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Effects of monetary and macroprudential policies – evidence from inflation targeting economies in the Asia-Pacific region and potential implications for China*

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Effects of monetary and macroprudential policies – evidence from inflation targeting economies in the Asia-Pacific region and potential implications for China*

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Abstract

We examine the effects of monetary and macroprudential policies in the Asia-Pacific region, where many inflation targeting economies have adopted macroprudential policies in order to safeguard financial stability. Using structural panel vector autoregressions that identify both monetary and macroprudential policy actions, we show that tighter macroprudential policies used to contain credit growth have also had a significant negative impact on macroeconomic aggregates such as real GDP and the price level. The similar effects of monetary and macroprudential policies may suggest a complementary use of the two policies at normal times. However, they could also create challenges for policymakers, especially during times when low inflation coincides with buoyant credit growth.

JEL classification: E58; E61

Keywords: financial stability; price stability; macroprudential policy; monetary policy; panel VAR

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1. Introduction

The international financial crisis provided a stark reminder that price stability is not sufficient to guarantee financial stability, leading central banks and other authorities to increasingly pursue macroprudential policies to mitigate systemic risk.[3] These policies, used to promote the resilience of the financial system and restrain the build-up of financial imbalances, differ in some aspects from monetary policy. Macroprudential policies often target specific sectors or practices, while monetary policy has a more widespread impact on the economy, setting the price of leverage for a given currency (Borio and Drehmann (2011); Stein (2013)). But there are also important similarities. As argued by Shin (2015), both policies can lead to a reallocation of spending over time by influencing the availability and cost of credit. Thus, it cannot be ruled out that macroprudential policies have aggregate demand effects as well, beyond their impact on financial stability.

The broader macroeconomic impacts of macroprudential policies may be most relevant for central banks with both price and financial stability objectives. Jeanneau (2014) notes that, based on a review of 114 central bank laws and statutes, 82% of central banks have explicit financial stability objectives. In many cases, these objectives and the related governance arrangements reflect the experience from the international financial crisis.[4] But the impacts of macroprudential policies are relevant also for central banks without financial stability mandates, should they matter for macroeconomic stabilisation.

This paper empirically examines the effects and interaction of monetary and macroprudential policies in four inflation targeting economies in the Asia-Pacific region: Australia, Indonesia, Korea and Thailand. The focus on inflation targeting economies allows us to study the effects of policies within a uniform monetary policy regime. Moreover, all four economies had explicit financial stability objectives under central bank laws or statutes at least during part of the sample period, in part motivating the use of macroprudential policies.[5] In the paper, we also draw some implications for China. While China is not an inflation targeter, it has been a frequent user of macroprudential tools, and the People's Bank of China has a financial stability objective. As shown by Shim et al (2013), Asia-Pacific economies were the largest users of prudential tools during the past two decades. A focus on this region thus allows us to draw more general lessons from the experience of using macroprudential policies. We consider only four countries in this region in the econometric exercise since some data are not available for other countries.[6]

Our work provides empirical evidence on the "macroeconomic" effects of macroprudential policy by examining its impact on aggregate activity like real GDP, and the price level, both of which monetary policy often targets, in addition to financial conditions. Although some past studies have analysed the impacts of

[3] See IMF-BIS-Financial Stability Board (2011)

[4] See BIS (2011)

[5] See Table 1 in Jeanneau (2014)

[6] Data on *total* credit extended to the private sector are not available for some of the other Asia-Pacific countries (see also the discussion in Section 3), or they adopted inflation targeting only recently (so that the sample period is very short).

macroprudential policy on specific sectors or on financial stability, empirical analysis on its macroeconomic effects has rarely been done previously.

The analysis is done by means of structural panel vector autoregressions that identify both monetary and macroprudential policy shocks and allow for rich interactions between policies and their assumed target variables. Although a recursive identification scheme (Sims, 1980) is used, the results are quite robust under many alternative identifying assumptions. The macroprudential policy actions in the model are measured as those applied for housing markets, based on data in Shim et al (2013), and thus affect credit extended to the private sector. The focus on credit as an indicator of financial stability is consistent with the literature that highlights the contribution of excessive credit growth to banking crises – a major source of financial instability – in the past (eg Borio and Lowe (2002); Borio and Drehmann (2009); Kaminsky and Reinhart (1999); Schularick and Taylor (2012)).

We find that while macroprudential policies indeed affect credit growth, they have also had an economically and statistically significant impact on inflation, with a contractionary shock to macroprudential policy leading to a fall in the price level. The effect likely operates through changes in aggregate demand, as output falls in response to a contractionary macroprudential shock. This empirical finding of a significant "macroeconomic" effect of macroprudential policy is a novel one that was not documented in past empirical studies. Monetary policy shocks affect not only the price level but also credit. Thus, judging by the responses of real GDP, prices and credit, the effects of monetary policy and macroprudential policy shocks bear a close resemblance.

One policy implication is that during normal times, monetary and macroprudential policies can help each other achieve the objectives of price and financial stability, implying a complementary use of two policies, although their simultaneous effects on both targets need to be taken into account appropriately. However, the similar effects of monetary and macroprudential policies could be challenging at times of low inflation and buoyant credit growth, as the policy authority then faces a dilemma: using one instrument (or both instruments in the same direction) would stabilise only one target variable, while using both in opposite directions would potentially result in the two instruments working at cross purposes.

Our work is linked to theoretical research incorporating both monetary and macroprudential policies in a unified framework, representing a shift from conventional sticky-price models that only include the interest rate instrument (eg Angelini et al (2014); Bailliu et al (2015); Quint and Rabanal (2014)). Indeed, our work can be regarded as the empirical counterpart to such theoretical research. We contribute to the existing literature by analysing the effects of macroprudential and monetary policy shocks jointly in a unified empirical framework, which has rarely been done in past studies.

Our work is also related to research about the effects of macroprudential policies. Most of the empirical research evaluates their impact on credit, either in specific sectors or in the economy as a whole (eg Bruno et al (2016); Cerutti et al (2016); Claessens et al (2013); Kuttner and Shim (2013); Tovar et al (2012)). Furthermore, the paper adds to the literature on the interconnectedness of monetary and macroprudential policies (eg Claessens (2013); Smets (2014)). The latter strand of research has highlighted the various links between monetary policy and financial stability: the impact of monetary policy on private sector risk taking (eg Borio and Zhu (2012)); a theoretical framework for leaning against credit imbalances when the central bank has a financial stability objective (Woodford (2012)) and the costs of doing so (Svensson (2016)); differences in the impacts of monetary and macroprudential policies on financial conditions (Zdzienicka et al (2015)); and the role that monetary policy has historically played in fuelling house price bubbles (eg Jorda et al (2015)).

