LUND UNIVERSITY
School of Economics and Management

The Interaction Between Monetary Policy and Macroprudential Policy

by

Glenn Nielsen

Master's Programme in Economics

NEKP01, Master Essay II

Lund, June 2019

Supervisor:
Fredrik N.G. Andersson

Abstract

The latest global financial crisis ignited the debate on whether the role of monetary policy's main objective, price stability, is enough to achieve financial stability. It also sparked an interest of new policy measures that directly targets the financial system, such as macroprudential policies. In this study, we empirically investigate how monetary and macroprudential policies interact to affect macroeconomic and financial stability. Using structural panel vector autoregressions for 11 OECD countries over the 1999Q1 to 2016Q4 period, we show that there is a considerable interaction between the two economic policies. Specifically, the results suggest that while monetary policy have effects on the real economy, it also affects financial conditions such as credit and house price growth. Similarly, macroprudential policy affects credit growth but have effects on the price level. Given the similar effect, authorities should act in a coordinated manner when deciding on monetary and macroprudential policies.

Keywords: monetary policy, macroprudential policy, macroeconomic stability, financial stability, panel VAR

Acknowledgements

I would like to give my sincerest gratitude to my supervisor, Fredrik N.G. Andersson, for the precious help throughout the writing process. Special thanks to my family for their never-ending support. Finally, I would like to express my gratitude to classmates and friends for having made this Master a joyful journey.

Table of Contents

1 Introduction

The financial crisis of 2007-2008 triggered a contraction in global economic activity, and has proven that financial sector problems may hurt the real economy. The crisis led to a rethinking of monetary policy frameworks that primarily focuses on price stability, as price stability has shown to not be a sufficient condition to achieve financial stability (Smets, 2014). It has also led to the development of other policies with the sole aim to contain financial imbalances, one of which is macroprudential measures (Richter, Schularick & Shim, 2018). Such macroprudential policies and instruments aim to strengthen the macro-financial stability and to contain (the build-up) of systemic risks. They are therefore meant to complement traditional macroeconomic stabilisation tools, such as fiscal and monetary policies, in reducing adverse effects on the real economy and to prevent economic and financial crises (Claessens, Ghosh and Mihet, 2014).

The inter-deployment of both monetary and macroprudential policies may however raise important coordination issues, since such policies differ in terms of primary objectives as well as transmission mechanisms (Beau et al., 2017). On the one hand, monetary policy has a widespread effect on the economy with the main objective of stabilizing prices or contributing to the stability of the real economy. On the other hand, macroprudential policies have two main objectives, often targeting specific sectors or practices (Kim & Mehrotra, 2017). First, through measures that ensure that banks have enough capital reserves and liquidity to absorb credit losses, macroprudential policies are used to strengthen the resilience of the financial system. Second, they are used to counteract financial imbalances by preventing debt and credit from rising too quickly (Guibourg et al., 2015). Nevertheless, while different policy instruments are assigned to specific objectives, they oftentimes indirectly affect a wider set of objectives. For example, macroprudential measures aimed at financial stability may have effects on other parts of the economy, such as inflation and resource utilisation. Similarly, monetary policies aimed at price stability may affect the financial sector (Shin, 2015). As such, it is important that both monetary and macroprudential policies act in a coordinated way and take interactions into account (Smets, 2014).

The need for coordination between monetary and macroprudential policies raises the issue of the appropriate institutional setup (Smets, 2014). Increasingly, attention has been focused on whether monetary policy should take explicit account for financial imbalances once macroprudential policies are in place (Guibourg et al., 2015; Zdzienicka et al., 2015). For example, coordination could be improved if the central bank safeguards both price and financial stability using monetary and macroprudential policies in conjunction (Gerba & Macchiarelli, 2015). However, the primary obstacle of this is that it may undermine the credibility and reputation of the central bank[1]. Although there is a growing body of literature that explores the coordination between macroprudential and monetary policies, no consensus has yet been reached on whether monetary policy should take explicit account of financial stability (Bank of England, 2015; Smets 2014). Furthermore, while there is an increasing recognition for the need of macroprudential policies, the effects of them are still not completely understood (Rubio & Carrasco-Gallego, 2016a), and hence, neither is their interaction with monetary policy.

The purpose of this paper is to explore the interaction between monetary policy and macroprudential policy. Specifically, this study seeks to answer the following research question: *How do monetary and macroprudential policies interact to affect macroeconomic and financial stability?* The paper takes its point of departure in that monetary policy and macroprudential policy pursue different core objectives, but that the conduct of each policy can indirectly have effects on the objectives of the other. In such circumstances, conducting monetary and macroprudential policies in conjunction yields superior outcomes compared to only conducting one of the mentioned policies at a time (Nier & Kang, 2016).

To investigate how monetary and macroprudential policies interact to affect the macroeconomy and financial system, this study uses a panel consisting of 11 OECD countries from 1999Q1 to 2016Q4. The estimation method is based on a structural panel vector autoregressive (VAR) model with impulse response functions. Specifically, we model causal effects from responses of several macroeconomic and financial variables following shocks from monetary and macroprudential policies. Following the narrative approach proposed by Romer and Romer (2004), we construct our own measure of monetary policy shocks. Macroprudential policy actions are taken from the database constructed by Alam et al. (2019) which includes tightening and easing actions for 17 macroprudential measures. In addition to these policy variables, the variables in our baseline VAR specification include GDP growth, inflation, household credit growth, bank credit growth and house price growth.

