Effectiveness and conduct of macroprudential policy in Indonesia in 2003-2020: Evidence from the structural VAR models

Dąbrowski, Marek A. and Widiantoro, Dimas Mukhlas

Cracow University of Economics

5 May 2022

Effectiveness and conduct of macroprudential policy in Indonesia in 2003-2020: Evidence from the structural VAR models

Marek A. Dąbrowski[*] and Dimas Mukhlas Widiantoro[**]

Abstract

The paper examines the effectiveness of macroprudential policy in Indonesia and policy reactions to economic developments. Using the structural vector autoregression and data on the regulatory LTV ratio, we investigate the policy effectiveness in controlling credit growth and real property prices along with the effects on economic activity. We find that the LTV-based policy in Indonesia is effective in taming credit growth in the medium run. It, however, is not the case with real property prices whose response to policy changes is counterintuitive and resembles the price puzzle found in the studies on monetary policy. Moreover, our results lend moderate support to the effect of LTV policy on economic activity, especially in the non-Covid-19 sample. We also show that the LTV policy in Indonesia is conducted in an active and circumspective way. In a series of robustness checks, we demonstrate that the results hold when the ordering of variables is changed, alternative proxies for macroprudential policy, output gap, and financial conditions are employed, or the sample is limited to the non-Covid-19 period.

Keywords: *macroprudential policy, loan-to-value policy, structural vector autoregressive models, financial stability*

JEL codes: E44, E58, F41,G10

---

[*] Corresponding author: Cracow University of Economics, Faculty of Economics, Finance and Law, Department of Macroeconomics, ul. Rakowicka 27, 31-510 Kraków, Poland, e-mail: marek.dabrowski@uek.krakow.pl.
[**] Cracow University of Economics, Doctoral School, ul. Rakowicka 27, 31-510 Kraków, Poland, e-mail: dimasmukhlas@gmail.com.

1. Introduction

The macroprudential policy has quickly been integrated into the set of key economic policies in the aftermath of the global financial crisis. The tendency to use housing-related macroprudential instruments like the regulatory loan-to-value (LTV) ratio has been more prominent in many Asian countries than in other regions (Shim et al., 2013, Kuttner & Shim, 2016, Zhang and Zoli, 2016, Kim et al., 2019). The LTV-based policies are, in general, found to be an effective tool for controlling asset prices and preventing excessive credit expansion (Cantú et al., 2020, Jung & Lee, 2017). The consensus on this issue, however, has not been reached yet (Lee et al., 2015, Araujo et al., 2020). In a recent study, Luangaram and Thepmongkol (2022) argue that the effectiveness of LTV-based policy in taming asset price growth depends positively on the stage of financial development.

In a related strand of literature, the macroeconomic effects of the macroprudential policy are investigated. Kim and Oh (2020) find that contractionary macroprudential policy shocks adversely affect output and price level and their effects are qualitatively similar to those of monetary policy (see also Kim & Mehrotra, 2018, Kim et al., 2019). Similarly, using a meta-analysis, Araujo et al. (2020) report that macroprudential tightening harms economic activity. This result, however, is not uncontroversial. Using a large cross-country panel, Richter et al. (2019) find that household credit, mortgage credit, and house prices can be controlled with LTV limits at a relatively small cost. It is because macroprudential measures have modest spillover effects on output and inflation.

In this paper, we contribute to both these threads in the literature by examining the effectiveness of macroprudential policy in Indonesia and shed more light on policy reactions to developments in the economy. Even though the conduct and effectiveness of macroprudential policy in Asian countries have already drawn some attention in the literature, country-specific studies are not abundant. With only a few studies exclusively devoted to Indonesia (see, e.g., Warjiyo, 2017, Wijayanti et al., 2020), the LTV-based policy in that country seems to be one of the relatively less investigated cases. Using the structural vector autoregression (SVAR) and data on the regulatory LTV ratio, we investigate the policy effectiveness in controlling credit growth and real property prices along with the effects on economic activity.

Our main findings can be encapsulated as follows. First, we find that the LTV-based policy in Indonesia is an effective tool for taming credit growth in the medium run. It, however, is not the case with real property prices whose response to policy changes turns out to be

counterintuitive and resembles the price puzzle found in the studies on monetary policy. Second, our results lend some support to the effect of LTV policy on economic activity, especially in the non-Covid-19 sample. Third, we show that the LTV policy is conducted in an active and circumspective way. Macroprudential authority makes credit less available when economic and financial conditions turn out to be more favourable. Fourth, in a series of robustness checks, we demonstrate that the results hold when the ordering of variables is changed, alternative proxies for macroprudential policy, output gap, and financial conditions are employed, or the sample is limited to the non-Covid-19 period.

Our main contribution to the literature is threefold. First, our paper is one of few studies that investigate the effectiveness of LTV-based policy in Indonesia. The extant analyses of macroprudential policy in Indonesia are based on data ending in the mid-2010s at best. Using the updated database on macroprudential policy developed by Alam et al. (2019), we provide fresh evidence on the effects of LTV-based policy. Second, within the SVAR framework, we carefully analyse both the effects of LTV-based policy and the reactions of macroprudential authority to economic and financial shocks. It enables us to assess whether the policy is advised or countercyclical as postulated, for example, by the theoretical framework of Sui et al. (2022). Third, similarly to Richter et al. (2019) and unlike many other papers that use the dummy type policy variable, we employ the LTV ratio, i.e. a measure that captures the intensity of policy actions. Finally, even though the adopted SVAR modelling approach is conventional, we go well beyond its mechanical application. In a battery of robustness checks, we demonstrate that the empirical results are not sensitive to specific assumptions.

The paper is structured as follows. The next section concisely reviews the related literature, focusing on the Asian economies. Section 3 outlines the framework and conduct of macroprudential policy in Indonesia in recent years. Section 4 briefly explains the empirical strategy adopted, whereas Section 5 describes the data. Section 6 discusses empirical results and offers robustness checks. The final section concludes.

2. Related literature

The related literature can be divided into two main strands. The first one elaborates on the effects of macroprudential policy on financial variables such as real estate prices, credit growth, household loans, and non-performing loans. The second strand discusses macroprudential

policy impact on macroeconomic variables such as GDP, industrial production, and consumer prices. This section focuses on the literature on Asian economies.

Macroprudential policy and financial stability

The effectiveness of macroprudential policy in maintaining financial stability in Asian countries has recently been investigated in many studies. In general, they lend support to the claim that macroprudential policy is effective in mitigating the build-up of financial risks, albeit the usefulness of particular instruments is heterogeneous. For example, using cross-country macro panel regressions and other techniques, Zhang and Zoli (2016) demonstrate that Asian economies use macroprudential policy tools more extensively than other regions. Moreover, they find that LTV ratio caps and housing tax measures are effective in reducing the growth of credit and housing price inflation and preventing banks from excessive use of financial leverage.

Given that many datasets on the macroprudential policy include binary variables, Lee et al. (2015) employ the Qual VAR framework to analyse policy effects in ten Asian countries, including Indonesia. They find that credit-related policy instruments can effectively dampen credit expansion and housing price inflation, whereas liquidity-related policy tools can effectively moderate the leveraged growth and housing price escalation. Both instrument groups have an immediate effect on credit expansions and a lagged effect on leverage growth in Indonesia. More recently, Cheng and Rajan (2022) document the synchronicity between house prices in nine East Asia and Pacific economies, including Indonesia, and global property prices. They find that synchronicity can be reduced with capital controls but not the exchange rate flexibility. When the capital account is open, the comovement of domestic and global house prices can be alleviated with borrower-based macroprudential policy measures such as debt-to-income (DTI) and LTV limits.