The paper is structured as follows. Section 2 discusses the data for macroprudential policies applied in this study and the potential channels through which macroprudential policies affect the real economy. Section 3 presents the methodology, and Section 4 shows empirical evidence about the effects and the interaction of monetary and macroprudential policies. Section 5 draws some implications for China, and we conclude in Section 6.

2. Macroprudential policy – channels and data

We use the database for policy actions on housing markets by Shim et al (2013) as a source for macroprudential policy measures. These data include both non-interest rate monetary policy measures and prudential tools. The monetary policy measures, ie reserve requirements, credit growth limits and liquidity requirements, affect the amount of funds that are available for lending to the private sector. The prudential tools, ie maximum loan-to-value ratio, maximum debt-service-to-income ratio, risk weights on housing loans and loan-loss provisioning on housing loans, are used by authorities to target housing credit. While the policy actions focus on housing markets, destabilising credit booms have frequently been associated with large increases in both housing credit and house prices (Jorda et al (2015)).

The cost and volume of credit play an important role in transmitting the impact of the various macroprudential policy measures to the real economy. Consider the action of raising reserve requirements, for banks facing a competitive deposit market but enjoying market power in the loan market (eg Reinhart and Reinhart (1999)). Assume also imperfect substitutability across funding sources. In this environment, the marginal cost of funding deposits is fixed, but banks' marginal revenue and loan demand curves are downward sloping in the interest rate. A hike in reserve requirements acts as an increased tax on banks, raising the cost of funding through deposits. With market power in the loan market, commercial banks pass through the higher funding costs to lending rates, resulting in both higher loan rates and a lower amount of credit available to the economy.

Consider also prudential measures that affect households' demand for housing credit, in the form of loan-to-value and maximum debt-service-to-income ratios. Kuttner and Shim (2013) show how the impacts of such policies can be studied within a two-period (overlapping generations) utility maximising model, where households choose between consumption today, consumption tomorrow and the quantity of housing. In period 1, in addition to consuming, the households purchase a home, and in period 2 they sell the house in order to finance consumption. In the case where the debt-service-to-income ratio is binding, a lower ratio leads households to either lower their housing demand or to reduce their first-period consumption. Similar effects can be shown for adjustments in loan-to-value ratios. As credit demand is affected, both the stock of credit and thus aggregate expenditure fall, *ceteris paribus*.

Yet another type of macroprudential action with potential real economy impacts is an increase in capital requirements. Cecchetti and Kohler (2014) show how, based on the model in Cecchetti and Li (2008), under some conditions capital adequacy and interest rates are substitutes. An increase in capital requirements reduces loan supply, and as loan rates rise to reduce excess demand for loans, the demand for goods falls, reducing output and inflation. There are second-round effects as well, working through loan supply and demand, and these may partly reverse the previous dynamics. But, in the new equilibrium, lending rates will be higher, and the stock of loans, output and inflation are all lower. This outcome is identical to that arising from an interest rate increase by the central bank. Increases in risk weights and direct credit restrictions can also be assumed to have similar effects, as the stock of loans falls.

In the four inflation targeting economies that we study, a total of 42 macroprudential measures were applied during the sample period.[7] Out of these, 33 were of the "prudential" type and 9 measures were "monetary". Moreover, 31 were in the direction of tightening and 11 in the direction of loosening.

In order to construct the measure of macroprudential policy, we accumulate the policy actions mentioned above to an index. When a macroprudential policy tightening (loosening) is undertaken, regardless of the type of measure or its intensity, the level of the index will increase (decrease) by one unit.[8] The new value of the index will be maintained until another policy action is taken. If two tightening measures are undertaken during the same quarter, and none in the direction of easing, the level of the index would increase by two units during that quarter. Our approach of accumulating the macroprudential actions to an index form is identical to Bruno et al (2016).[9]

3. Methodology

In this section, we construct a panel structural vector autoregressive (SVAR) model to identify monetary and macroprudential policy shocks, analyse their effects on the real economy and examine any interactions between the two policies.

3.1. The panel VAR model

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

7 Q1 2000-Q2 2012. For Thailand and Indonesia, the sample periods are Q1 2002-Q2 2012 and Q1 2005-Q2 2012, respectively.

8 For instance, a one-time tightening in the debt-service-to-income ratio by any magnitude would increase the level of the index by one unit, similarly to a tightening of the loan-to-value ratio by any magnitude. Due to such a construction, the effects of policies should be interpreted as average responses to the various policy actions, acknowledging uncertainty as regards the impacts of *individual* measures. We also note that the obtained results are conditional on the type of policy actions applied and their intensity in the economies under study.

9 Our measure is also comparable to the macroprudential policy variable by Zdzienicka et al (2015) who weight the various policy actions identically and model changes in macroprudential policy by using a dummy variable. However, our approach differs from Cerutti et al (2016) who capture the introduction or the abolishment of the various measures in their index but do not take into account changes in the levels of the individual instruments over time.

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).

3.2. The empirical model

The vector of endogenous variables, y^i, is written as $[RGDP^i, CRD^i, CPI^i, PP^i, R^i]'$. Since we are interested in analysing the effects of two policy shocks, we include two policy instruments. The policy interest rate (*R*) is included as the monetary policy instrument and the index of macroprudential policies (*PP*) based on Shim et al (2013) as the macroprudential policy instrument. Then, we also include two policy target variables representing the price and financial stability objectives. The consumer price index (*CPI*) represents the target variable for monetary policy for inflation targeting central banks, while the stock of total credit to the private sector (*CRD*) is used as the target for macroprudential policy. The focus on credit is justified by the empirical regularity that strong credit growth has typically preceded crises (eg Kaminsky and Reinhart (1999); Schularick and Taylor (2012)). Drehmann (2013) reports that the early warning indicator properties of *total* credit are superior to bank credit. In addition, an important aim of macroprudential tools is to address threats from excessive credit expansion (IMF-BIS-Financial Stability Board (2011)).[10] Real GDP (*RGDP*) is included as a measure of overall economic activity.