The results show that contractionary monetary policy significantly reduces output, household credit, bank credit and house price growth. Inflation eventually falls following contractionary

[1] Too high expectations could, for example, be placed on the effectiveness of the central bank to deal with both price and financial stability simultaneously (see e.g. Borio, 2014).

monetary policy. However, our analysis suggests a price puzzle. A macroprudential policy tightening significantly reduces household and bank credit and leads to a fall in inflation but has limited effects on output or house price growth. Thus, our results indicate that monetary and macroprudential policies work through related channels, affecting both macroeconomic and financial stability. We also show that our results are robust to other specifications and changes in the assumptions about the underlying identification.

The rest of this paper is organised as follows. Section 2 lays out the nexus between monetary and macroprudential policies by discussing the difference in policy objectives and instruments as well as how the two policies interact with each other. Section 3 presents the econometric method used for the empirical analysis. Section 4 presents the data. Section 5 shows the empirical analysis and discusses the main results. Furthermore, various extensions, alternative specifications and robustness to the baseline study are added. Finally, Section 6 concludes the analysis with some final remarks.

2 The Nexus Between Monetary and Macroprudential Policies

The global financial crisis of 2007-2008 ignited a debate among monetary policymakers on the extent of incorporating financial stability goals related to limiting systemic risks. Before the crisis, it was believed that monetary policy was enough to prevent financial instabilities and that the financial system was self-correcting (Yellen, 2010). While concentrating on achieving price stability, central banks may in fact have overlooked achieving financial stability (Galati & Moessner, 2012). Policymakers have now realised the need for policies and regulations that deal with financial supervision. Recently, many countries have established new institutions[2] focusing solely on macroprudential policies meant to prevent systemic risks to the financial system (Angelini, Neri & Panetta, 2012).

2.1 Monetary and macroprudential policy framework

Up until the crisis, there was a broad convergence in the literature on the objective of monetary policy (Galati & Moessner, 2012). The most common objective for monetary policy, at least

[2] Some examples of institutions focusing solely on the supervision of macroprudential policy regulation are the European Systemic Risk Board (ESRB) in the European Union and the Financial Stability Oversight Council (FSOC) in the United States (Angelini, Neri & Panetta, 2012). The Bank of England is one of the few institutions internationally who are responsible for both monetary, macroprudential and microprudential, policies and to operate all of these (Bank of England, 2015).

under flexible inflation targeting, is that of price stability and real stability because this creates good conditions for sustainable growth. Furthermore, it means stabilising inflation around a target and resource utilisation around its long-term sustainable rate (Svensson, 2018).

The literature on macroprudential policy has not reached a similar consensus on its objectives (Galati & Moessner, 2012). Inspired by the early contributions of Crocket (2000) [3], macroprudential policies are broadly aimed at keeping the financial system sound and prevent the build-up of financial imbalances (Smets, 2014). Or put simply, macroprudential policies are aimed at financial stability. Specifically, however, there is no agreement on what constitutes financial stability because the analysis of financial stability is still, compared to e.g. price stability, in its infant stage of development and practice (Schinasi, 2004). However, according to Galati and Moessner (2012), there are two different broad views on financial stability. The first view defines financial stability as resilience to exogenous shocks to the financial system. The second view instead illustrates the importance of a financial system that is resilient to shocks originating within the system. In addition, it highlights how vulnerable the financial system is to normal shocks rather than large shocks.

Notwithstanding their inadequately defined purpose, the intuition behind the need for macroprudential policies arises from key externalities and market failures associated with activities of financial intermediaries and markets. Such instances can lead to excessive procyclicality and the accumulation of financial imbalances, resulting in crises and other negative economic outcomes (Cerutti, Claessens, and Laeven, 2017). This can loosely be referred to as limiting "systemic risk", i.e. limiting the likelihood of financial distress, and corresponding cost, to the financial system as a whole (Crocket, 2000).

As discussed, monetary and macroprudential policies differ in terms of primary objectives. At the same time, different instruments are used to achieve the respective objectives. The division between monetary and macroprudential policies' objectives and instruments is consistent with Tinbergen's effective assignment principle, which states that one should have as many instruments as objectives and the instruments should be assigned to those objectives that they can most efficiently achieve (Tinbergen, 1952). Or alternatively, "policies should be assigned

[3] Crocket (2000) differentiates between microprudential and macroprudential policies. Microprudential policies are policies applicable to limiting the likelihood of failure for individual institutions. The focus on these types of policies are aimed at limiting idiosyncratic risk (Crocket, 2000).

to the frictions that they have a comparative advantage in addressing" (Bean et al., 2010, p. 314).

