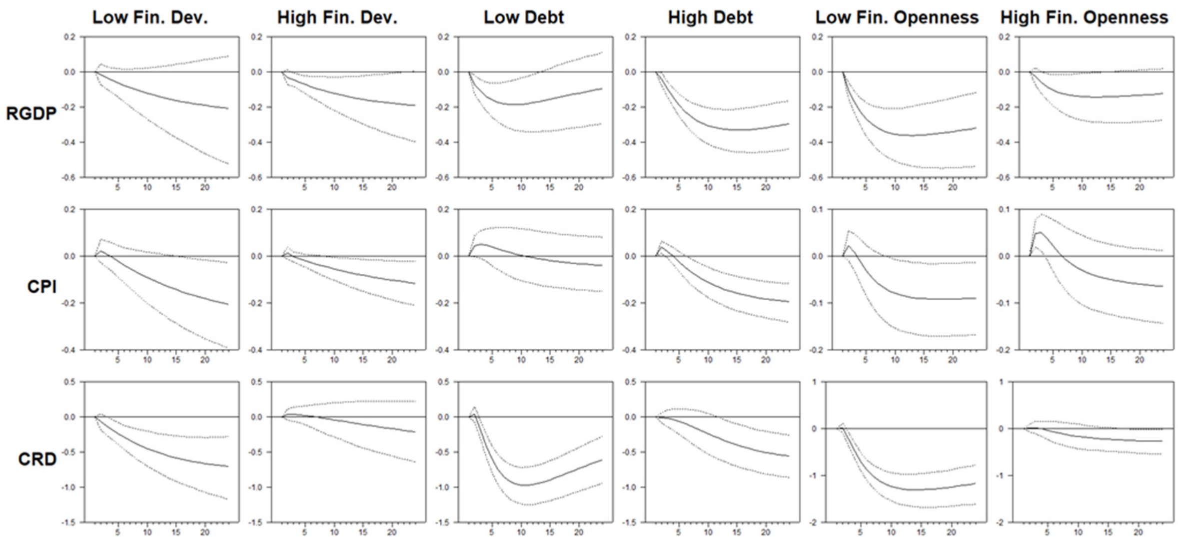
[13] In addition, the probability bands associated with the impulse responses appear relatively wide and include zero responses in the case of credit in countries at higher levels of financial development.

[14] On the other hand, Baskaya et al (2016) find that in financially more developed economies, price-based measures of macroprudential policy, such as reserve and liquidity requirements and risk weights, are more effective in taming credit than in financially less developed countries.

[15] This result may appear surprising, as macroprudential policy tightening could prove more binding when the level of debt is high. However, it is consistent with our estimates that show a stronger macroprudential policy response to credit shocks in countries where the level of debt is lower (see Section 4.2).

Macroeconomic effects of macroprudential policies, by country group

Figure 8



Notes: The column headings denote the shocks and the row headings the response variables. RGDP = real GDP; CRD = total credit; CPI = consumer price index; PP = macroprudential policy measure; R = policy interest rate. For example, the impulse response in the first row, first column, shows the response of real GDP to a macroprudential policy shock in economies with lower financial development. The size of the underlying shock in PP is approximately 0.4 units for the models in the first row, 0.5 units in the model for low financial openness and 0.3 units in the model for high financial openness. The x-axes show the number of quarters that have passed from the shock.

More closed economies appear to display somewhat stronger responses to contractionary macroprudential policy shocks, especially in terms of credit and consumer prices. One potential source of such differences is international leakages in financially more open economies. For example, Avdjiev et al (2017) show that tighter LTV ratios and local currency reserve requirements in a country lead to greater international bank flows into that country. Similar findings are reported in Reinhardt and Sowerbutts (2015).

In sum, our results show that the macroeconomic effects of macroprudential policy estimated in Kim and Mehrotra (2018) hold more generally in a large panel of economies. As found in Kim and Mehrotra (2018), macroprudential policy shocks do have significant effects on output and the price level in addition to credit, which are similar to the effects of monetary policy shocks. However, our results further show that the detailed transmission mechanism of macroprudential policy is different from monetary policy. While monetary policy has more comprehensive effects, macroprudential policy affects investment and household debt, rather than consumption and corporate credit. At the same time, the results highlight differences in the macroeconomic effects of macroprudential policy across countries depending on their macro-financial characteristics.