The vector of exogenous variables, x, 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 in the United States on the real economy, financial conditions and monetary policy in the Asia-

[10] Total credit to the private sector is also used in the construction of the credit gap, ie the deviation of credit-to-GDP from its long run trend, which is a reference point for the use of countercyclical capital buffers under Basel III (BCBS (2010); Drehmann and Tsatsaronis (2014)). In our analysis, we include credit instead of credit-to-GDP gap partly because GDP is also included as an endogenous variable and partly because we prefer to use the raw data.

Pacific region. The cross-border impact of monetary policy in the United States has been highlighted in several recent studies; see eg McCauley et al (2015); Kim and Shin (2015); and Chen et al (2015).

For identification, the three macro variables (*RGDP*, *CRD*, *CPI*) 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 regarded as an extension of the model by Christiano et al (1999) that identifies monetary policy shocks. The model considered in Christiano et al (1999) allows the monetary authority to set the monetary policy instrument after observing the current and lagged values of macro variables such as real GDP and the price level.

Thus, under our identifying assumptions, the monetary authority is allowed to set the interest rate considering also credit conditions, in line with the increased relevance of financial stability objectives. The theoretical model by Bailliu et al (2015) similarly considers an augmented Taylor-rule for the monetary authority, where the policy interest rate is set to respond to deviations of nominal credit growth from its steady state value.

Macroprudential policy is likely to be set by considering current financial conditions such as credit (eg Quint and Rabanal (2014)), but it may additionally have output stabilisation aims as stated in CGFS (2010) and modelled in some recent studies (eg Angelini et al (2014); Gelain and Ilbas (2014)). The latter authors argue that output stabilisation concerns reflect indirect effects from financial disruptions that are not explicitly included in the loss function of the macroprudential authority. Further, we cannot exclude the possibility that macroprudential policy takes into account price developments in the economy, especially when the central bank is the authority in charge of macroprudential policy.[11] Our model allows for these possibilities by letting macroprudential policy react to output, the price level and credit contemporaneously.

Although our identifying assumption can be controversial, the results are similar under alternative identifying assumptions. First of all, the results are similar under alternative identifying assumptions on macroprudential policy instrument, for example, when we change the ordering between two policy instruments and when we assume that macroprudential policy instrument is contemporaneously exogenous to all variables including the three macro variables. In addition, the results are similar when these policies are allowed to affect credit contemporaneously. We show these results in Section 4.2.

The sample periods, using quarterly data, span Q1:2000–Q2:2012 for Australia and Korea; Q1:2002–Q2:2012 for Thailand; and Q1:2005–Q2:2012 for Indonesia. All four central banks pursued inflation targeting during the period under investigation. Furthermore, in all four countries, the central bank had explicit financial stability

[11] In our sample of economies, the central bank is currently the sole body in charge of macroprudential policy in Thailand; the macroprudential mandate is shared between multiple agencies in Indonesia and Korea; and in Australia the regulator decides on the use of macroprudential tools. These differences in frameworks should not affect the macroeconomic impact of the estimated policy shocks in the analysis, but it could affect the interaction between monetary and macroprudential policies (see also Ueda and Valencia (2014)).

objectives under laws or statutes at least during part of the sample period, in part motivating the use of macroprudential policies.[12]

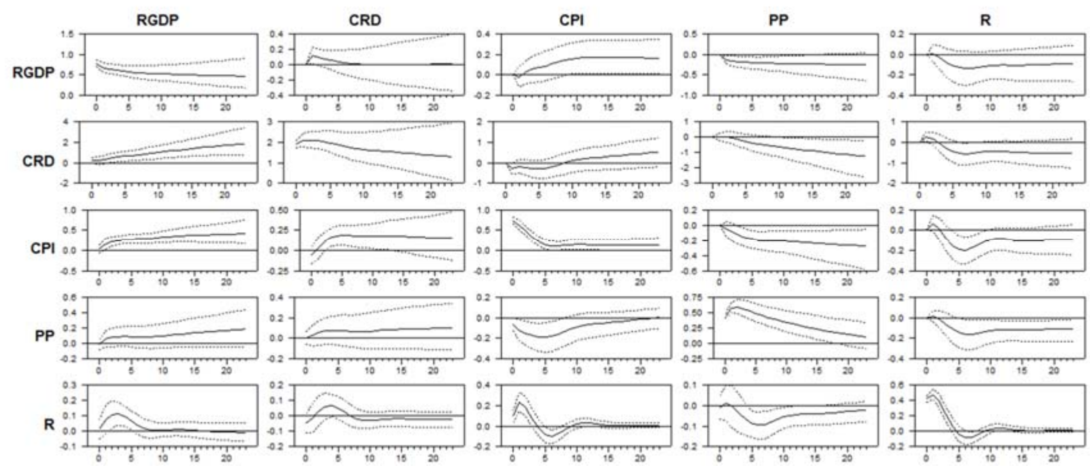
A logarithmic transformation is applied for the series on consumer prices, real GDP and credit. All series are included in the estimation in levels. Two lags are used in the VAR. Our statistical inference is not problematic in the presence of unit roots and cointegrating relations because we follow Bayesian inference. We use the Monte-Carlo integration method, described in RATS (2013), to construct posterior probability bands for impulse responses.[13]

4. Results

4.1. Baseline model

All impulse responses from the estimated system, with 90% probability bands, are shown in Figure 1. Each column of the graph shows the responses of the five endogenous variables to a different shock. Our focus is on the responses to macroprudential and monetary policy shocks, shown in the fourth and fifth columns, respectively.

Impulse responses from panel VAR model | Figure 1



Note: The column headings denote the shocks and the row headings the responses of the indicated variable to each shock. *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.

Sources: authors' calculations.

[12] See Table 1 in Jeanneau (2014)

[13] The reader is referred to Sims (1988) and Sims and Uhlig (1991) for general discussion on Bayesian inference in the presence of unit roots and cointegrating relations.