Similar results on macroprudential policy are reported in country-specific studies. Jung and Lee (2017) find that the DTI and LTV policies effectively curb excessive household debt and subsequent house price bubbles in Korea. The former instrument is more important in stabilising housing prices than the latter. The DTI and LTV policies in Korea are also studied by Kim and Oh (2020). Using the structural VAR framework, they show that DTI and LTV shocks have significant effects on housing prices and household bank loans. Bruneau et al. (2018) use Canadian data to demonstrate that the countercyclical LTV policy that responds to

the credit-to-income ratio is useful in stabilising household indebtedness and reducing spillovers from the housing market into consumption. Moreover, it is superior to monetary policy that reacts to credit fluctuations since the latter has large adverse consequences on the real economy. Warjiyo (2017) discusses the macroprudential framework in Indonesia and explains that the central bank's mandate combines price and financial system stability. The macroprudential policy based on LTV limits, reserve requirements and a capital conservation buffer is found successful in mitigating the build-up of systemic risks to financial stability. Zhang et al. (2020) investigate the effects of and likely conflicts between monetary and macroprudential policies in China. Using the VAR framework with time-varying parameters, they show that the macroprudential tightening shock reduces systemic risk in the medium run, whereas monetary tightening increases that risk. The beneficial impact of macroprudential policy stems from its relatively high effectiveness in controlling asset prices.

Interestingly, Luangaram and Thepmongkol (2022) point out that the evidence from country-specific studies is more heterogeneous than that from cross-country studies. They hypothesize that the impact of LTV policy on asset prices and investment depends on the level of financial development and show that the policy is more effective in countries with high financial depth (Hongkong, Singapore, South Korea) than in those with low private credit-to-GDP ratios (Indonesia, the Philippines).

There is a related strand of research that uses bank-level data. Its focus is on the effectiveness of macroprudential policy at the microeconomic level and on policy implications. Data from more than four thousand banks in 46 economies, including 29 Indonesian banks, are used by Morgan et al. (2019) to evaluate the effectiveness of LTV policy. Mortgage lending is found to be sensitive to LTV policy, albeit the effect is heterogeneous: it is the strongest for small banks with few bad loans and the weakest in big banks troubled with many non-performing loans. Thus, the recommendation is to use the LTV policy with the complementary macroprudential policy tools. Cantú et al. (2020) assess the macroprudential policy effectiveness in Australia, Indonesia, New Zealand, the Philippines, and Thailand. Applying meta-analysis techniques and confidential supervisory bank-level data, they show that macroprudential policies are effective in curbing excessive household credit growth and the build-up of banks' non-performing loans (NPL) ratios. Moreover, the policy effects are not symmetric: a tightening affects credit growth more strongly than an easing. The panel data on 104 Indonesian banks are employed by Wijayanti et al. (2020) to examine the impact of Bank Indonesia policy on household credit growth and credit risk. They find that LTV and

macroprudential intermediation ratios can be used to control the growth of household loans and reduce the NPL ratio. Macroprudential tightening, however, is not that effective in slowing down household loan growth when real GDP growth is high.

In a recent study, Ono et al. (2021) examine data on more than 400 thousand business loans from the real estate registry in Japan and demonstrate that the LTV ratios are counter-cyclical, even though both the value of loans and the value of land pledged as collateral are individually pro-cyclical. Moreover, they find that high LTV-loans are granted to riskier firms but at the same time are faster growing than firms with low LTV-loans. The important policy implication is that a simple LTV cap might be ineffective and limit access to finance for firms with above-average growth opportunities.

Macroprudential policy and macroeconomy

Macroprudential policy is found in the literature to affect the real macroeconomy. Using the vector autoregression framework for 11 Asian economies, Kim et al. (2019) show that the macroprudential policy tightening harms credit and output, and these effects are similar to those of monetary policy. Their result implies that the mix of macroprudential and monetary policies can be used to resolve the policy conflict when the credit growth is strong, but the real economy stumbles. Using a larger sample of 32 advanced and emerging market economies, Kim and Mehrotra (2019) get similar results. They investigate the transmission of both policies and uncover that shocks in macroprudential policy predominantly spread on residential investment and credit to households, whereas monetary shocks have more general effects on the economy. A similar result is reported by Richter et al. (2019), who analyze the effects of a change in maximum LTV ratio on output and inflation. They find that the cut in LTV ratio by ten percentage points reduces output by 1.1%. This effect holds only in emerging market economies and is asymmetric: the LTV tightening has a stronger impact than loosening.

The impact of macroprudential policy on the macroeconomy is detected in other studies as well. Kim and Oh (2020) demonstrate that LTV and DTI policies in Korea are effective not only in controlling house prices and household bank loans but also in changing CPI and industrial production. The effect, however, is slower than that of monetary policy shocks. At the same time, both macroprudential policy tools are more appropriate for financial stability objectives than monetary policy. In a study that includes ten emerging market economies, Juhro et al. (2021) show that macroprudential policy can complement monetary policy in controlling

inflation, credit growth, and the credit cycle. They find, however, that the capital account openness makes such a policy mix less effective, so they argue for using other policy options, e.g. exchange rate stabilization, as well.

3. An outline of macroprudential policy in Indonesia

The interest in and work on addressing systemic risk with macroprudential policy gathered momentum after the global financial crisis. Some emerging market economies, however, had used macroprudential policy before within a broader "macro-financial" stability framework (Lim et al., 2011). Indonesia was one of them. With an eye on financial system stability Bank Indonesia (BI), which is the central bank of Indonesia, started to develop its macroprudential function in the early 2000s (Warjiyo, 2017), and the Financial System Stability Bureau was established in 2003 (Riyanto, 2016). Initially, a macroprudential policy was considered a plain extension of microprudential regulation and supervision that adds a system-wide perspective. The BI was accountable for both policies.

The institutional setup of macroprudential policy was reformed in the 2010s. At that time, the Financial Service Authority (*Otoritas Jasa Keuangan*, OJK) was established and made accountable for microprudential policy, whereas macroprudential policy was left to the BI. In the mid-2010s, policy coordination between BI, OJK, the Ministry of Finance, and the Deposit Insurance Institution (*Lembaga Penjamin Simpanan*, LPS) was strengthened with the establishment of the Financial System Stability Committee (*Komite Stabilitas Sistem Keuangan*, KSSK) (Riyanto, 2016). The coordination is aimed at crisis prevention and resolution, and one of the KSSK's key responsibilities is to determine and coordinate the response to systemic banking crises (IMF, 2017).

Macroprudential policy in Indonesia is an integral part of the central bank policy. The other components include a flexible inflation targeting geared at price stability, exchange rate policy and capital flow management aimed at sustaining the inflation target and preventing excessive volatility in financial markets from spillover into the domestic financial system (Warjiyo, 2017). The leading role of the BI in macroprudential policy is justified by Riyanto (2016) with the central bank's information advantage concerning the interactions in the financial system and the functioning of the real economy.

The macroprudential policy objectives in Indonesia are threefold: (1) identification and mitigation of systemic risk that can arise from the excessive credit growth and asset price bubbles, (2) fostering a balanced and sound bank intermediation function, (3) enhancing financial system efficiency and improving access to finance (Warjiyo, 2016).

Following Lim et al. (2011), macroprudential policy tools can be divided into credit-related, liquidity-related, and capital-related.[1] The BI has used so far instruments that belong to all these categories with varying degrees of intensity. The main macroprudential policy tools in Indonesia are the LTV cap, the macroprudential intermediation ratio (MIR), the macroprudential liquidity buffer (MLB), and the countercyclical capital buffer (CCyB) (Wijayanti et al., 2020).