4.2. Estimated macroprudential policy response to credit shocks

The estimated panel VAR allows us to examine the endogenous response of macroprudential policy to various macroeconomic shocks. Here, our focus is on the responses to credit shocks.[16] Another issue of interest is how the endogenous response of macroprudential policy to credit shocks compares with that of monetary policy. Below, we first examine policy responses computed from the baseline model for the full sample of 32 economies. Then, we examine the results for various country groups.

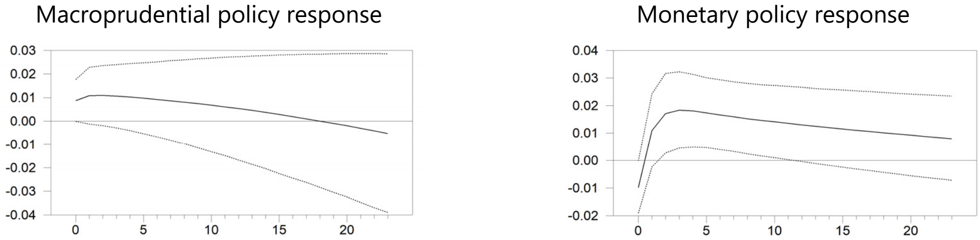
We first consider policy responses directly observed from the impulse responses in the model. From the third column of Figure 3, we can infer how macroprudential and monetary policy react to credit shocks. Credit increases up to 2% in a few quarters after the shock, and then decreases back to the initial level over time. In response to the credit shock, the macroprudential policy index, *PP*, increases on impact by 0.025 units, while the policy interest rate, *R*, increases by 0.03 percentage points in a few quarters. Both responses are different from zero with 95% probability. These impulse responses suggest that both macroprudential and monetary policy tighten to stabilise credit conditions in the presence of positive credit shocks, but the magnitude of the policy response is small.

In Figure 9, we further quantify macroprudential and monetary policy responses to increases in credit, in the presence of credit shocks. This is done by combining the impulse responses of *CRD* to credit shocks, and the responses of *PP* or *R* to credit shocks (see Section 3 for more details). The solid line shows the median response, and the dotted lines are 90% probability bands. The macroprudential policy index increases by approximately 0.01 units on impact when credit increases by 1%, which is different from zero with 95% probability. As time passes, *PP* goes back to the initial level. The policy interest rate, in turn, does not move much on impact when credit increases by 1%. However, it increases by up to 0.19 percentage points over five quarters and then declines toward the initial level. The increase in *R* is different from zero with 95% probability from three to ten quarters.

[16] We note two points about the exercise. First, the estimated policy response here only captures the reaction to shocks, not to endogenous movements in credit (or other variables). The difference between responding to shocks and to endogenous movements is one potential reason why the estimated magnitude of interest rate and macroprudential policy responses is low: it is possible that authorities react more strongly to overall developments in the relevant variables. Second, our methodology makes no distinction between credit shocks that stem either from increased credit demand or credit supply. In practice, policy could respond more strongly to supply-driven credit expansions that result from looser lending standards, than to increased household credit demand driven by greater income prospects.

Policy responses to 1% changes in credit in the presence of credit shocks, full sample

Figure 9



Notes: The x-axes show the number of quarters that have passed from the shock.