There is a clear consensus in the literature on the use of a short-term nominal interest rate as the primary instrument for monetary policy to achieve price stability (Söderström & Westermark, 2009). Over the last decade, communication, playing a supportive role, has also been increasingly used by central banks as a monetary policy tool to influence financial markets, enhancing the predictability of future decisions, and to achieve their objectives (Blinder et al., 2008). More recently, in response to the latest global financial crisis, unconventional monetary policy such as quantitative easing and negative interest rates was used to relieve financial distress and to achieve macroeconomic stability (Dell'Ariccia, Rabanal & Sandri, 2018). As extensively discussed by Ramey (2016), there exist many studies that consider the effects of monetary policies in achieving the goal of price and macroeconomic stability[4]. Typically, results show that monetary policy has an effect on output, prices, employment and other macroeconomic variables.

In normal times, to prevent crises, macroprudential policy measures are supervision, regulation and communication (Svensson, 2018)[5]. To address various externalities and market failures that cause financial disturbances, several macroprudential tools have been proposed aimed mainly at the banking system (Cerutti, Claessens, and Laeven, 2017). For example, Cerutti, Claessens, and Laeven (2017) group these measures into five typical sub-categories[6]: (i) quantitative restrictions on borrowers, instruments or activities; (ii) capital and provisioning requirements; (iii) other quantitative restrictions on financial institutions' balance sheets; (iv) taxation/levies on activities or balance sheet composition; and (v) other, more institutional-oriented measures, such as accounting changes, changes to compensation, etc. The first four of these macroprudential instruments capture variation across time, institution, or country, while structural measures are contained in the fifth instrument. Moreover, the first group of

[4] This literature typically employs vector autoregressive (VAR) models with impulse response functions where macroeconomic variables respond to monetary policy shocks. Monetary policy could in such instances either be instrumented by a short-term interest rate or a monetary aggregate (e.g. Christiano, Eichenbaum & Evans, 1996; 1999), or estimated as exogenous shocks from quantitative and narrative data (e.g. Romer and Romer, 2004; Coibion 2012; Cloyne and Hürtegren, 2016; and Champagne and Sekkel, 2017).

[5] During crisis times, to manage the crisis, monetary, macroprudential, fiscal and resolution authorities all jointly cooperate to minimise the effect of the crisis and restore financial stability. By coordinating policies between different authorities, expectations from the private sector may positively be affected which also helps in the stabilisation process (Svensson, 2018).

[6] Another common two-way classification of macroprudential policy instruments are borrower- or lender-oriented tools (Cerutti, Claessens, and Laeven, 2017). Macroprudential policy instruments can also be distinguished between single versus multiple, broad-based versus targeted, fixed versus discretion, or in coordination with other policies (Lim et al., 2011).

instruments captures the demand for financing, while the rest captures the supply side of financing.

Several studies review the effectiveness of macroprudential policies in achieving their target of financial stability by either focusing on the link between macroprudential policies and credit or the risk of a financial crisis[7]. It is typically found that macroprudential policies are effective at dampening procyclical credit and leverage (see e.g. Lim et al., 2011), curbing credit and asset growth (see e.g. Cerutti, Claessens & Laeven, 2017; Claessens, Ghosh & Mihet, 2014; Akinci & Olmstead-Rumsey, 2018), or dampening house price growth or real-estate booms (see e.g. Zhang & Zoli, 2014 Cerutti, Dagher & Dell'Ariccia, 2015). Complementary to these are case studies that use micro-level data focusing solely on either a specific country or specific macroprudential policies (see e.g. Jiménez et al., 2017).

2.2 The interaction between monetary and macroprudential policies

As discussed, economic policies could in principle be differentiated according to their respective objectives and instruments. In practice however, there are considerable interactions between different economic policies that need to be considered (Svensson, 2018). For example, monetary policy may influence credit growth through its effect on interest rates, something that perhaps should be accounted for when conducting macroprudential policy. Similarly, we may believe that macroprudential actions indirectly affect the real economy and price stability, and these effects must be considered in the conduct of monetary policy. Thus, the interaction depends on the importance of taking financial stability considerations into account when conducting monetary policy. Moreover, coordination is warranted since conflicts of interest may otherwise lead to a "push-me, pull-you" nature if monetary and macroprudential policies are used aggressively in opposite directions (see e.g. De Paoli & Paustian, 2013). Hence, there are important side effects to be considered between monetary and macroprudential policies as the interaction between the two policies can either strengthen or weaken the effectiveness of each policy in achieving its goal (IMF, 2013).

Most of the debate on monetary policy side effects on financial stability has been centred around central bank's policy interest rate that are too low for too long resulting in the build-up of financial imbalances. But monetary policy can potentially affect financial stability in other ways, either desirable or undesirable, depending on size and magnitude, and being contingent on the

[7] Most of this evidence stem from relatively new studies, following recent creations of several country and cross-country databases covering macroprudential actions (see e.g. Lim et al. 2011, Lim et al. 2013; Shim et al. 2013; Cerutti, Dagher, & Dell'Ariccia, 2015; Cerutti et al., 2016; Cerutti, Claessens & Laeven, 2017; Budnik & Kleibl, 2018; Kuttner & Shim, 2016).

stage of the financial cycle (Nier & Kang, 2016). Conversely, macroprudential policies can influence the conduct of monetary policy. For example, as illustrated by Antipa and Matheron (2014), since macroprudential policies affect credit levels and contain house price accelerations, they may also change the composition and level of output and inflation.