The regulatory LTV limit has been used since 2012 in order to contain the excessive mortgage lending and dampen the housing price growth. The limit was tightened in 2013, and since that time, it has been relaxed several times. Even though mortgage lending accounts for 10% of overall lending only, the LTV policy is important as it conveys signals to market participants on how the central bank assesses financial stability conditions (Wijayanti et al., 2020). Moreover, the LTV policy was complemented by setting the minimum level of down payment on automotive loans (Warjiyo, 2017).

The BI implemented the MIR for the first time in 2018 to promote sound bank intermediation (BI, 2019). The instrument replaced the loan-to-funding (LTF) ratio-based reserve requirement, which had been in use since 2015, and the loan-to-deposit (LTD) ratio-based reserve requirement introduced in 2011. The BI sets the upper bound for the MIR to contain a bank appetite for risk and the lower bound to ensure a sufficient level of liquidity in an economy. Banks that perform outside the MIR range are subject to the additional reserve requirement. The BI used these instruments to contain bank intermediation in 2013 and relaxed them in the following years (Wijayanti et al., 2020).

The MLB was implemented in 2018 as a refinement of the previous policy on the secondary reserve requirement (BI, 2019). It requires banks to have a liquidity buffer in the form of rupiah securities that can be used for monetary operations. The BI sets the MLB as a

---

[1] In a more elaborate division of macroprudential instruments, Galati & Moessner (2018) use the dimension of systemic risk (time and cross-sectional/structural) and the intermediate objectives to which tools are assigned. See also Cerutti et al. (2017) who divide instruments into borrower-oriented (e.g. LTV ratio) and lender-oriented (e.g. loan-to-deposit ratios).

percentage of rupiah deposits. The liquidity buffer was changed only once: the BI decided to raise it in 2020 (BI, 2022).

The CCyB policy aims at strengthening the resilience of the banking sector. It was introduced at the beginning of 2016 with a buffer set at 0% of risk-weighted assets. Since that time, the BI evaluates the level of CCyB no less than once every six months. The buffer, however, has not been changed so far.

The two macroprudential instruments used by the BI for the longest time are caps on the LTV ratio and the MIR, LTF/LTD ratios (Wijayanti et al., 2020). Lim et al. (2011) classify the former as a credit-related tool, whereas the latter, given its impact on the required reserves, can be classified as a liquidity-related instrument (see also Galati & Moessner, 2018). In the empirical part, we focus on the effectiveness of macroprudential policy in containing credit growth and property price inflation. Thus, we employ data on the regulatory LTV ratio. In the robustness checks, however, we also analyse the overall stance of macroprudential policy.

4. Empirical strategy

Our empirical strategy is straightforward. We employ the VAR model to estimate the dynamic relations between variables and then, imposing the recursive identifying restrictions, estimate the responses to structural shocks. We start with the standard reduced-form VAR model

$$y_t = c + A_1 y_{t-1} + \cdots + A_p y_{t-p} + u_t$$

where u_t is independent and identically distributed with mean 0 and covariance matrix Σ_u and c is a $(K \times 1)$ vector of intercepts. A $(K \times 1)$ vector y_t contains the values of K variables assumed at date t. The model includes four variables: output gap, credit-to-GDP gap, change in real property prices, and the loan-to-value ratio, so $y_t = [ygap_t, ctygap_t, dphp_t, ltv_t]'$.

Then the so-called B-model is used to isolate the structural shocks ε_t from the reduced-form residuals u_t (see, e.g., Lütkepohl, 2007, Kilian & Lütkepohl, 2017). The relations between them are assumed to be of the form $u_t = B\varepsilon_t$. The structural moving average representation of the VAR model is

$$y_t = \mu + A(L)^{-1} B\varepsilon_t$$

where $A(L) = I - A_1 - \cdots - A_p$ is the matrix polynomial in the lag operator L and $\mu = A(L)^{-1}c$.

Variances of structural shocks are normalized to one, so $\varepsilon_t \sim (0, I_K)$ and $\Sigma_u = BB'$. Given the symmetry of the covariance matrix Σ_u, additional restrictions are needed to obtain the matrix B. These we impose assuming that matrix B has a recursive structure. The economic justification of this assumption and its implications are discussed in Section 6.

Finally, we analyse the impulse response functions to structural shocks. The relative importance of structural shocks is assessed with the forecast error variance decompositions. It is worth mentioning, that the confidence intervals around point estimates of impulse response functions are based on a bootstrap method. The 95% confidence intervals are constructed using Hall's percentile method (Hall, 1992, Lütkepohl, 2007, p. 709 ff). The number of bootstrap replications is set to 1000.

5. Data

The set of data includes four key variables, i.e. output gap, credit-to-GDP gap, change in real property prices, the regulatory loan-to-value ratio, and additional variables employed in robustness checks (Table 1). The sample spans from 2003q1 to 2020q4. The output gap is derived from the quarterly data on real GDP using the method developed recently by Hamilton (2018). In his study, Hamilton (2018) restated the major drawbacks of the Hodrick-Prescott (HP) filter and offered an alternative way to isolate the cyclical component of a time series. It is a regression-based method in which the variable y at date $t + h$ is regressed on its p most recent values as of date t, and the residuals are used to construct the cyclical (transient) component of y. For quarterly data, h and p are set to 8 and 4, respectively. Given the popularity of the HP filter in the empirical literature, we use it in the robustness checks.

The credit-to-GDP gap and the year-on-year change in real (CPI-deflated) residential property prices are retrieved from the online BIS database. In one of the robustness checks, the rate of growth of real total credit to the private non-financial sector is used instead of the credit-to-GDP gap. The total credit is deflated with the CPI.

Finally, the stance of macroprudential policy is measured with the regulatory limits to loan-to-value (LTV) ratio obtained from the updated database of Alam et al. (2019). The indicator is a monthly average of LTV limits on real estate mortgage loans (both residential and

commercial). The quarterly indicator is constructed as an average that prevails in the last month of the quarter. This is in line with the ordering of variables in which the indicator of macroprudential policy is ordered last. In the robustness checks, two other measures of macroprudential policy are used: the LTV ratio in the first month of the quarter and the broader measure of macroprudential policy. The latter is an indicator that includes changes in 17 instruments of that policy and not only in the regulatory LTV ratio. The details of its construction are provided in Alam et al. (2019). If the tightening (easing) events dominate in a given period, the dummy-type indicator equals 1 (-1). Inaction or neutral action are coded as 0.