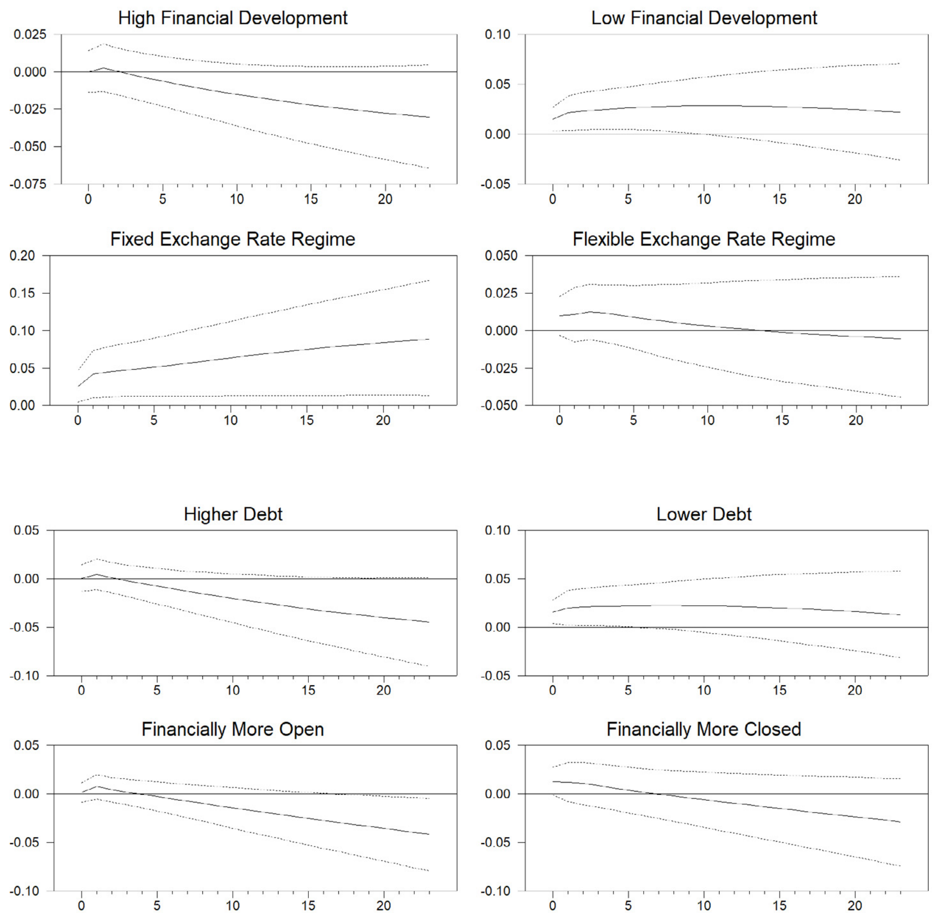
Thus, the results in Figure 9 show that both monetary and macroprudential policies tighten endogenously as a response to an increase in credit, in the presence of credit shocks. The response of macroprudential policy to credit developments is consistent with the postulated reaction function in theoretical models (eg Bailliu et al (2015); Gelain and Ilbas (2017)). Similarly, the response of interest rates is consistent with augmented Taylor rules in models where the monetary authority reacts to credit developments (eg Kannan et al (2012); Verona et al (2017)). However, there is a difference in timing between the two policies, as macroprudential policy tightens contemporaneously as a response to the credit shock, but a positive interest rate response only occurs with a lag. The delay in the interest rate response might be related to the fact that monetary policy needs to consider various objectives in addition to financial stability.

There is also an interesting interaction between monetary policy shocks and the macroprudential policy response. Macroprudential policy loosens endogenously as a response to a contractionary monetary policy shock, as was shown in the fifth row and fourth column of the baseline impulse responses in Figure 3. This may suggest that macroprudential policy tries to stabilise credit conditions affected by monetary policy, while the latter may pursue other, more traditional, objectives such as inflation and output stabilisation. This finding is identical to the one documented in Kim and Mehrotra (2018) for four inflation targeting economies. It arises even in the presence of near-zero unconditional (contemporaneous) correlation between interest rates and the macroprudential policy index for the 32 economies in our dataset.[17]

[17] Figure 3 also shows another dimension of the interaction between the two policies, ie the interest rate response to a contractionary macroprudential policy shock. While the response seems to be positive in the full sample, further estimations show that interest rates rise in EMEs but fall in advanced economies in response to a macroprudential policy shock. However, the statistical significance of these effects generally tends to be weak.

Macroprudential policy response to credit in the presence of credit shocks, different country groups

Figure 10



Notes: The x-axes show the number of quarters that have passed from the shock.

Next, we analyse if macro-financial country characteristics play a role in how macroprudential policy responds to credit shocks. We consider whether the macroprudential responses to credit shocks differ for economies with different levels of financial development; relatively more fixed and flexible exchange rates; higher and lower debt; and financially more open and closed economies. The exchange rate country groups are based on the de facto classification by Aizenman et al (2013)[18]; the other country groups are the same as in Section 4.1. The results are shown in Figure 10.