Smets (2014) describes three different views that highlight the interaction between monetary and macroprudential policies as well as their conceptual framework. These views differ in the way they perceive the importance of this interaction and to what extent monetary policy can achieve financial stability. The first view is called the "modified Jackson Hole consensus"[8]. According to this, each policy has its own instruments to achieve its respective primary goals. In fact, monetary policy should have a narrow focus of price stability, while macroprudential authorities should only take financial stability concerns into account (Praet, 2018). Hence, the interaction between the two policies is limited.

The second view on the interaction between monetary and macroprudential policies is called "leaning against the wind vindicated"[9]. It acknowledges the fact that the monetary policy stance may affect financial agents risk taking behaviour and that a weak financial system negatively affects price stability. Furthermore, it acknowledges that macroprudential policies cannot alone affect the financial cycle and that such policies also interact with the business cycle in several ways. According to this view, the scope of monetary policy is therefore enlarged to also encompass financial stability as a secondary objective next to price stability (Smets, 2014).

The third view is called "financial stability is price stability". It proposes a new definition on the objective of monetary policy. Accordingly, financial and price stability are so interconnected that one cannot separate the two (Praet, 2018). In this view, monetary policy should first consider actions aimed at financial stability, addressing malfunctioning financial markets and easing the monetary transmission process. Here, the interaction between monetary and macroprudential authorities is crucial to limit threats of financial dominance (Smets, 2014).

Taken these views into considerations, there is a growing amount of theoretical literature that explores the interaction between monetary and macroprudential policies using model-based

[8] The Jackson Hole consensus was a popular pre-crisis view stating that monetary policy should only consider asset price developments only if they affect spending via wealth effects and thus on the outlook of price stability. Specifically, central banks should not target asset prices, they should not deal with bubbles, and they should follow up after the burst of a bubble by injecting enough liquidity to avoid a macroeconomic meltdown (Issing, 2011).
[9] Leaning against the wind is a tighter monetary policy (i.e. a higher policy interest rate) than what is consistent with conventional flexible inflation targeting without accounting for financial stability considerations (Svensson, 2017b).

simulations. The results have however shown that the interaction between monetary and macroprudential policies may have compounding, neutral or conflicting results on macroeconomic and financial stability[10] (Beau et al., 2017). Central to this literature is what the respective objectives of monetary and macroprudential authorities should be and whether monetary and macroprudential policies should act in a coordinated or in a non-coordinated way (Rubio & Carrasco-Gallego, 2016a). For example, studies have shown that prudential regulations can maintain financial stability while simultaneously supporting monetary policy in maintaining macroeconomic stability (N'Diaye, 2009). On the other side, Borio and Shim (2007) have emphasised the complementary role of macroprudential policy as a built-in stabiliser to monetary policy.

The optimal coordination of monetary and macroprudential policies is investigated by Quint and Rabanal (2013) in a two-country Dynamic Stochastic General Equilibrium (DSGE) model in a currency union. Their simulation suggests that macroprudential policies can act as a substitute for countries that do not conduct their own independent monetary policy. In a DSGE model with financial frictions, heterogenous agents and housing, Beau et al. (2017) find that the optimal coordination outcome is achieved when monetary policy focuses solely on price stability together with a macroprudential authority that leans against credit growth. Furthermore, when monetary and macroprudential policies have their separate objectives, performance is improved when monetary policy considers any side effects on the macroeconomy from macroprudential policies. Angelini, Neri and Panetta (2012) also consider the coordination between monetary and macroprudential policies in a DSGE model with a bank sector. They find that a lack of cooperation may result in conflicts during normal times. Hence, monetary and macroprudential authorities should complement each other.

Few studies expand on this theoretical literature by empirically investigating the interaction between monetary and macroprudential policies. Kim and Mehrotra (2017) examine the effects of monetary and macroprudential policies in the Asia-Pacific region using a structural panel VAR framework. Their analysis suggests that contractionary monetary policy and tightening macroprudential policy both reduce credit, inflation and output. The authors therefore argue that coordination between the two policies is warranted considering their similar effect on the real economy and financial stability. Zdzienicka et al. (2015) use data on exogenous monetary policy shocks and macroprudential measures for the US to examine the policies interaction.

[10] This theoretical literature is based on model simulations. One reason for the non-agreeing results could be that they are highly dependent on parameter values, which may be imprecisely estimated (Beau et al., 2017).

They find that monetary policy shocks have a significant and persistent negative impact on bank credit and property price growth which attenuates long-term financial stability. Macroprudential measures on the other hand, immediately affect these financial conditions but last for a shorter duration. Chadwick (2018) investigates the effectiveness of monetary and macroprudential shocks on credit growth, industrial production growth, loan rates, inflation and credit growth volatilities in a VAR framework for Turkey. The author finds that macroprudential measures are effective at taming credit, inflation and volatility growth, especially when they are conducted in coordination with monetary policy. Using a meta-analysis technique on five Latin American countries, Gambacorta and Murcia (2017) find that macroprudential policies are more effective at curbing credit growth when used in conjunction with monetary policy.