Table 1 Data description and sources

Variable	Description	Source
output gap	Derived with the Hamilton (2018) method; based on quarterly data on GDP (not seasonally adjusted)	own compilation based on data from the CEIC database
credit-to-GDP gap	The difference between the credit-to-GDP ratio and its long-term trend; in percentage points. Long-term trend obtained with a one-sided Hodrick-Prescott (HP) filter with a lambda of 400,000. Based on the total credit to the private non-financial sector	BIS Statistics
change in property prices	The year-on-year change in the real residential property prices; in percentage points	BIS Statistics
LTV ratio	The regulatory limits to loan-to-value ratio; in percentage points	Updated dataset of Alam et al. (2019)
output gap (HP)	derived with the HP filter; based on quarterly data on GDP (seasonally adjusted)	own compilation based on data from the CEIC database
real credit growth	The year-on-year growth rate of real (CPI deflated) total credit to the private non-financial sector; in percentage points	own compilation based on data from the BIS Statistics
broad policy indicator	The dummy-type indicator for 17 macroprudential policy instruments; coded as -1, 0, 1 when tightening, neutral, easing events dominate, respectively.	Updated dataset of Alam et al. (2019)

6. Empirical results

Baseline results

The number of lags in the VAR model suggested by information criteria is ten (the Akaike criterion) or one (the Schwartz criterion). The model with ten lags, however, does not seem to be a good choice as it would require us to reduce the sample substantially and at the same time, with more than 40 parameters to estimate, it could not be considered parsimonious. On the other hand, the model with a single lag is likely to be too restrictive to capture the dynamic relations between variables. We tried such a specification and found out that the residuals are serially correlated. Thus, we decided to use four lags, a conventional choice for VAR models with quarterly data. Moreover, the residuals do not exhibit autocorrelation: both, the Ljung-Box statistic with up to 16 lags and the LM statistic for up to 4 lags, are insignificant with p-values of 0.82 and 0.53, respectively.[2] The ARCH effects are also non-existent in such a specification (the p-value of the VARCH-LM statistic is 0.16).

A simple recursive identification scheme is employed to isolate the structural shocks. In other words, we use the so-called B-model and obtain the matrix B by a Cholesky decomposition. Thus, we impose zero restrictions on the instantaneous responses to structural shocks. We label these shocks as output shock, financial shock, real estate shock, and macroprudential policy shock. It is assumed that the output gap reacts instantaneously to the output shocks only. It is because the output is a slow-moving variable. The on-impact responses of the credit-to-GDP gap to real estate shocks and macroprudential policy shocks are both set to zero. It seems reasonable since, being regulated, financial institutions usually act cautiously and follow specific loan granting procedures. Moreover, it would be unwise to expect that there are no lags in the impact of macroprudential policy on the economy. The change in real property prices is restricted to react with a lag to policy shocks. It would be inadvisable to expect no lags in the impact of macroprudential policy either on credit or real estate prices. The instantaneous responses of macroprudential policy are not restricted to zero for any shock. This follows the construction of the policy indicator: it is the regulatory limits to LTV ratio in the last month of the quarter.

The impulse response functions to structural shocks are reported in Figure 1. The output shocks have a non-negligible impact not only on the output gap but also on the other model variables. A positive shock brings about a two-quarter lagged increase in the credit-to-GDP

---

[2] The LM statistic includes the small sample correction (see, e.g., Lütkepohl, 2007, p. 173).

gap, and it persists for six quarters. Real estate prices respond positively to the output shock with a longer lag of two years, and the significant positive effect lasts for almost one year. It can be related to the reaction of the LTV ratio, which decreases in response to a positive change in economic activity, albeit the change is lagged by a year and lasts for around two years. It seems that macroprudential authority is willing to make the credit less available when economic conditions are favourable and prevent in this way the excessive credit growth.

The financial shock makes the credit-to-GDP higher for five years. Responses of real estate prices to this shock are positive but insignificant. The decrease in LTV ratio is again in with the countercyclical policy, albeit the response is insignificant.

The responses to the real estate shock are more pronounced. Obviously, the rate of change in property prices reacts positively to this shock. Interestingly, the credit-to-GDP gap increases, whereas the LTV ratio goes down. The former can be related to the stronger demand for credit in the face of higher real estate prices. The latter is a symptom of cautious macroprudential policy.

The beneficial macroprudential policy shock is found to have a lagged positive impact on the output gap, although the effect is at the border of significance. This finding is in line with the results reported in Richter et al. (2019), who show that macroprudential tightening reduces economic activity but admit that the effect is imprecisely estimated (see also Araujo et al., 2020). The response of the credit-to-GDP gap is positive as expected, although it is lagged by two years (and becomes significant no sooner than after three years). In other studies, the LTV policy is also found to be effective in controlling credit growth. Wijayanti et al. (2020) report that the LTV measure was successfully used to contain the housing mortgage growth in Indonesia in the 2010s (see also Lee et al., 2015). Surprisingly, the change in real property prices is negative, so the more expansionary macroprudential policy does not seem to stimulate the demand for real estate or/and exerts a stronger impact on the supply side of the real estate market than on the demand side. Even though the response of prices is puzzling, it fits well the argument put forward by Luangaram and Thepmongkol (2022). They argue that in countries with underdeveloped financial markets, both the interest rate and real estate prices are relatively unresponsive to the LTV policy. In line with their argument is finding by Lee et al. (2015), who observe that the response of house prices to credit-related macroprudential policy tightening in China, India, and Indonesia, is positive, although some responses are not significant.

The relative importance of shocks in shaping the variability of modelled variables can be assessed with the forecast error variance (FEV) decomposition. The results of the FEV decomposition are reported in Table 2. At the short-run horizon, the variables are driven mainly by variable-specific shocks. They account for 77% to 95% of the variability. At the long-run horizon, their contribution to the FEV of the output gap is almost unchanged, whereas for the FEV of the other variables, it is substantially smaller. Interestingly, the macroprudential policy shocks are an important source of variability of the credit-to-GDP gap, changes in real property prices, and the LTV ratio. The policy shocks account for 9%, 16%, and 30 % of the FEV of these variables, respectively. The output gap is less susceptible to macroprudential policy shocks. Their share in the FEV amounts to less than 5%. In line with the impulse response functions, the macroprudential policy hardly responds to financial shocks, but it is susceptible to output and real estate shocks. Overall, the policy based on the regulatory LTV ratio is effective: unexpected policy changes are a non-negligible source of variability of the credit-to-GDP gap and changes in real residential prices, although they are rather ineffective in shaping variability of the output gap. At the same time, the policy itself is affected by all shocks except for the financial shock.

Table 2 Contribution of shocks to forecast error variance

Forecast horizon	Proportions of forecast error accounted for by:			
	output shocks	financial shocks	real estate shocks	policy shocks
Output gap				
1	1.00	0.00	0.00	0.00
4	0.95	0.03	0.01	0.00
20	0.91	0.04	0.02	0.03
Credit-to-GDP gap				
1	0.02	0.98	0.00	0.00
4	0.10	0.77	0.13	0.00
20	0.25	0.38	0.27	0.09
Change in real property prices				
1	0.05	0.04	0.91	0.00
4	0.06	0.02	0.79	0.13
20	0.24	0.03	0.57	0.16
Macroprudential policy indicator				
1	0.00	0.01	0.01	0.98
4	0.01	0.03	0.07	0.90
20	0.46	0.04	0.21	0.30

Robustness checks

In this subsection, we check whether the results reported so far are robust to changes in the way our analysis has been carried out. In what follows, we change the ordering of variables, use the alternative macroprudential policy indicator, proxy output gap with the HP filter, use the growth of real credit instead of the credit-to-GDP gap, and limit the sample to the non-Covid-19 period.

First, even though the ordering of variables in the structural VAR model has been carefully justified with economic reasoning, we realise that the variable ordering can be controversial, all the more that it can influence the results. Thus, we place the macroprudential policy indicator first. At the same time, to make such an ordering reasonable, the macroprudential policy indicator is defined as the LTV ratio in the first month of the quarter. It is in line with the Cholesky decomposition under which the first variable in a model does not respond on impact to shocks in other variables.

Second, our approach can be considered too restrictive with respect to the set of policy instruments included in the analysis. The macroprudential policy apparatus goes beyond the regulatory LTV ratio. Thus, we employ a broader measure of macroprudential policy that is based on 17 policy instruments included in the database by Alam et al. (2019). The comprehensive indicator can take three values: -1, 0, and 1, which denote the easy, neutral, or tight policy, respectively. These values have the opposite interpretation to changes in the LTV ratio. Therefore, for convenience of comparison of results, we re-coded the comprehensive indicator of macroprudential policy in such a way that its rise (decline) corresponds to policy easing (tightening).