There are major differences in the macroprudential policy responses to credit shocks across the country groups. Firstly, the endogenous response is stronger in

[18] More specifically, we use a measure of exchange rate stability vis-à-vis a base currency. In our estimations for the country groups based on exchange rate flexibility, we exclude countries that are part of the euro area.

countries at lower levels of financial development (Figure 10, upper right-hand panel). This is consistent with the more frequent use of macroprudential policy measures in emerging markets than in advanced economies. The stronger endogenous response may reflect the possibility that the room for policy evasion could be more limited in less sophisticated financial systems with a smaller number of financial instruments and sources of funding.[19] Then, policymakers may be more inclined to apply macroprudential tools to address financial risks. Indeed, in our dataset, the number of macroprudential actions undertaken is greater in economies at lower levels of financial development (179 measures in total) than in the more advanced ones (122 policy actions).

Second, the response of macroprudential policy is stronger in countries with less flexible exchange rate regimes (Figure 10, second row). This could result from constraints in using policy interest rates to counter financial stability risks in such economies. Economies with more flexible exchange rates also tighten macroprudential policy in response to credit shocks, but the reaction is weaker overall and peters out more quickly.

Third, countries with lower average debt levels display a stronger response of macroprudential policy to credit shocks (third row). This suggests that the high level of debt in some countries may reflect weaker policy responses of the past. In particular, in high debt economies, the contemporaneous response of macroprudential policy to credit shocks is close to zero and then turns negative.

Fourth, the macroprudential policy response to credit shocks is slightly stronger in financially more closed economies (fourth row), where the private sector may be less able to counteract tighter macroprudential policies by borrowing from abroad. Thus, macroprudential policy may be used more frequently due to its potentially greater effectiveness. Indeed, Figure 8 showed that contractionary macroprudential policy shocks have larger effects on credit in financially more closed economies.

We perform an identical exercise for the monetary policy (interest rate) responses to credit shocks and report the results in Appendix Figure A1. At times, countries that respond strongly with macroprudential policy to credit shocks also tend to respond more strongly with interest rates. In particular, the interest rate response is greater in economies with lower financial development and in countries with smaller stocks of debt. However, although the differences are small, the interest rate response is slightly stronger in financially more open economies, which could partly compensate for the weaker macroprudential policy response. Moreover, not surprisingly, countries with flexible exchange rates appear to use the leeway granted by their policy framework to respond more strongly to credit shocks with interest rates. By contrast, as shown in Figure 10, countries with more fixed exchange rates tend to respond more vigorously with macroprudential policy.

[19] This result could also reflect the possibility that monetary policy may be less effective in financially less developed economies. However, monetary policy appears to respond more strongly to credit shocks in financially less developed than in the more developed economies, as shown in Figure A3 and discussed further below.

4.3. Some extensions and robustness tests

In this section, we consider some extensions and robustness tests to the baseline model. We change the ordering of the policy instruments; include additional country-specific dummy variables to control for banking crises; consider alternative country samples based on the use of macroprudential policy and the incidence of financial crises; and include real house prices in the model. In these estimations, we focus on the responses of all endogenous variables to macroprudential and monetary policy shocks, and on the response of macroprudential policy to credit shocks.

First, we change the ordering of the two policy instruments. Figure A2 in the Appendix shows that the impulse responses from the full model are similar when the interest rate is assumed to be contemporaneously exogenous to macroprudential policy. Moreover, the macroprudential and monetary policy responses to credit shocks are robust to this alternative ordering of policy instruments, as shown in Figure A3.