3 Method

In this paper, we identify the interaction between monetary and macroprudential policies and analyse how they affect the macroeconomy and the financial system. To do this, a structural panel vector autoregressive (VAR) model similar to Kim and Mehrotra (2017) is constructed. Our model captures monetary and macroprudential policies as well as the real economy and financial system. From the estimated VAR model, we derive impulse response functions. This allows us to measure the causal effects on the macroeconomy and financial system following exogenous policy shocks.

For the purpose of this paper, VAR models are attractive since variables affecting the macroeconomy and financial sector typically are serially correlated. Hence, by including lags in the specification, short-term responses of monetary policy shocks and macroprudential policy actions to the real economy and financial system are controlled for. VAR models also allow for the feedback effect of our macroeconomic and financial variables to be accounted for from such shocks (Zdzienicka et al., 2015).

3.1 The structural panel VAR model

To investigate how our macroeconomic and financial variables are affected by monetary and macroprudential policies we consider a parsimonious VAR model with the following variables: real GDP growth (y_{it}), inflation (π_{it}), household credit growth ($HHCRD_{it}$), bank credit growth

($BCRD_{it}$), house price growth (HP_{it}), macroprudential policy actions (MAP_{it}), and monetary policy shocks (MOP_{it}). Specifically, we estimate the following structural panel VAR:

$$X_{it} = c_i + B(L)X_{it-1} + d_i + u_{it} \tag{1}$$

where $B(L)$ is a lag polynomial with P lags. The vector of endogenous observables is defined as: $[y_{it}, \pi_{it}, HHCRD_{it}, BCRD_{it}, HP_{it}, MAP_{it}, MOP_{it}]'$, c_i is an exogenous $M\times1$ constant vector, d_i are exogenous panel-specific fixed effects[11][12], and u_{it} is an $M\times1$ vector of reduced form residuals with $\text{var}(u_{it}) = \Sigma$. In our baseline specification, we estimate the VAR model with $P = 4$ lags since a lag length of 1 year[13] is common in the VAR literature on monetary policy (Coibion, 2012)[14].

Our model therefore captures three parts of the economy. These are the policy domain, the real economy and the financial system. As discussed, the inclusion of monetary policy and macroprudential policy stems from the objective of examining the interaction between the two policies and investigate their effects on the macroeconomic and financial stability. The policy domain therefore consists of these two variables.

In modelling the real economy, the inflation rate is used as the policy variable for price stability, while real GDP growth is used as an overall indicator of the macroeconomy. Monetary policy can affect the real economy in several ways[15]. For example, contractionary monetary policy causes aggregate demand to fall which puts downward pressures on prices, thus affecting output and inflation (Svensson, 2012). Macroprudential policies on the other hand, may change the composition and level of output and inflation by affecting credit levels and containing house price accelerations (Antipa & Matheron, 2014).

---

[11] We experimented with different types of fixed effects, such as adding specific time dummies, or by including quarterly dummies or a linear trend. All variations yielded very similar result to our baseline specification. Furthermore, adding time fixed effects meant that we had to restrict our lag length which we did not deem optimal since the model can then only capture very short-term effects.

[12] The estimation of dynamic panel models by including fixed effects may be biased (the so called "Nickell bias" (Nickell, 1981)) as the lagged dependent variable is correlated with the unobserved effects. As a result, we experimented with dropping the panel-specific fixed effects. This did not change our results. Furthermore, since our time dimension is relatively large ($T = 72$), and larger than our cross-sectional dimension ($N = 11$), this bias is minimised.

[13] Quarterly data is used for the analysis.

[14] The lag length could potentially be determined by a selection criterion instead, like the Akaike information criterion (AIC) or the Schwarz Bayesian information criterion (BIC). However, as discussed by Cobion (2012) in the case of autoregressive models, the BIC is consistent but tend to select too few lags if the sample size is short, while the AIC asymptotically selects too many lags (see also Ng & Perron, 2005).

[15] Increasing interest rates typically cause the exchange rate to appreciate since capital flows in from abroad. This causes net exports to fall since domestic goods lose competitiveness relative to foreign goods. At the same time, higher interest rates affect the demand for consumption and investment negatively (Svensson, 2012).

Similarly, household credit, bank credit and house price growth are used as the target variables to achieve financial stability in the financial system. Macroprudential policies are aimed to limit systemic financial risk either to specific institutions and sectors or to contain procyclical financial imbalances. If macroprudential policies are effective at achieving their target, we expect that a macroprudential policy tightening reduces the growth rates of these three variables. Monetary policy can also affect financial stability through several channels. For example, it operates through the balance sheet and bank lending channels by affecting the supply and demand for credit (Mishkin, 1996). Furthermore, monetary policy operates through the default channel. Specifically, contractionary monetary policy can negatively affect borrowers credit quality, increasing the probability of borrowers defaulting on their loans, which in turn can lead to financial crises (Nier & Kang, 2016)[16].

From the estimated VAR system, we recover impulse response functions from shocks of the endogenous variables. Impulse response functions are useful tools when studying interactions between variables in a VAR system (Lütkepohl, 2008). Following Sims (1980), we apply Cholesky decomposition on the variance-covariance matrix of the reduced form residuals, Σ, to orthogonalize impulse response functions for the estimated parameters from the structural form equation[17]. This identification imposes recursive zero restrictions on contemporaneous structural parameters (Kim & Mehrotra, 2017).