Third, notwithstanding its deficiencies, the Hodrick-Prescott filter is still employed to estimate the output gap in many studies. We follow this convention and use the cyclical component as an estimate of the output gap. We have also tried the modified (boosted) HP filter developed recently by Phillips & Shi (2021). The results, however, are very much alike, so we do not report them.

Fourth, the BIS credit-to-GDP gap estimates are subject to critique (see, e.g., the discussion in Jokipii et al., 2021). In order to check whether the results are sensitive to the choice of the variable measuring financial developments, we give up the concept of the gap itself and use the growth rate of credit to the private non-financial sector (deflated with the CPI) instead.

Finally, we leave the non-Covid-19 period out of the sample. In this way, we can check whether the results remain robust in the shorter sample that excludes the severe non-economic disturbance to a real economy and financial system. Moreover, these results are easier to compare with the pre-Covid studies.

We re-run the whole analysis for each robustness check. To conserve space, we report two sets of results: the responses of all variables to macroprudential policy shocks and the reactions of a macroprudential policy indicator to all shocks. The full results are available upon request.

In Figure 2, the responses to macroprudential policy shock across alternative robustness checks are illustrated. In general, they are similar to those obtained in the baseline specification, although there are some differences that merit comments.

The output gap remains unresponsive to policy shock in all robustness checks except for the non-Covid-19 sample (RC5). In the shortened sample period, a favourable policy shock increases the output gap for around three to four years. This observation, however, can be reconciled with the baseline specification in which the rise in the output gap is also observed. The difference is that in the baseline, the (lagged) expansionary effect is not significant. It, in turn, can be explained by the hike in uncertainty brought about by the pandemic and the concurrent abrupt decline in the GDP.

Likewise, in the baseline model, macroprudential policy easing has a lagged stimulative effect on the credit-to-GDP ratio gap when the LTV ratio is ordered first (RC1), the output gap is isolated with the HP filter (RC3), and the sample period excludes 2020 (RC5). In two other robustness checks, the impact remains positive but is insignificant. It can be associated with the scope of the comprehensive policy indicator (RC2) that covers not only credit-related instruments but also those that are liquidity-related and capital-related (Lee et al., 2015). Integrating both a trend and a cycle, the growth rate of real credit (RC4) is probably a too coarse measure of cyclical developments.

The response of changes in real property prices is alike across all robustness checks: the initial drop is followed by the rise, albeit the latter is at the border of significance. There are two exceptions. The initial decline is insignificant if the comprehensive policy indicator is used (RC2), whereas when the growth of credit is employed (RC4), the subsequent increase can hardly be observed. The key finding, i.e. the negative response of property prices to policy easing, is insensitive to changes in the design of our analysis.

These findings are corroborated by the forecast error variance (FEV) decompositions reported in Table 3. The FEV accounted for by the macroprudential policy shocks is tabulated for each robustness check in a single column. Again, in general, the contribution of these shocks is quite close to that obtained in the baseline model. In some robustness checks, however, the shocks are found to be more important for the output gap (RC2, RC5) and the credit-to-GDP gap (RC1, RC5). Interestingly, our baseline specification can be considered conservative regarding the importance of policy shocks for real estate prices. In all robustness checks, the long-term contribution of policy shocks ranges from 22% to 32% and is above that in the baseline case (16%). The only exception is the model with the credit growth (RC4) in which the contribution is lower.

Table 3 Contribution of macroprudential policy shocks to forecast error variance

Forecast horizon	Proportions of forecast error accounted for by policy shocks under:				
	RC1	RC2	RC3	RC4	RC5
Output gap					
1	0.00	0.00	0.00	0.00	0.00
4	0.00	0.01	0.00	0.00	0.09
20	0.04	0.17	0.01	0.01	0.27
Credit indicator					
1	0.00	0.00	0.00	0.00	0.00
4	0.01	0.01	0.00	0.01	0.00
20	0.23	0.02	0.11	0.03	0.20
Change in real property prices					
1	0.03	0.00	0.00	0.00	0.00
4	0.26	0.11	0.15	0.13	0.15
20	0.32	0.25	0.22	0.08	0.22
Macroprudential policy indicator					
1	1.00	0.89	0.98	0.98	0.98
4	0.95	0.66	0.85	0.90	0.90
20	0.70	0.54	0.52	0.17	0.58

The responses of a macroprudential policy indicator to shocks are depicted in Figure 3. Each row illustrates the reactions obtained under the alternative setting (robustness check). By and large, changes in the macroprudential policy indicator are in line with those obtained for the baseline specification. A favourable output shock makes macroprudential authority tighten its policy, albeit the response is not significant if the LTV ratio is ordered first (RC1) or the

sample ends in 2019 (RC5). In the setting with the HP filter-based output gap (RC3), the policy response is positive and insignificant.

Similarly to the baseline model, the responses to a financial shock are negative and insignificant in all robustness checks. It is only when the comprehensive indicator of macroprudential policy is used (RC2) that the reaction becomes positive, although it remains insignificant. Interestingly, when the HP filter-based output gap is used (RC3), the response of the LTV ratio is significantly negative. It is in line with our assessment that macroprudential policy is countercyclical.

There are almost no differences between the baseline case and the other settings concerning the response to the real estate shock. It is uniformly negative, significant, lagged by two to four quarters and lasts for around three years. This is also the case in the robustness check with the comprehensive policy indicator (RC2), although the reaction is insignificant.

The FEV of macroprudential policy indicator across robustness checks is reported in Table 4. In general, the decompositions are similar to those for the baseline case. Some differences, however, can be observed, especially for the importance of shocks in the long run. The output shock accounts for a relatively small variance of policy indicator in the models with the LTV ratio ordered first (RC1), the output gap obtained with the HP filter (RC3), and estimated on the non-Covid sample (RC5). The contributions of financial and real estate shocks to the FEV of policy indicator remain close to those obtained in the baseline model. The former shocks are slightly more important in the setting with the HP filter-based GDP gap (RC3). The latter shocks have a smaller contribution when the comprehensive macroprudential policy indicator is used (RC2).

Overall, the results of robustness checks lend support to our findings in the baseline setting. In particular, the relatively strong two-way linkages between macroprudential policy and real property prices are not sensitive to the changes in the design of our analysis.

Table 4 Contribution of shocks to forecast error variance of macroprudential policy indicator

Forecast horizon	Proportions of forecast error accounted for by:			
	output shocks	financial shocks	real estate shocks	policy shocks
RC1. LTV ratio first				
1	0.00	0.00	0.00	1.00
4	0.01	0.03	0.01	0.95
20	0.05	0.08	0.17	0.70
RC2. Broader macroprudential policy indicator				
1	0.03	0.05	0.03	0.89
4	0.26	0.07	0.02	0.66
20	0.32	0.11	0.03	0.54
RC3. HP-based output gap				
1	0.00	0.02	0.00	0.98
4	0.01	0.10	0.04	0.85
20	0.07	0.20	0.21	0.52
RC4. Credit growth				
1	0.00	0.02	0.00	0.98
4	0.01	0.03	0.06	0.90
20	0.61	0.03	0.19	0.17
RC5. Non-Covid-19 sample				
1	0.00	0.01	0.00	0.98
4	0.01	0.03	0.05	0.90
20	0.04	0.06	0.32	0.58

7. Conclusions

This paper investigates the effectiveness and the conduct of LTV policy in Indonesia in recent years. We believe that the case of Indonesia is noteworthy because it is still relatively less investigated in the literature even though Indonesia is one of the most populated countries with rising economic importance in the Asian region.