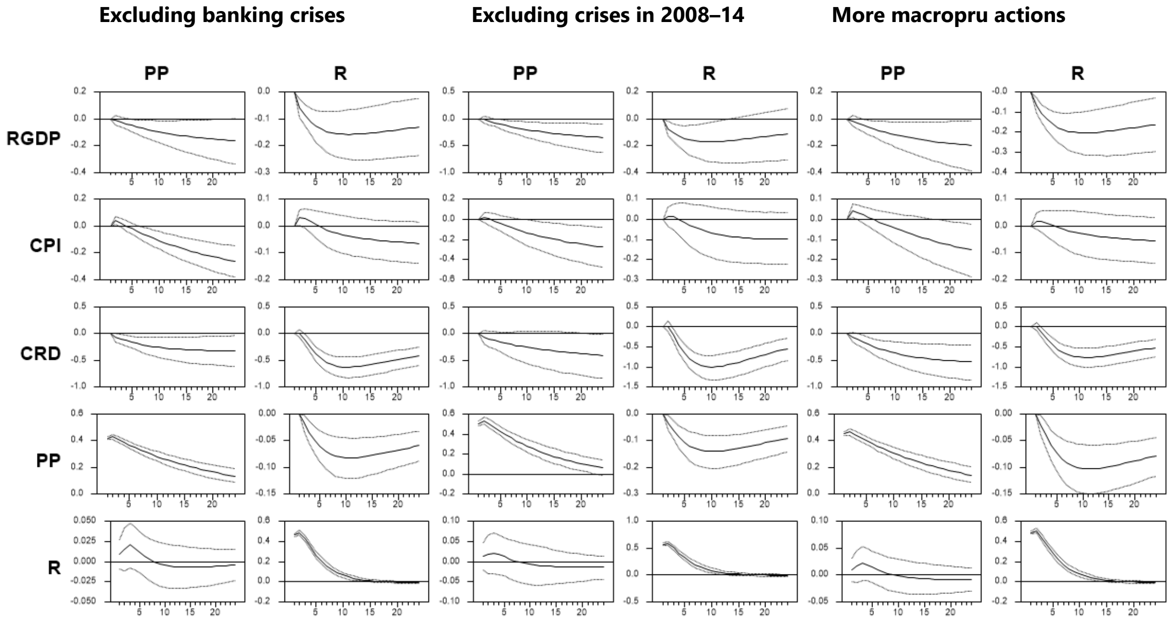
Second, we include additional country-specific dummy variables to control for banking crises. While the baseline model already includes a dummy variable for the Great Financial Crisis, other banking crises occurring during the sample could affect the estimates. For the start dates and the duration of crises, for countries in the EU, we use the information on systemic crises published by the European Systemic Risk Board[20]; for other economies, we use the dataset on systemic banking crises by Laeven and Valencia (2012). Columns 1 and 2 in Figure 11 and Appendix Figure A4 show that the baseline results are robust to the inclusion of the additional country-specific crisis dummy variables.

Third, instead of using dummy variables to deal with crisis periods, we omit some countries from the sample. In particular, as the dynamics between the endogenous variables may have changed over the sample period due to the Great Financial Crisis and/or the European debt crisis, we exclude from the sample all economies that went through a banking crisis over the period 2008–14. The remaining sample includes 15 economies. The results, shown in Columns 3 and 4 of Figure 11 and Appendix Figure A4, are robust to this reduction in sample size.

[20] See https://www.esrb.europa.eu/pub/financial-crises/html/index.en.html

Impulse responses to macroprudential and monetary policy shocks, robustness tests

Figure 11



Notes: Columns 1 and 2 show the responses with additional banking crisis dummy variables; Columns 3 and 4 exclude all countries that went through a crisis during the Great Financial Crisis and/or the European debt crisis; Columns 5 and 6 exclude countries that took three or less macroprudential policy actions during the sample period. The x-axes show the number of quarters that have passed from the shock.

Fourth, we exclude those economies that took a smaller number of macroprudential policy actions during the sample period. Including only those countries that took four or more policy actions implies excluding Austria, Belgium, Finland, Greece, Italy and South Africa from the sample. Columns 5 and 6 of Figure 11 and Appendix Figure A4 show that the results are robust to this change in the country composition.