We follow the traditional macroeconomic VAR literature (see Christiano, Eichenbaum & Evans, 1999; 2005) by allowing our macroeconomic and financial variables to not instantaneously respond to economic policy shocks, whereas there might be a simultaneous feedback effect from these variables to the policy variables. Specifically, we assume that our macroeconomic and financial variables [y_{it}, π_{it}, $HHCRD_{it}$, $BCRD_{it}$, HP_{it}] are contemporaneously exogenous to the macroprudential policy actions and monetary policy shocks [MAP_{it}, MOP_{it}]. This assumption is important because we cannot exclude the possibility that the economic authorities take the current macroeconomic and financial environment into consideration when setting economic policies (Kim & Mehrotra, 2017).

This allows the stance on the two policies to be determined after observing the current state of the macroeconomy and financial situation. For example, macroprudential policy is likely determined after considering current financial conditions such as credit but may also take output

[16] Other channels through which monetary policy can affect financial stability is the exchange rate channel (see e.g. Svensson, 2017a), the asset price channel (see e.g. Mishkin, 2001), and the risk-taking channel (see e.g. Neuenkirch & Nöckel, 2018).
[17] As shown in section 5.4, our results are however robust to alternative identifying assumptions.

stabilisation into account. Furthermore, especially when the central bank is the authority in charge of macroprudential policy, we cannot exclude the possibility of macroprudential policies that consider inflationary developments in the economy (Kim & Mehrotra, 2017). Intuitively, it is also reasonable to assume that the macroeconomic and financial variables respond sluggishly to the policy shocks. Since we are only interested in macroprudential and monetary policy shocks, which are ordered below the other endogenous variables, the order of our macroeconomic and financial variables does not matter.

4 Data

The panel dataset is comprised of 11 OECD countries covering the quarterly period from 1999Q1 to 2016Q4. The countries considered are Australia, Canada, Czech Republic, Denmark, the Euro Area, Hungary, South Korea, Norway, Sweden, United Kingdom and United States. Since a common monetary policy is being conducted by the European Central Bank for the Euro Area countries, these countries are grouped together. Countries and time period are chosen with respect to data availability.

We use a panel method for two reasons. First, estimating the VAR model separately for each country limits the degrees of freedom, thus reducing the explanatory power. Second, some countries have implemented relatively few macroprudential policies. Using panel methods, we can therefore more easily capture the overall effect of macroprudential policies on the macroeconomic and financial variables.

To derive statistical inference, VAR models require the use of stationary data[18]. Since inflation is one of the variables of interest in the study, which is stationary in levels[19], we also need the other variables to conform to this. The way our monetary and macroprudential policy variables are measured entails that they are stationary by construction. The macroeconomic and financial variables are measured as their respective growth rates and they are therefore also stationary. Thus, non-stationarity should not be a problem[20].

[18] Unless in the case of cointegration.
[19] Empirical findings on the stationarity of the inflation rate are inconclusive (Zhou, 2013). As we will present, the inflation rate used in this study is estimated as the first difference of the Consumer Price Index. To check for stationarity, we conducted a series of unit root tests. The results indeed confirmed that the inflation variable was stationary.
[20] We nevertheless conducted a series of unit root tests to confirm this. The results confirmed that all our variables were stationary.

As previously discussed, our model captures three parts of the economy. The policy domain is captured by monetary and macroprudential policies. Inflation and GDP growth are used to proxy the real economy. Finally, the financial system is modelled by household credit, bank credit and house price growth. In the sections below we provide a description of these variables together with definitions, measurements and sources. In Appendix 1, a summary of this information is available.

4.1 Monetary policy shocks

The main estimation challenge to overcome when estimating the effects of monetary policy shocks is its non-exogenous nature[21]. For example, the decision of a particular monetary policy stance depends on the current and future economic development. Moreover, real macroeconomic variables, such as inflation, unemployment and economic growth, and interest rates are determined simultaneously (Champagne & Sekkel, 2017). Hence, a measure of monetary policy shocks needs to be unrelated to economic development, at least in the short term (Zdzienicka et al., 2015). Failing to account for this leads to identification problems in the estimation such as endogeneity bias. In particular, the identification of monetary policy shocks is represented by the following equation:

$$S_t = f(\Omega_t) + \mu_t \tag{2}$$

Where the intended monetary policy variable, S_t, is a combination of the policymakers' information set, Ω_t, where *f(.)* is a linear function capturing them monetary authorities' systematic reaction, and where μ_t represents unexpected monetary policy shocks.

We use in this paper a narrative approach inspired by the seminal work of Romer and Romer (2004) to identify these monetary policy shocks[22]. This approach is useful because it purges endogenous behaviour in response to future economic development by capturing the policymakers' information set prior to the policy decision (Romer & Romer, 2004). Many studies use conventional measures of monetary policy which, by construction, are likely to be

[21] Other issues are that policymakers do not only take the contemporaneous state of the economy into account when deciding on, for example, the stance on monetary policy, but also future macroeconomic conditions and that policymakers base their decisions on real-time data available at hand during the time of decision, however, many studies use final revised data (Cloyne & Hürtegren, 2016; Champagne & Sekkel, 2017).