Using the data covering the last two decades, we build a set of alternative SVAR models. They enable us to demonstrate that the LTV policy can contain the credit expansion in the medium term. Policy transmission to the real property prices, however, is counterintuitive and resembles the well-known price puzzle identified in many studies on monetary policy (see, e.g., Jung & Ryu, 2020, Aginta & Someya, 2022). At the same time, the puzzling price response is in line with a recent finding by Luangaram and Thepmongkol (2022), who claim that in a country with low financial development, more restrictive LTV limits cannot have a significant impact on interest rates and property prices. The adverse effect of macroprudential tightening

on economic activity is more difficult to establish empirically. Even though the negative output gap widens after the LTV tightening, the response is insignificant. The adverse impact, however, is nonnegligible in the pre-Covid-19 period.

Our approach makes it also possible to address the issue of countercyclicality of LTV policy. We find the macroprudential authority in Indonesia sets the LTV limits circumspectly. It tightens the policy in response to expansionary shocks in the real estate market and the economy. The former reaction is substantial and robust, whereas the latter is less distinct.

Arguably, the results we obtained do not justify drawing irrefutable policy implications. There is, however, one that merits some attention. It fits the point raised by Galati & Moessner (2018) that a combination of tools is likely to be more effective in tackling a market failure and the multiple instrument policy recommended by Lim et al. (2011). Given that, on the one hand, the LTV policy is effective in containing credit growth in the medium run and, on the other hand, the short-run policy impact on real property prices is counterintuitive, we think that the one-handed policy restricted to setting the LTV limits may be suboptimal. It should be complemented with stabilising property price changes, be it another macroprudential policy tool or monetary policy.

References

Aginta, H., & Someya, M. (2022). Regional economic structure and heterogeneous effects of monetary policy: evidence from Indonesian provinces. *J. Econ. Struct.*, *11*(1), 1–25. https://doi.org/10.1186/S40008-021-00260-6/TABLES/5

Alam, Z., Alter, A., Eiseman, J., Gelos, G., Kang, H., Narita, M., Nier, E., & Wang, N. (2019). Digging Deeper--Evidence on the Effects of Macroprudential Policies from a New Database. *IMF Work. Pap.*, *WP/19/66*. https://doi.org/10.5089/9781498302708.001

Araujo, J., Patnam, M., Popescu, A., Valencia, F., & Yao, W. (2020). Effects of Macroprudential Policy: Evidence from Over 6,000 Estimates. *IMF Work. Pap.*, *WP/20/67*. https://www.imf.org/en/Publications/WP/Issues/2020/05/22/Effects-of-Macroprudential-Policy-Evidence-from-Over-6-000-Estimates-49440

BI. (2019). *Economic Report on Indonesia 2018*. https://www.bi.go.id/en/publikasi/laporan/Pages/LPI_2018.aspx

BI. (2022). *Macroprudential Policy Instrument*. https://www.bi.go.id/en/fungsi-utama/stabilitas-sistem-keuangan/instrumen-makroprudensial/default.aspx

Bruneau, G., Christensen, I., & Meh, C. (2018). Housing market dynamics and macroprudential policies. *Can. J. Econ. / Rev. Can. d'Economique*, *51*(3), 864–900. https://www.jstor.org/stable/45173071

Cantú, C., Gambacorta, L., & Shim, I. (2020). How effective are macroprudential policies in Asia-Pacific? Evidence from a meta-analysis. *BIS Pap.*, *110*.

Cerutti, E., Claessens, S., & Laeven, L. (2017). The use and effectiveness of macroprudential policies: New evidence. *J. Financ. Stab.*, *28*, 203–224. https://doi.org/10.1016/J.JFS.2015.10.004

Cheng, R., & Rajan, R. S. (2022). House price decoupling in East Asia and the Pacific: Trilemma versus dilemma revisited. *Int. Rev. Econ. Financ.*, *79*, 518–539. https://doi.org/10.1016/J.IREF.2022.02.055

Hall, P. (1992). *The Bootstrap and Edgeworth Expansion*. New York : Springer. https://doi.org/10.1007/978-1-4612-4384-7

Hamilton, J. D. (2018). Why You Should Never Use the Hodrick-Prescott Filter. *Rev. Econ. Stat.*, *100*(5), 831–843. https://doi.org/10.1162/REST_A_00706

IMF. (2017). Indonesia: Financial System Stability Assessment-Press Release and Statement by the Executive Director for Indonesia. *IMF Staff Ctry. Reports*, *17*(152). https://doi.org/10.5089/9781484303559.002

Jokipii, T., Nyffeler, R., & Riederer, S. (2021). Exploring BIS credit-to-GDP gap critiques: the Swiss case. *Swiss J. Econ. Stat.*, *157*(7), 1–19. https://doi.org/10.1186/S41937-021-00073-1/FIGURES/13

Juhro, S. M., Prabheesh, K. P., & Lubis, A. (2021). The effectiveness of trilemma policy choice in the presence of macroprudential policies: Evidence from emerging economies. *Singapore Econ. Rev.* https://doi.org/10.1142/S0217590821410058

Jung, C., & Ryu, J. E. (2020). The price puzzle revisited. *Appl. Econ. Lett.*, *27*(6), 441–446. https://doi.org/10.1080/13504851.2019.1630705

Jung, H., & Lee, J. (2017). The effects of macroprudential policies on house prices: Evidence from an event study using Korean real transaction data. *J. Financ. Stab.*, *31*(August), 167–185. https://doi.org/10.1016/J.JFS.2017.07.001

Kilian, L., & Lütkepohl, H. (2017). *Structural vector autoregressive analysis*. Cambridge : Cambridge University Press.

Kim, J., Kim, S., & Mehrotra, A. (2019). Macroprudential policy in Asia. *J. Asian Econ.*, *65*, 101149. https://doi.org/10.1016/j.asieco.2019.101149

Kim, S., & Mehrotra, A. (2018). Effects of Monetary and Macroprudential Policies—Evidence from Four Inflation Targeting Economies. *J. Money, Credit Bank.*, *50*(5), 967–992. https://doi.org/10.1111/JMCB.12495

Kim, S., & Mehrotra, A. (2019). Examining macroprudential policy and its macroeconomic effects - some new evidence. *BIS Work. Pap.*, *825*. www.bis.org

Kim, S., & Oh, J. (2020). Macroeconomic effects of macroprudential policies: Evidence from LTV and DTI policies in Korea. *Japan World Econ.*, *53*, 100997. https://doi.org/10.1016/j.japwor.2020.100997

Kuttner, K. N., & Shim, I. (2016). Can non-interest rate policies stabilize housing markets? Evidence from a panel of 57 economies. *J. Financ. Stab.*, *26*, 31–44. https://doi.org/10.1016/J.JFS.2016.07.014

Lee, M., Asuncion, R. C., & Kim, J. (2015). *EffEctivEnEss of MAcroPruDEntiAl PoliciEs in DEvEloPing AsiA: An EMPiricAl AnAlysis*. www.adb.org

Lim, C., Columba, F., Costa, A., Kongsamut, P., Otani, A., Saiyid, M., Wezel, T., & Wu, X. (2011). Macroprudential Policy: What Instruments and How to Use Them? Lessons from Country Experiences. *IMF Work. Pap.*, *WP/11/238*.