Figure 1 shows that both policy shocks are contractionary in their nature: *PP* increases in response to macroprudential policy shocks and *R* rises in response to monetary policy shocks. Both result in a statistically significant fall in *CPI* and *CRD*; the negative response of each variable is different from zero with more than 95% probability. That is, monetary policy contraction reduces not only the price level but also the level of credit. Similarly, contractionary macroprudential policy decreases not only credit but also the price level. The latter finding is likely to arise, as macroprudential policies affect aggregate demand. Indeed, we find a significant negative effect from tighter macroprudential policies on real GDP.[14]

It is of interest to compare the relative responses of credit and prices to the two policy shocks, as there may be differences in the relative effectiveness of monetary and macroprudential policies in stabilising the two target variables.[15] In response to a monetary policy shock of one standard deviation, the declines in *CRD* and *CPI* are 0.55% and 0.18%, respectively, at two-year horizon, based on median responses, producing a ratio of 3.0. In response to a macroprudential policy shock of one standard deviation, the declines in *CRD* and *CPI* are 0.45% and 0.20%, respectively, yielding a ratio of 2.2. Although the ratio of credit responses to price responses is slightly different, the probability that the ratio under monetary policy shocks is larger than the ratio under macroprudential shocks is only 65.3% based on simulation exercises, which suggests that the difference is not significant at a conventional significance level.[16] In the first row of Table 1, we report the probability that the ratio of credit-to-price responses under monetary policy shocks is larger than the ratio under macroprudential policy shocks at various horizons. The results show that the probability ranges from 49% to 67% at one-to-four year horizons, which suggests that the difference is not significant at any conventional 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	48.5%	65.3%	67.0%	60.0%
CRD/RGDP	53.4%	69.0%	55.3%	51.3%

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

Source: authors' calculations.

14 The impulse responses of the variables in the system (except for the macroprudential policy index) are invariant to changes in the scaling of the index; for instance, the responses do not change if every macroprudential policy action is set to change the index value by 0.5 units instead of one unit.

15 Moreover, the two policy variables are measured in different ways so the nature of the policy shocks is different. A monetary policy shock of one standard deviation here corresponds to a 48 basis points increase in the interest rate, while a one standard deviation shock to macroprudential policy amounts to an increase of 0.6 units in the constructed macroprudential policy index. As it is not easy to compare the effect on each variable separately, we compare the relative size of *CRD* and *CPI* responses, instead of the size of the responses of each variable.

16 The probability is calculated by comparing the ratios for 10,000 draws from simulations.

Comparing similarly the relative responses of credit to GDP, the corresponding ratio at two-year horizon is 4.2 in the case of monetary policy shocks and 2.2 in the case of macroprudential policy shocks, based on the median response. Although the difference in the ratios is larger in this case, the probability that the ratio of credit-to-output responses under monetary policy shocks is larger than the ratio under macroprudential policy shocks at two-year horizon is 69.0% based on simulation exercises. In addition, the difference in the probability is still not statistically significant at any horizon as shown in Table 1. Thus, we do not find any evidence that the relative effectiveness of the two policies in stabilising credit and the price level, and credit and real GDP, would be clearly different.

The impacts of macroprudential policy shocks on credit can be broadly compared to findings from existing literature. Cerutti et al (2016) find that a one standard deviation change in their macroprudential policy index reduces (real) credit growth by 2.2 percentage points in advanced economies and by 8.3 percentage points in emerging markets. Although these numbers tend to be larger than our finding, we note that their measure does not capture changes in the level of intensity of the individual instruments - only whether the measures were in place or not. If the impact of *introducing* a particular measure is large, this may be reflected in the estimated relationship between the macroprudential policy index and credit. For the United States, Zdzienicka et al (2015) estimate that a macroprudential policy tightening reduces the level of real bank credit by 1.6% after 6 quarters but the effect goes to zero in the long run, which is more in line with our estimates.

Some interesting interactions can be observed between the policy instruments. In response to contractionary macroprudential shocks, the interest rate declines after a few quarters. This monetary expansion may be interpreted as an endogenous policy action to stabilise the price level that has declined after a contractionary macroprudential shock. Similarly, contractionary monetary policy shocks lead to expansionary macroprudential policy, which can be interpreted as an endogenous policy response to changes in the credit condition following monetary policy shocks. We note that Bruno et al (2016) show a positive correlation between the levels of interest rate and cumulated macroprudential policy actions – our results suggest that there may additionally exist a lagged endogenous policy response that partly counters the impact of shocks to the other policy instrument.[17]

To infer the relative importance of the policy instruments in explaining the volatility of target variables, a forecast error variance decomposition is computed. Table 2 reports the results with 90% probability bands. We find that macroprudential policy shocks tend to play a more important role in explaining the fluctuations in prices than monetary policy shocks. At a 4-year horizon, macroprudential policy shocks explain 12.3% of CPI fluctuations, while monetary policy shocks explain 6.0%. On the other hand, the contribution of both shocks to credit fluctuations is relatively small, less than 6% at any horizon. Thus, the role of monetary policy shocks in explaining credit fluctuations is somewhat limited, but the contribution of macroprudential shocks to CPI fluctuations is rather strong. The latter finding is again likely to stem from the aggregate demand impacts of

[17] Bruno et al (2016) document a positive correlation between the two policy instruments. However, this seems to be generated as an endogenous policy response in the presence of other structural shocks. For example, a positive correlation between the two policy instruments is found as a response to shocks to real GDP in Figure 1. By excluding the correlation conditional on shocks to macro variables, the remaining correlation between the two policy instruments is small. In such a case, the ordering between the two policy instruments does not change the results much as shown in Section 4.2.

macroprudential policies – shocks to the macroprudential instrument explain 9.3% of output fluctuations at a 4-year horizon. As tighter macroprudental policies lead to a fall in current expenditure, output falls, putting downward pressure on prices.

Forecast error variance decomposition, monetary and macroprudential shocks — Table 2

Horizons		1 year	2 year	3 year	4 year
CPI	*PP* shock	1.9 (0.2, 7.6)	7.2 (1.6, 17.4)	10.3 (2.4, 23.8)	12.3 (2.7, 28.5)
	R shock	1.2 (0.3, 3.7)	6.4 (1.2, 16.8)	6.5 (1.2, 17.4)	6.0 (1.0, 17.1)
CRD	*PP* shock	0.4 (0.0, 3.0)	1.6 (0.2, 7.9)	3.6 (0.4, 14.7)	5.9 (0.5, 21.0)
	R shock	0.9 (0.3, 3.4)	3.0 (0.6, 10.0)	3.8 (0.6, 13.2)	4.0 (0.5, 14.2)
RGDP	*PP* shock	3.7 (0.3, 10.7)	6.6 (0.8, 17.4)	8.2 (1.0, 21.8)	9.3 (1.1, 25.7)
	R shock	0.6 (0.1, 3.3)	2.3 (0.2, 10.5)	2.7 (0.2, 12.0)	2.9 (0.2, 12.9)

The table shows the forecast error variance decomposition of *CPI*, *CRD*, and *RGDP* due to *PP* and *R* shocks, in per cent. 90% probability bands are in parentheses.