[22] Since Bernanke and Blinder (1992) and Sims (1992), conventional research has instead tackled the simultaneity issue between macroeconomic variables and interest rates by employing vector autoregression (VAR) methods when identifying monetary policy shocks. Other studies, following Uhlig (2005), use sign restrictions on the impulse response of several macroeconomic variables to identify the monetary policy shocks. Bernanke, Boivin and Eliasz (2005) identify the monetary transmission mechanism by incorporating a broad set of conditioning information, summarised by a small number of factors, to better proxy for the policymakers' information set using factor augmented VARs.

endogenous. For example, the money supply depends on the current economic climate since it is affected by the money multiplier. Furthermore, central bank policy interest rates also likely move endogenously with macroeconomic changes. Failing to account for this may lead to biasedness by underestimating the negative impact of increases in interest rates on the real economy (Romer & Romer, 2004). These issues are addressed using our approach to measure monetary policy shocks.

To construct the monetary policy shocks, the method is to first estimate a first stage regression of the intended monetary policy target rate, S_t, at each policy decision. Romer and Romer (2004) estimate monetary policy shocks for the US and use the target rate from minutes of the Federal Open Market Committee (FOMC) meetings as the intended monetary policy target rate. In this paper, we study a panel of countries and instead use the respective countries' central bank policy rate as the intended policy target[23].

Specifically, to overcome the endogeneity issues discussed above, the first stage panel regression we estimate is the following augmented Taylor rule[24]:

$$\Delta i_{it} = \alpha + \beta\, i_{it-1} + \sum_{t=-1}^{0} \gamma_j \Delta y_{it} + \sum_{t=-1}^{0} \varphi_j \pi_{it} + \sum_{t=-1}^{0} \rho_j \Delta u_{it} + \eta_i + \lambda_t + MOP_{it} \qquad (3)$$

where the dependent variable, Δi_{it}, is the intended policy rate measured as the quarterly change in the central bank policy rate, indicated by the subscript t, for each country, indicated by subscript i. i_{it-1} is the level of country i's central bank policy rate the previous quarter, which is included to capture any tendency toward mean reversion in the central banks' monetary policy behaviour. Δy_{it}, π_{it} and Δu_{it} are the real output growth, inflation, and the unemployment rate growth, and η_i and λ_i are country and time fixed effects respectively.

The estimated residuals of our first stage regression, MOP_{it}, is our exogenous monetary policy shock variables. These shocks capture the unexpected monetary policy behaviour of central banks that is not included in their information sets about the current economic development. Therefore, these shocks are to be regarded as exogenous changes in the central banks' monetary policy stance and could reflect a multitude of actions including deliberately induced policy

[23] During the time period of study, the central bank policy rate has been the intended monetary policy target for most countries in our sample.
[24] Since there may be a relationship between e.g. output and unemployment (Okun's law) and for robustness, we experimented with different first-stage regressions, such as changing the lags of each variables, excluding the fixed effects, using different lag lengths and adding leads. This did not substantially change the estimated coefficients nor the residuals.

surprises or tightening and easing of monetary policy (Cloyne & Hürtegren, 2016). These monetary policy shock variables will later be used in the second stage to investigate the effect of monetary policy on our macroeconomic and financial variables.

4.2 Macroprudential policy actions

We use data from the Integrated Macroprudential Policy (iMaPP) Database prepared by Alam et al. (2019) as macroprudential policy actions in this paper. This database was made available on March 2019, and this is one of the first study outside of Alam et al. (2019) to use its data to assess the effectiveness of macroprudential measures. The iMaPP database consolidates data on macroprudential policies from five major existing databases. They are Lim et al. (2011), Lim et al. (2013), Global Macroprudential Policy Instrument (GMPI, 2013), Shim et al. (2013), the European Systemic Risk Board (ESRB) database, and the International Monetary Fund's (IMF) Annual Macroprudential Survey, together with additional information from other sources such as the Bank for International Settlements (BIS), the Financial Stability Board (FSB), the IMF official documents, various surveys, and national sources.

The definition of what constitutes a macroprudential policy in the database is the use of primarily prudential tools to limit systemic risk. This consists of both demand-side and supply-side macroprudential measures. The database provides both with dummy-type indices of tightening and loosening actions for 17 of such macroprudential policy instruments together with their respective subcategories (Alam et al., 2019). A list of each macroprudential policy instrument is available in Appendix 1.

Following Alam et al. (2019), we classify a variable that takes the value equal to 1 in the quarter in which at least one of the abovementioned macroprudential policies was employed, value equal to -1 in the quarter a macroprudential easing was employed, and zero otherwise (see also Zdzienicka et al., 2015).

In the European Union, the European Systemic Risk Board (ESRB) recommend that each member state designates its own macroprudential authority in charge of conducting financial stability policies. Some countries have given power to authorities that are separate from the central bank to implement their macroprudential policies. Other countries have their central bank oversee macroprudential policies as well. Finally, some countries have decided to share the responsibility of macroprudential policies between the central bank and another institution. Spain however is the only country that do not have any competent macroprudential supervisory authority[25] (Rubio & Carrasco-Gallego, 2016b). Since we have grouped the Euro Area countries into one in this study, we use a weighted index based on each member country's economic mass to calculate macroprudential actions for the whole area each quarter. We acknowledge the shortcomings and speculations about the validity of this, and hence also tested to exclude the Euro Area in the empirical analysis. This provided similar results to our baseline[26].