Luangaram, P., & Thepmongkol, A. (2022). Loan-to-value policy in a bubble-creation economy. *J. Asian Econ.*, *79*, 101433. https://doi.org/10.1016/j.asieco.2021.101433

Lütkepohl, H. (2007). New introduction to multiple time series analysis. In *New introduction to Multiple Time Series Analysis*. Berlin, Heidelberg : Springer. https://doi.org/10.1007/978-3-540-27752-1

Morgan, P. J., Regis, P. J., & Salike, N. (2019). LTV policy as a macroprudential tool and its effects on residential mortgage loans. *J. Financ. Intermediation*, *37*, 89–103. https://doi.org/10.1016/j.jfi.2018.10.001

Ono, A., Uchida, H., Udell, G. F., & Uesugi, I. (2021). Lending pro-cyclicality and macroprudential policy: Evidence from Japanese LTV ratios. *J. Financ. Stab.*, *53*, 100819. https://doi.org/10.1016/j.jfs.2020.100819

Phillips, P. C. B., & Shi, Z. (2021). Boosting: Why you can use the HP filter. *Int. Econ. Rev. (Philadelphia).*, *62*(2), 521–570. https://doi.org/10.1111/IERE.12495

Richter, B., Schularick, M., & Shim, I. (2019). The costs of macroprudential policy. *J. Int. Econ.*, *118*, 263–282. https://doi.org/10.1016/j.jinteco.2018.11.011

Riyanto, E. (2016). *BIS central bankers' speeches Erwin Riyanto: Unveiling macroprudential policy*. https://www.bis.org/review/r160811c.pdf

Shim, I., Bogdanova, B., Shek, J., & Subelyte, A. (2013). Database for policy actions on

housing markets. *BIS Q. Rev.*, *September*, 83–95.

Sui, J., Liu, B., Li, Z., & Zhang, C. (2022). Monetary and macroprudential policies, output, prices, and financial stability. *Int. Rev. Econ. Financ.*, *78*, 212–233. https://doi.org/10.1016/J.IREF.2021.11.010

Warjiyo, P. (2016). Central bank policy mix: key concepts and Indonesia experience. *Bul. Ekon. Monet. Dan Perbank.*, *18*(4), 379–408. https://doi.org/10.21098/BEMP.V18I4.573

Warjiyo, P. (2017). Indonesia: the macroprudential framework and the central bank's policy mix. *BIS Pap.*, *94*. https://www.bis.org/publ/bppdf/bispap94n.pdf

Wijayanti, R., Adhi P, N. M., & Harun, C. A. (2020). Effectiveness of macroprudential policies and their interaction with monetary policy in Indonesia. *BIS Pap.*, *110*. https://www.bis.org/publ/bppdf/bispap110d.pdf

Zhang, A., Pan, M., Liu, B., & Weng, Y.-C. (2020). Systemic risk: The coordination of macroprudential and monetary policies in China. *Econ. Model.*, *93*, 415–429. https://doi.org/10.1016/j.econmod.2020.08.017

Zhang, L., & Zoli, E. (2016). Leaning against the wind: Macroprudential policy in Asia. *J. Asian Econ.*, *42*, 33–52. https://doi.org/10.1016/j.asieco.2015.11.001
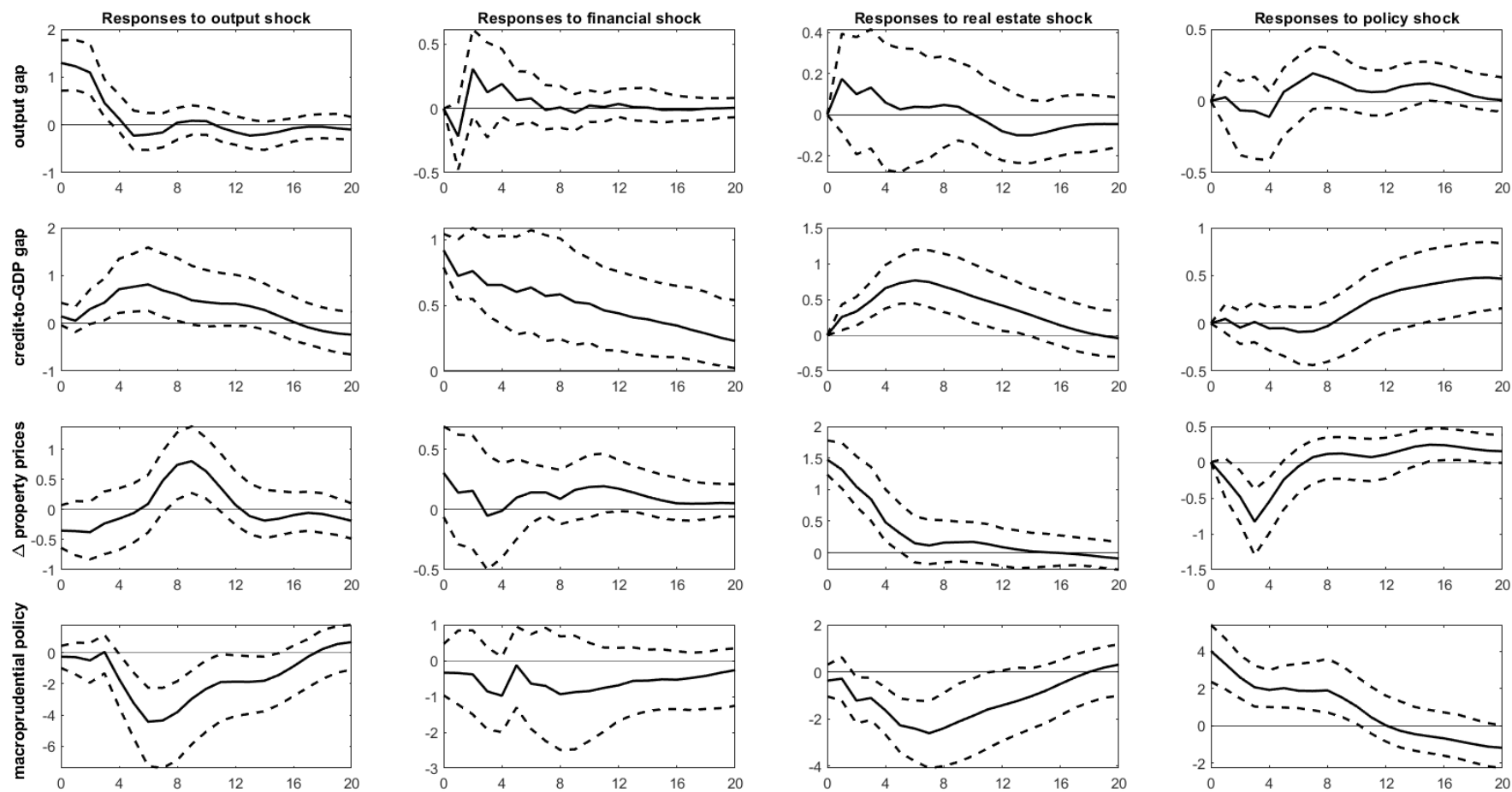
Figure 1 Impulse response functions to structural shocks