Source: authors' calculations.

The similar effects of macroprudential and monetary policies could prove particularly problematic when inflation is low but credit growth is buoyant. Under such circumstances, contractionary macroprudential policy shocks would increase the disinflationary pressure. While expansionary monetary policy could counteract this, the two instruments would end up pushing in opposite directions. As argued by Shin (2015), private sector agents would then be simultaneously encouraged to both borrow more and borrow less, arguably resulting in conflicting incentives.

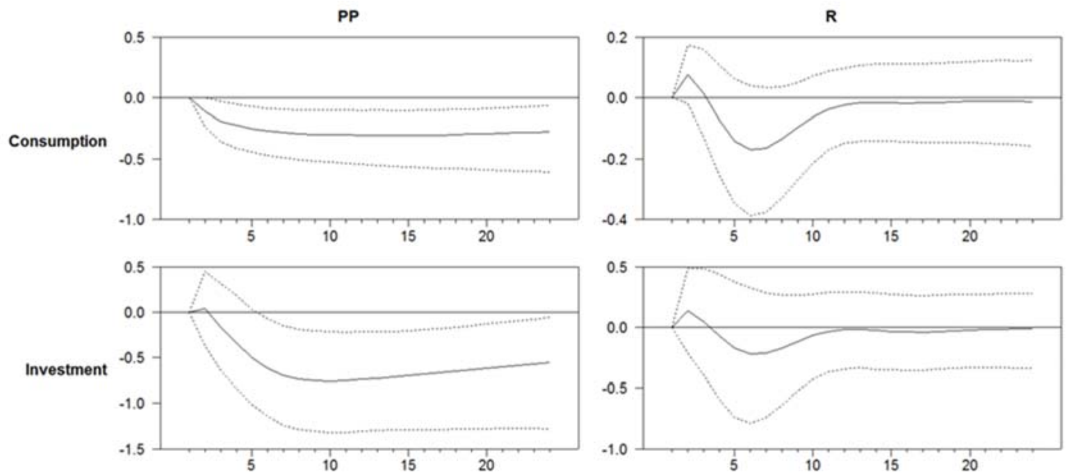
We further note that the simultaneous occurrence of low inflation and strong credit growth need not reflect shortcomings on the part of macroeconomic policy. It could arise, as the timing of business cycles does not coincide with financial cycles (Borio (2014)). It could also stem from the nature of shocks, with a supply shock driving credit up and pushing prices down (Jonsson and Moran (2014)). In related work, Kim and Mehrotra (2016) show that in the four Asia-Pacific economies under study, 15% of the country-year observations during 2000–12 featured low inflation but rapid credit growth. In particular, inflation was below the mid-point of the inflation target but the deviation of credit-to-GDP from its trend at levels that had been indicative of financial stability concerns in the past.

4.2. Extended models and robustness

To infer the transmission mechanism of the two policy shocks, we further investigate their effects on two components of GDP. As suggested in Section 2, macroprudential policy shocks could affect both consumption and investment, through their impact on credit. We extend the baseline model accordingly, including real consumption and real investment as additional endogenous variables, one by one. These variables are assumed to be contemporaneously exogenous to the two policy variables, as their adjustment tends to be sluggish.

Figure 2 shows that contractionary *PP* shocks indeed decrease both private consumption and investment significantly.[18] Contractionary *R* shocks also decrease both private consumption and investment, but the error bands are wide, which might stem from the fall in the degrees of freedom when an additional variable is included in the model.

Consumption and investment response to policy shocks — Figure 2



Note: The column headings denote the shocks and the row headings the responses of the indicated variable to each shock. *PP* = macroprudential policy measure, *R* = policy interest rate. For example, the impulse response in the first row, second column, shows the response of private consumption to an interest rate shock.

Sources: authors' calculations.

Next, we extend the baseline model to include the bilateral exchange rate against the US dollar because exchange rate changes might be an important transmission channel. Bruno and Shin (2015) outline a model in which local currency appreciation loosens financial conditions by strengthening borrowers' balance sheets, leading to greater bank risk-taking and lending to local borrowers. All variables in the extended model are assumed to be contemporaneously exogenous to the exchange rate, as the exchange rate is likely to reflect all possible information instantaneously.

The results, shown in Figure A1 of the Appendix, suggest that the impacts of the two policy shocks remain robust to the inclusion of the exchange rate variable, albeit with reduced statistical significance. Both contractionary monetary policy and macroprudential policy shocks lead to exchange rate appreciation in the short run. Interestingly, a depreciation shock to the domestic currency (a rise in *X*) indeed leads to a fall in the

[18] Our result is consistent with Sonoda and Sudo (2015) who study the impacts of Quantitative Restriction (QR) policies that asked banks to limit lending to the real estate sector in Japan from the 1970s to the 1990s. The authors find that QR policy shocks had broader impacts on the macroeconomy, including on consumption and investment.

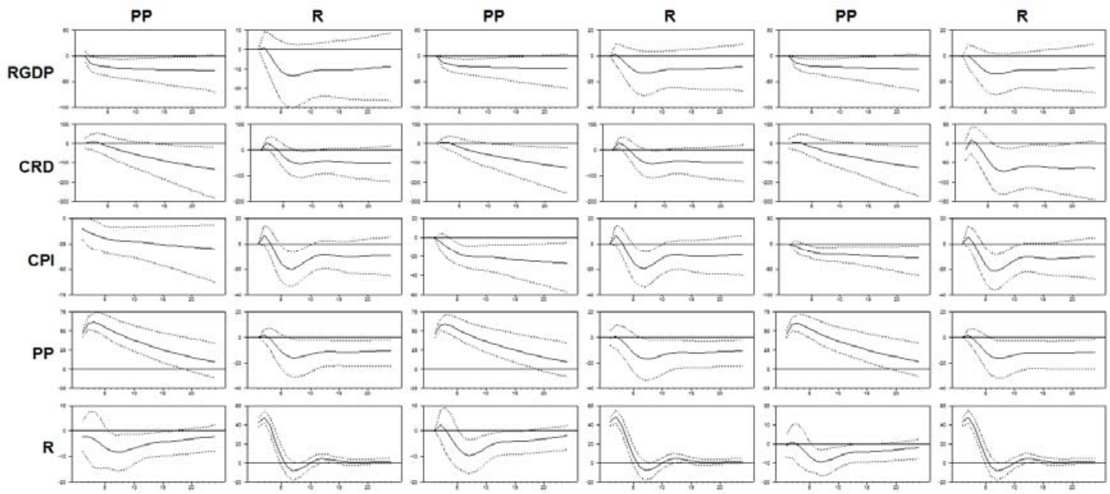
level of credit, consistent with Bruno and Shin (2015). To the extent that exchange rate appreciation has coincided with credit booms, the credit growth observed in the data may have been amplified by underlying exchange rate movements.