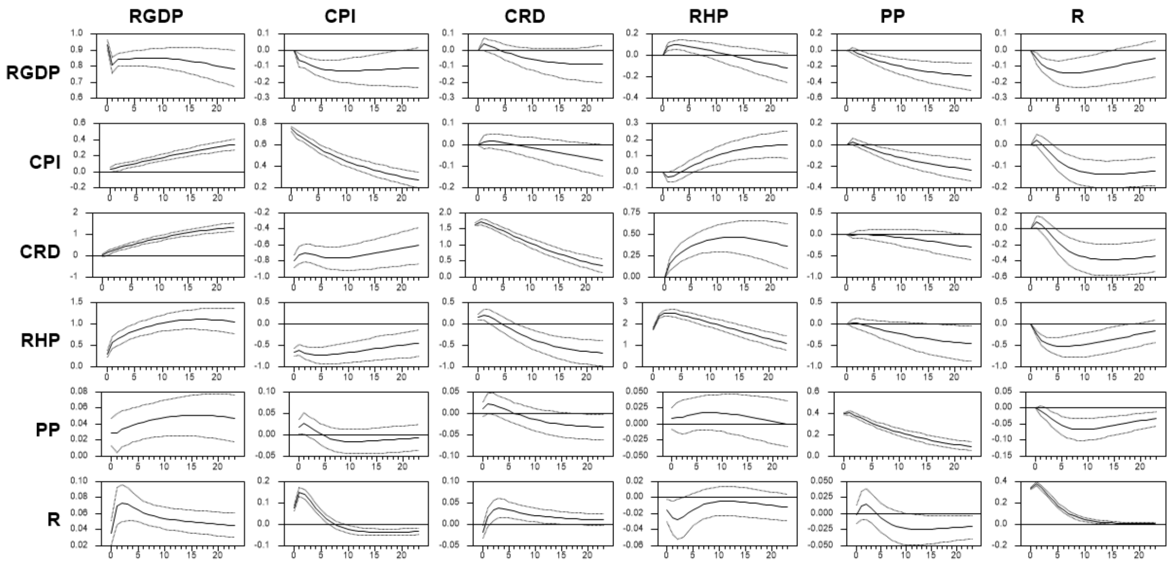
Finally, we include real house prices as an additional endogenous variable in the system. As macroprudential policy may respond to movements in house prices, we assume that house prices are contemporaneously exogenous to macroprudential policy.[21] All impulse responses from the model with real residential house prices (included in the estimation in log levels) are shown in Figure 12. We observe that both contractionary monetary and macroprudential policy shocks lead to declines in house prices, but overall the macroeconomic effects of the two shocks are similar to those in the baseline model. Interestingly, the results suggest that neither monetary nor macroprudential policies stabilise real house prices in the presence of real house price shocks. In particular, the positive response of macroprudential policy to real house price shocks is less significant than that to real credit shocks. Moreover, the interest

[21] At the same time, the results are not sensitive to the relative ordering between credit and house prices.

rate declines in response to real house price shocks but increases in response to real credit shocks.

Impulse responses, model with real house prices

Figure 12



Notes: The column headings denote the shocks and the row headings the response variables. RGDP = real GDP; CRD = total credit; RHP = real house price; CPI = consumer price index; PP = macroprudential policy measure; R = policy interest rate. For example, the impulse response in the first row, fifth column, shows the response of real GDP to a macroprudential policy shock. The x-axes show the number of quarters that have passed from the shock.

5. Conclusions

In this paper, we provided novel evidence both on the use and the effects of macroprudential policy, in a sample of 32 advanced and emerging economies. Using panel vector autoregressions, we find that macroprudential policy shocks have effects on key macroeconomic variables, real GDP and the price level, beyond their impact on credit, similarly to monetary policy. However, the transmission mechanism of the two policies to aggregate economic activity is different. Whereas macroprudential policy shocks mostly affect investment, in particular residential investment, and household credit, monetary policy shocks affect both consumption and investment, and credit to firms as well as credit to households.

We also provided evidence on the macroprudential and monetary policy response to credit shocks. Positive credit shocks are met with a contractionary macroprudential and monetary policy responses, which suggests that the policies are working in a complementary fashion. However, the magnitude of the macroprudential policy tightening tends to be small and depends on the macro-financial characteristics of the country. The response of macroprudential policy to credit shocks appears to be larger in financially less developed economies, and it is also stronger in countries with less flexible exchange rates.

One policy implication of our results is that policy trade-offs could occasionally arise from the similar macroeconomic effects of macroprudential and monetary policies. For example, if an economy is undergoing a credit boom but inflation is low, contractionary macroprudential policy coupled with expansionary monetary policy would result in the two policies working at cross purposes in terms of their effects on credit and inflation. However, such trade-offs are partly kept in check by the observation that macroprudential policy tends to have a narrower effect on the economy in terms of the expenditure components and the affected sectors, compared with monetary policy. Moreover, and perhaps more importantly, the policy trade-offs may arise mainly in the short run. While tighter macroprudential policy could dampen credit and aggregate demand in the near term, an improved resilience of the economy in the longer run could have quite opposite effects: stronger capital positions could enhance banks' lending capacity and the transmission of monetary policy (see eg the evidence in Gambacorta and Shin (2018)).