Notes: Broken lines are bootstrapped confidence intervals. The number of bootstrap replications is 1000.
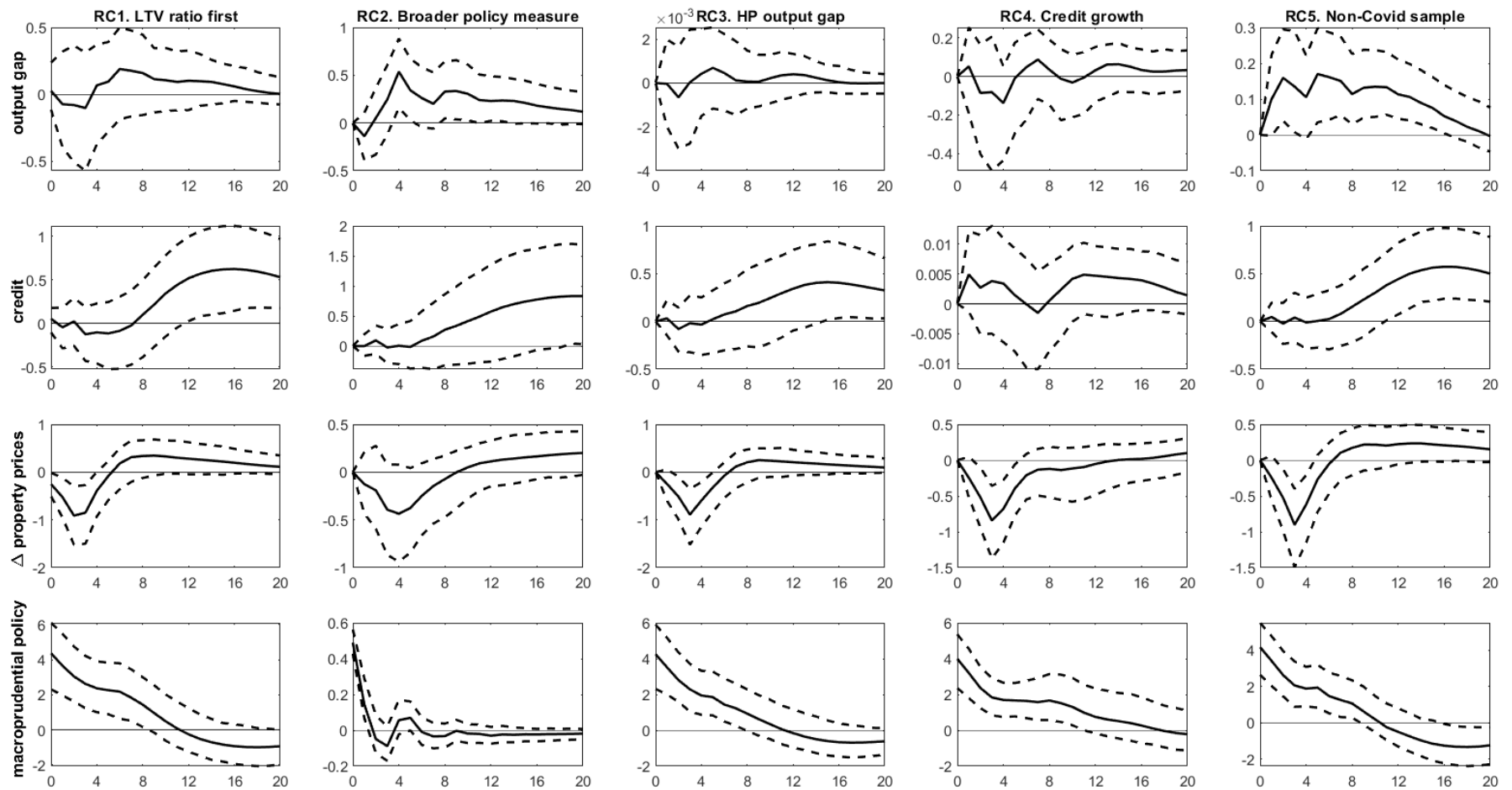
Figure 2 Responses to macroprudential policy shocks in alternative robustness checks

Notes: Broken lines are bootstrapped confidence intervals. The number of bootstrap replications is 1000.
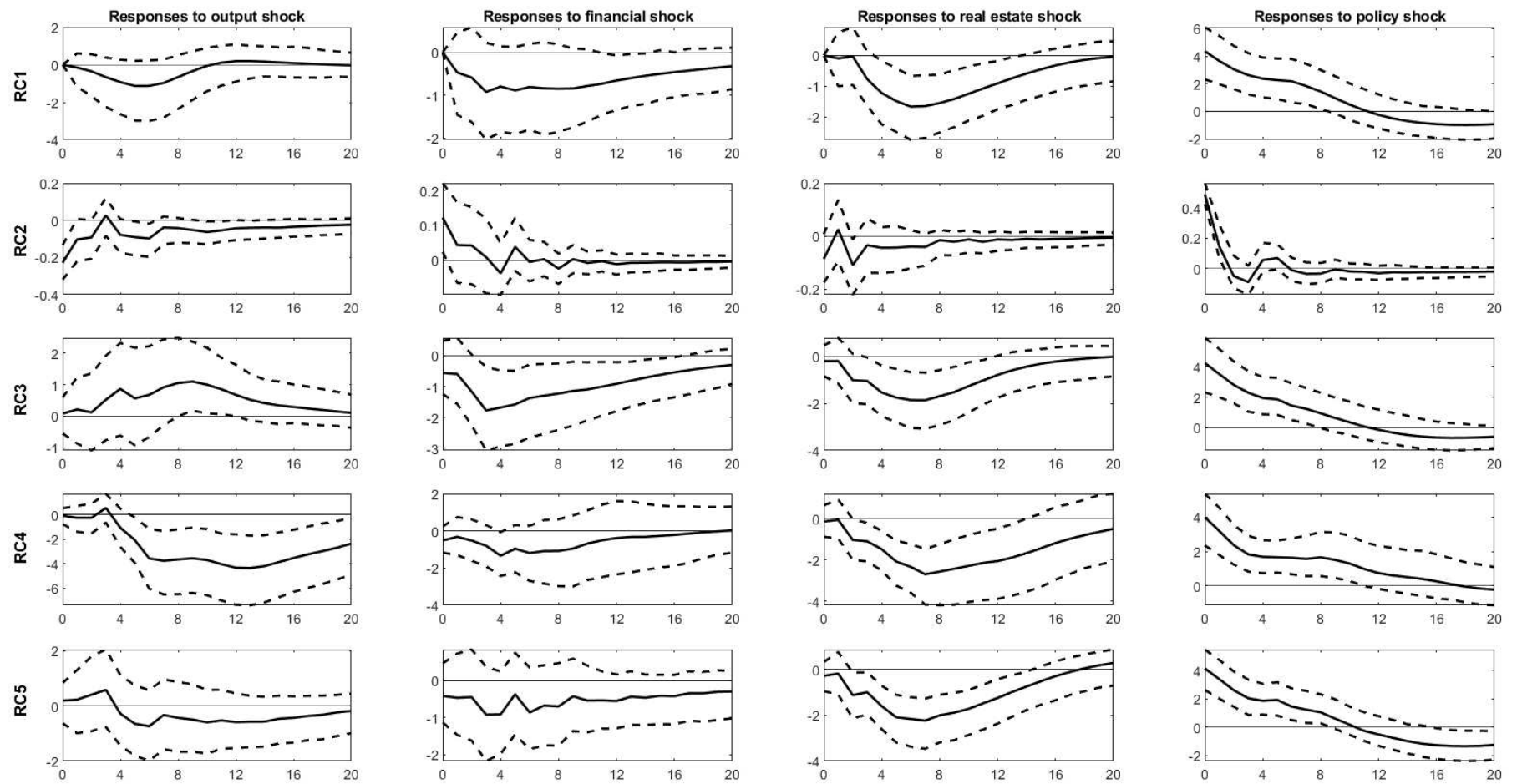
Figure 3 Responses of macroprudential policy in alternative robustness checks

Notes: Broken lines are bootstrapped confidence intervals. The number of bootstrap replications is 1000.