Finally, we conduct various exercises to check the robustness of the main results. We begin by considering alternative orderings in the VAR. First of all, we show results under alternative identifying assumptions on macroprudential policy shocks. We find that the results are similar under any alternative identifying assumptions on macroprudential policy shocks, which results from low correlation between innovations in macroprudential policy and innovations in other variables. In Figure 3, we report some results from models under extreme assumptions. The first two columns display the results from a model where macroprudential policy instrument is assumed to be contemporaneously exogenous to all other variables, while the third and fourth columns show the results from a model where all variables are assumed to be contemporaneously exogenous to the macroprudential policy instrument.[19] In the latter model, we change the ordering between the two policy instruments from the baseline model. That is, the interest rate is assumed to be contemporaneously exogenous to the measure of macroprudential policy. In addition, the last two columns in Figure 3 display the results from an alternative identification scheme in which the two policy instruments are allowed to affect credit contemporaneously.[20] The figure suggests that the results are robust to these alternative identifying assumptions.

[19] We assume that the ordering among the other four variables is the same as that in the baseline model. However, the results on the effects of macroprudential shocks are similar even when the ordering among the other four variables changes.

[20] Policy actions could in principle affect credit immediately, so here we allow for contemporaneous effects of policy shocks on credit.

Impulse responses, alternative identifying assumptions Figure 3



Note: The column headings denote the shocks and the row headings the responses of the indicated variable to each shock. *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, second column, shows the response of real GDP to an interest rate shock. The first two columns show the responses in the case where the macroprudential policy instrument is contemporaneously exogenous to all other variables. The third and fourth columns show the responses from a model where all variables are assumed to be contemporaneously exogenous to the macroprudential policy instrument. The fifth and sixth columns show the case in which the two policy instruments are allowed to affect credit contemporaneously.

Sources: authors' calculations.

Next, we further investigate the robustness of the results by using different datasets of macroprudential tools. First, we use the data in Lim et al (2013) collected by the IMF, covering loan-to-value and debt service-to-income ratios, capital requirements and risk weights, provisioning requirements, foreign currency lending limits, credit growth limits, reserve requirements, limits on maturity mismatch and net open position and restrictions on profit distributions. The measures used in the estimation are constructed similarly to the benchmark model, ie accumulating the changes in policy to an index over time.

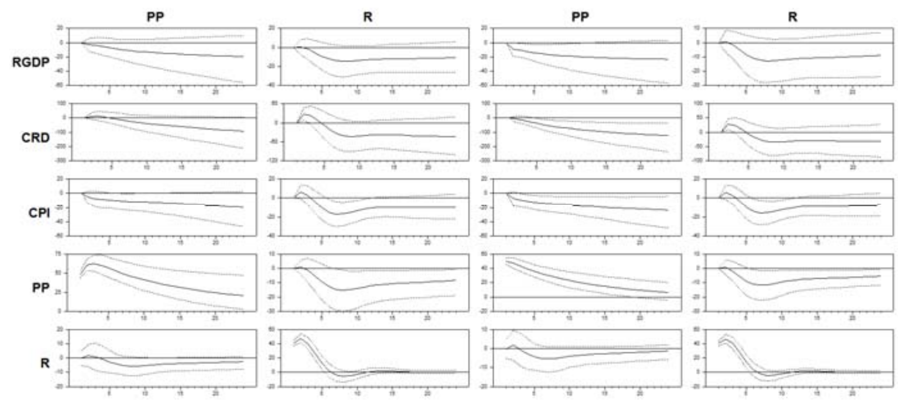
In addition, we experiment with macroprudential data in Akinci and Olmstead-Rumsey (2015). These data build on Lim et al (2011), Kuttner and Shim (2013) and national sources; after 2011, they are extended by using national sources and an IMF survey called Global Macroprudential Policy Instruments (GMPI). The data are also cross-checked against other cross-country data (eg Cerutti et al (2016)), as well as the GMPI survey. The macroprudential measures in this dataset comprise the loan-to-value ratio, debt-to-income ratio, "other housing measures"[21], housing-related countercyclical capital requirements, housing-related loan-loss provisioning, non-housing related countercyclical capital requirements, non-housing loan-loss provisioning, non-housing

21 "Other housing measures" include higher regulatory risk weights for mortgage loans, quantitative limits on mortgage lending, taxes on property gains, and stricter requirements related to the creditworthiness of mortgage borrowers.

consumer loan measures and non-housing credit growth limits. Again, we construct a macroprudential policy index identically to the benchmark model.

The first two columns in Figure 4 show the impacts of policy shocks using the measure based on Lim et al (2013); the last two columns show the results using a measure based on Akinci and Olmstead-Rumsey (2015). The resulting dynamics are qualitatively similar to our benchmark results based on Shim et al (2013), for both alternative policy indicators.

Impulse responses, alternative measures of macroprudential policy actions Figure 4

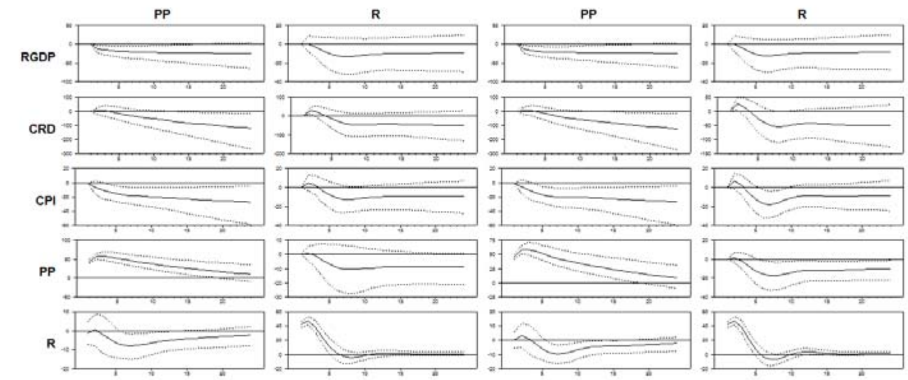


Note: The column headings denote the shocks and the row headings the responses of the indicated variable to each shock. *RGDP* = real GDP, *CRD* = total credit, *CPI* = consumer price index, *PP* = macroprudential policy measure, *R* = policy interest rate. For example, the impulse response in the first row, second column, shows the response of real GDP to an interest rate shock. The first two columns show the responses with the macroprudential policy indicator based on Lim et al (2013). The third and fourth columns show the responses with the macroprudential policy indicator based on Akinci and Olmstead-Rumsey (2015).