Another policy implication is that there are likely to be differences, stemming from the economy's macro-financial characteristics, in how macroprudential policy affects the real economy and how effectively it can respond to financial risks.

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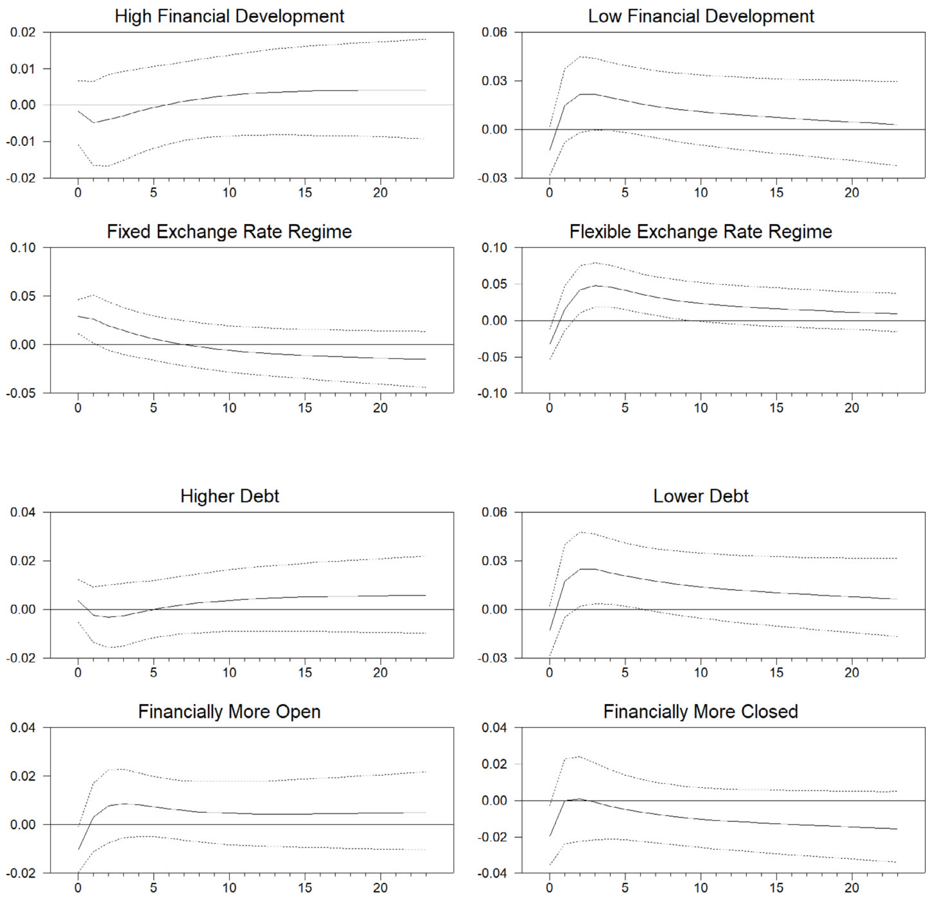
Appendix