Sources: authors' calculations.

Finally, we included the crisis dummy (Q3:2008–Q2:2009) since the economy may have behaved differently during the global financial crisis. Then, we replace the Federal Funds rate with the U.S. shadow policy rate constructed by Lombardi and Zhu (2014), as an exogenous variable. Lombardi and Zhu (2014) constructed the shadow policy rate to correctly measure the monetary policy stance of the U.S. when the policy interest rate reaches the zero lower bound and a variety of unconventional policy measures are implemented. The first two columns in Figure 5 show the impacts of policy shocks when the crisis dummy is introduced; the last two columns show the results using the U.S. shadow policy rate. The results are qualitatively similar to our benchmark results.

Impulse responses, crisis dummy, shadow policy rate Figure 5



Note: The column headings denote the shocks and the row headings the responses of the indicated variable to each shock. *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, second column, shows the response of real GDP to an interest rate shock. The first two columns show the responses when the global financial crisis dummy is introduced in the model. The third and fourth columns show the responses when the shadow policy rate, instead of the Federal Funds rate, is used as an exogenous variable in the model.

Sources: authors' calculations.

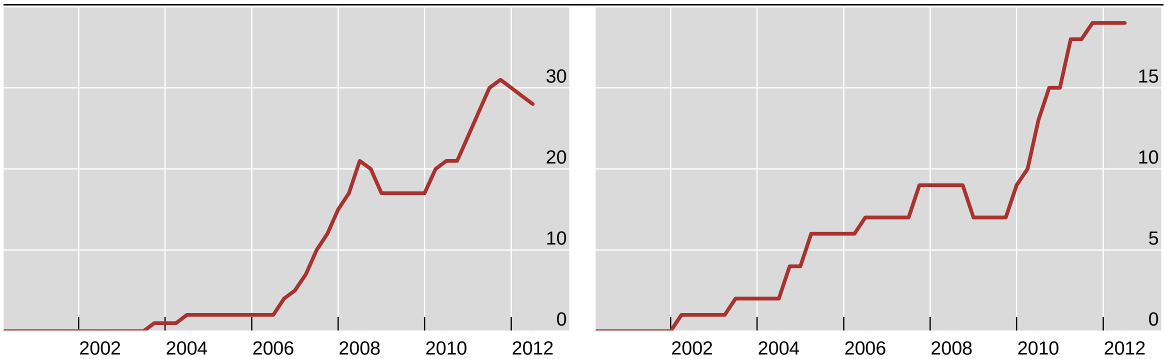
5. Some implications for China

While the previous analysis focuses on inflation targeting economies, it is of interest to discuss the use of macroprudential policies in another country in the Asia-Pacific region, China. As stipulated in the amended Central Bank Law of 2003, one of the major functions of the People's Bank of China is "preventing and mitigating systemic financial risks to safeguard financial stability".[22] China announced in its 12th Five-year Programme that it would build a "countercyclical financial macroprudential management framework" (PBoC, 2011). Furthermore, in December 2015, the People's Bank of China announced a new mechanism: the "macroprudential assessment" involves an expansion in the type of credit instruments and factors (eg leverage; liquidity) considered when evaluating systemic risk. And regarding the importance of other central bank objectives, while China is not an inflation targeter, its monetary policy places high importance on price stability (Zhou, 2016).

Macroprudential policy actions in China — Figure 6

Monetary measures, index[1] — Prudential measures, index[2]

[22] http://www.pbc.gov.cn/english/130712/index.html



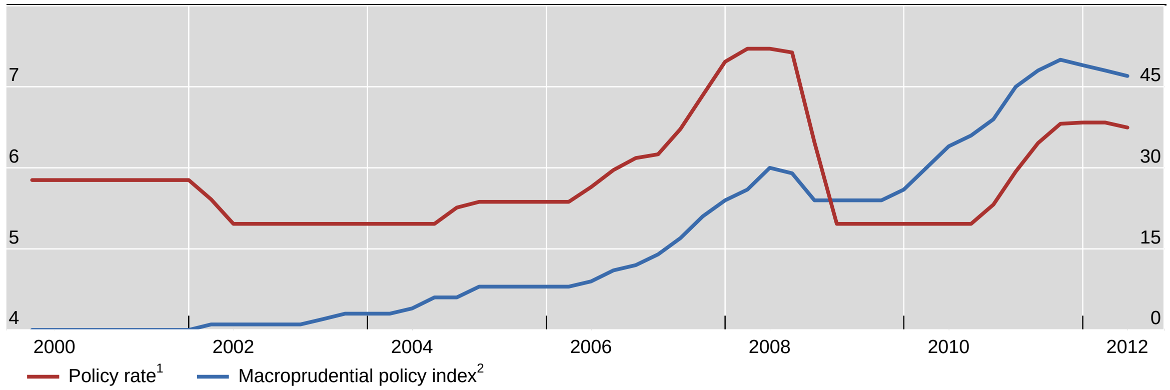
[1] Monetary measures include reserve requirements, credit growth limits and liquidity requirements. A macroprudential policy tightening (loosening), regardless of the type of measure undertaken, increases (decreases) the value of the index by 1, with the new value maintained until another policy action is taken. [2] Prudential measures include maximum loan-to-value ratio, maximum debt-service-to-income ratio, risk weights on housing loans and loan-loss provisioning on housing loans. Index constructed as in Footnote 1.

Source: Shim et al (2013); authors' calculations.

The data in Shim et al (2013) highlight the frequent use of macroprudential measures in recent years by Chinese policymakers. Figure 6 shows two macroprudential policy indices for China, constructed using the methodology described in Section 2. The index in the left-hand panel considers "monetary" measures, including reserve requirements that have been the most frequently used macroprudential tool in China during our sample period (41 adjustments in total). The right-hand panel includes "prudential" instruments, of which loan-to-value ratios were adjusted 14 times during our sample period, while debt-service-to-income limits were changed 8 times. There has been a clear tendency for macroprudential policy in China to tighten over time, with only a short interruption in the upward trend in the two indices in the aftermath of the international financial crisis.