Monetary policy response to credit shocks, different country groups

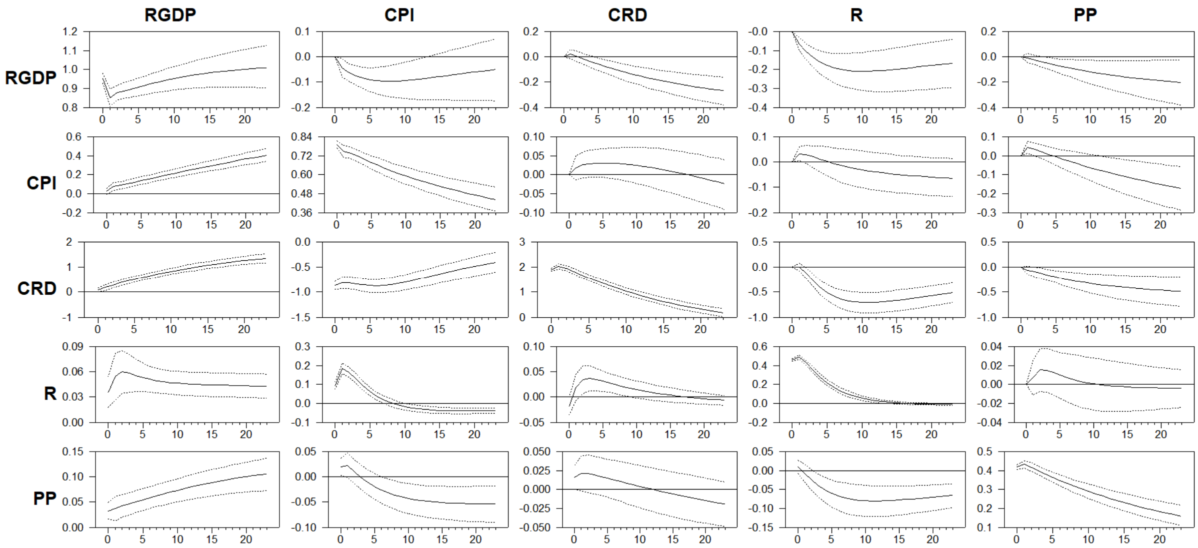
Figure A1



Notes: The x-axes show the number of quarters that have passed from the shock.

Impulse responses, alternative ordering of policy instruments

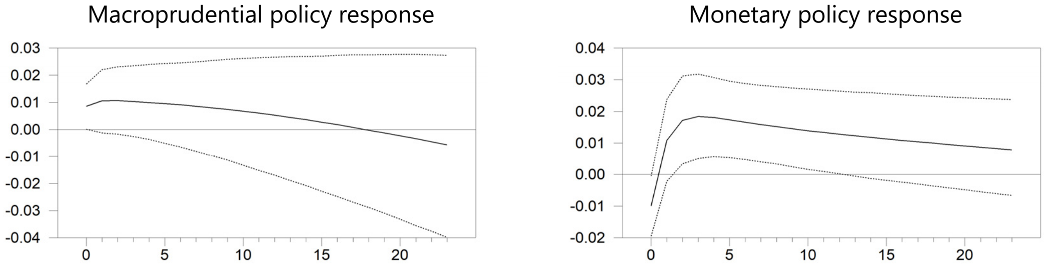
Figure A2



Notes: The column headings denote the shocks and the row headings the response variables. RGDP = real GDP; CRD = total credit; CPI = consumer price index; PP = macroprudential policy measure; R = policy interest rate. For example, the impulse response in the first row, fifth column, shows the response of real GDP to a macroprudential policy shock. The x-axes show the number of quarters that have passed from the shock.

Policy responses to 1% changes in credit in the presence of credit shocks, alternative ordering of policy instruments

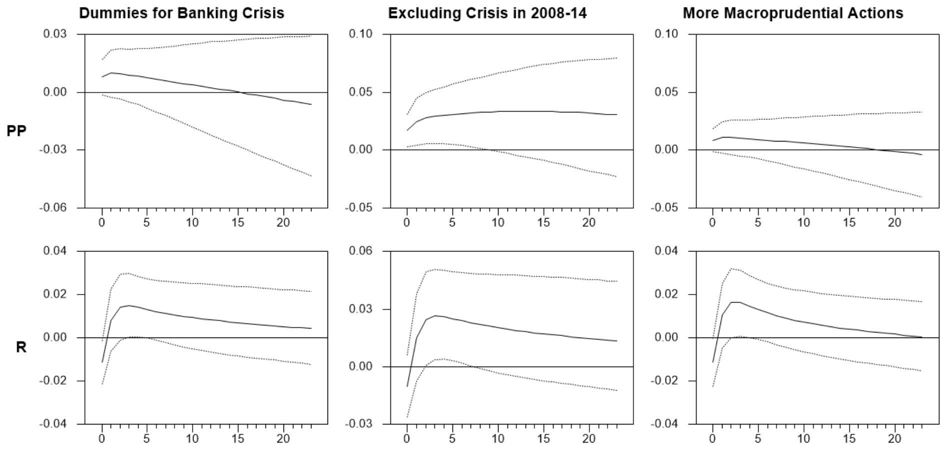
Figure A3



Notes: In the model, the interest rate is ordered before the macroprudential policy instrument. The x-axes show the number of quarters that have passed from the shock.

Policy responses to 1% changes in credit in the presence of credit shocks

Figure A4



Notes: The first row shows the macroprudential policy and the second row the monetary policy responses, for different samples (see Section 4.3). The x-axes show the number of quarters that have passed from the shock.

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