Policy interest rate and macroprudential measures in China

Figure 7



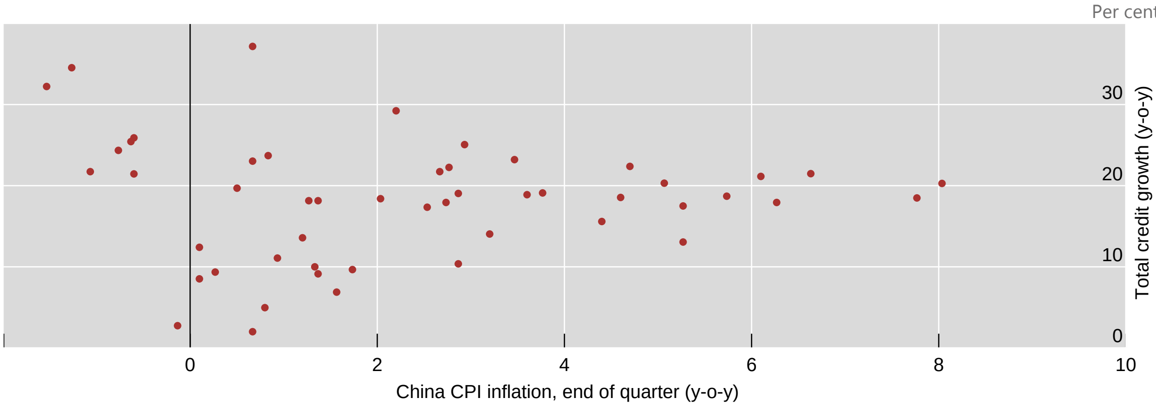
[1] One-year lending rate [2] Includes both monetary and prudential measures; see Figure 6 for details.

Source: Shim et al (2013); authors' calculations.

How has macroprudential policy interacted with monetary policy in China? Figure 7 shows the dynamics of the policy interest rate jointly with an aggregate macroprudential policy index, the latter including both monetary and prudential measures. There is a clear positive co-movement between the two indicators. A monetary policy tightening in the form of a higher nominal interest rate tends to coincide with tighter macroprudential policy – the correlation coefficient between the two series is 0.44. This is consistent with Bruno et al (2016) who find that macroprudential and monetary policies have been used in a complementary way in the Asia-Pacific region, even when controlling for global liquidity and country-specific variables such as GDP growth and inflation. Considering our finding from structural vector autoregressions in Section 4, such a co-movement of policies may reduce the risk that monetary and macroprudential policies affect credit, real GDP and the price level in opposite directions. Yet, challenges with stabilising both macroeconomic and financial conditions at times of low inflation and high credit growth remain. Figure 8 shows that during Q1:2000-Q2:2012 in China, there were a total of 10 quarters with inflation below 2% but credit growth (y-o-y) exceeding 20%.

Inflation outcomes and credit growth[1]

China, Q1:2000-Q2:2012 Figure 8



[1] Total credit to the non-financial sector

Source: BIS

6. Conclusion

The experience from the international financial crisis led central banks and other authorities to increasingly pursue macroprudential policies to mitigate systemic financial risk. This is consistent with the widespread adoption and prominence of financial stability objectives by central banks, in addition to their well-established price stability mandates. Using structural panel vector autoregressions, we have examined the effects of monetary and macroprudential policies in four inflation targeting economies in the Asia-Pacific region: Australia, Indonesia, Korea and Thailand. In our analysis, the target variable for the macroprudential authority is assumed to be the stock of credit extended to the private sector, and the policy instrument at its disposal consists of various domestic macroprudential measures targeting the housing market.

Our main finding is that the impacts of monetary and macroprudential policy shocks on key macro variables have been similar, with both contractionary policy shocks leading to a decline in real GDP, the price level and the stock of credit. These dynamics suggest that macroprudential and monetary policies work partly through related channels, affecting aggregate demand.

The results also suggest that the two policies can help each other to achieve the targets of price and financial stability, but their simultaneous effects on both targets need to be taken into account appropriately. This may be particularly challenging in an environment of low inflation and strong credit growth. In such a context, using the two instruments simultaneously may lead to interest rates and macroprudential policies working at cross purposes, given their similar impacts on the real economy. Thus, coordination in the setting of the two policies may be quite important.

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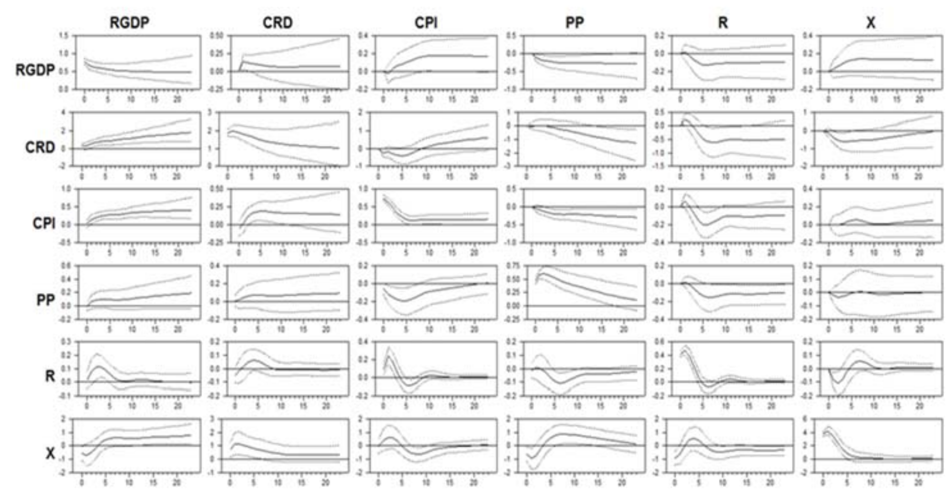
Appendix

Impulse responses from panel VAR, including the exchange rate Figure A1



Note: The column headings denote the shocks and the row headings the responses of the indicated variable to each shock. *RGDP* = real GDP, *CRD* = total credit, *CPI* = consumer price index, *PP* = macroprudential policy measure, *R* = policy interest rate, *X* = exchange rate. For example, the impulse response in the first row, fifth column, shows the response of real GDP to an interest rate shock.

Source: authors' calculations.