The issue of endogeneity is also shared by many studies on macroprudential policies (see e.g. Lim et al., 2011). For instance, OLS estimates tend to be biased downwards since rising credit and asset growth typically increases the likelihood of implementing macroprudential policies (Zdzienicka et al., 2015). Since the macroprudential policy variable is measured in a different way, we do not use the same procedure as done for the monetary policy variable to overcome the endogeneity issue. However, by lagging our macroprudential policy variable we can partly address the endogeneity issue (Nier et al., 2012). Furthermore, using our structural panel VAR model, this bias is further limited since we order the macroprudential policies below the macroeconomic and financial variables. Nevertheless, as a robustness we consider changing the order of our policy variables (section 5.4). The signs, magnitudes and significance of the impulse responses did not change much. We interpret this as endogeneity not being a major issue in our estimations[27].

4.3 Macroeconomic and financial variables

With the aim to capture how monetary and macroprudential policies interact to affect macroeconomic and financial stability, several explanatory variables are used as potential determinants of such stability. They are chosen in line with previous research as being powerful predictors of macroeconomic and financial stability.

For the variables relating to macroeconomic stability in the real economy, real GDP growth rates and the inflation rate are used. The real GDP growth rates are expressed as the percentage change in the natural log of the original series, while inflation is expressed as the percentage change in the natural log of the Consumer Price Index. Both series are seasonally adjusted. These two variables are theoretically justified as being related to macroeconomic stability and have been used in similar studies investigating how they are affected by shocks to monetary policy (Romer & Romer, 2004; Olivei & Tenreyo, 2007; Coibion, 2012; Cloyne & Hürtegren,

[25] If needed, the Bank of Spain would act as the macroprudential authority (Rubio & Carrasco-Galleo, 2016b).
[26] Not presented in the empirical analysis nor as a robustness, however.
[27] Endogeneity may still exist despite this. In such instances, the macroprudential policy shocks should be interpreted with caution by focusing on their sign rather than magnitude (Nier et al., 2012; Dumičić, 2018).

2016; Champagne & Sekkel, 2017). The variables are extracted from the Organisation for Economic Cooperation and Development (OECD) database.

Financial stability is not as easily determined or measured as compared to, for example, price stability. This is because different elements in the financial system are interconnected with a complex set of interactions among themselves and together with the real economy (Gadanecz & Jayaram, 2009). To investigate how monetary and macroprudential policies affect the financial system, we measure financial stability using three variables. These are the growth rates of real household credit, bank credit and house prices. The justification of using these variables is that they have previously been argued to be powerful predictors of financial stability (Gourinchas & Obstfeld, 2012; Jordà, Schularick, & Taylor, 2011; 2015; Borio & Drehmann, 2009; Zdzienicka et al., 2015), while crises have typically been preceded by strong credit growth (Kaminsky & Reinhart, 1999; Schularick & Taylor, 2012). Data on household and bank credit are collected from the BIS total credit statistics. The growth rates in house prices are derived from the real house price indices of OECD and from Oxford Economics (using Datastream). These variables are seasonally adjusted.

5 Empirical Analysis

The empirical analysis starts with estimating the first-stage regression for our monetary policy shock series. It is then followed by a descriptive presentation of the monetary and macroprudential policies. The baseline regression of our structural panel VAR model is thereafter conducted, followed by extensions and robustness tests to our baseline specification.

5.1 Monetary policy shocks: first-stage regressions

We isolate monetary policy shocks from the difference in countries' central bank policy rate that are orthogonal to their information set by estimating Equation 3. We include our full panel of 11 countries between 1999Q1 to 2016Q4. The results from this estimation are presented in Table 1.

The results weakly suggest that the countries conducted a countercyclical monetary policy over the sample period. For example, the sum of the coefficients on the inflation rate is 0.024. In other words, a 1 percentage point increase in the inflation rate is associated with an increase in the central banks' policy rate by 2.4 basis points. The sum of the change in unemployment rate yields negative coefficients which also confirms the countercyclical tendency in monetary policy among the central banks. The sum of the coefficients on the GDP growth however also yields a negative effect, which is not concordant with the notion of countercyclical monetary policy.

In sum, the results from our panel estimates are comparable to Romer and Romer (2004) and show that the point estimates appear to have reasonable and expected signs and magnitudes. More importantly, we can now predict the residuals from this first-stage regression to construct our new measure of exogenous monetary policy shocks which are purged from the information set of policymakers.

Table 1. Determinants of the change in central banks' policy rate

Variable	(1) Δi
Constant	0.0019***
	(0.0005)
Initial central bank policy rate	-0.0960***
	(0.0149)
Real GDP growth	-0.006
	(0.0231)
Real GDP growth$_{t-1}$	-0.0403*
	(0.0230)
Inflation	-0.1126***
	(0.0265)
Inflation$_{t-1}$	0.1366***
	(0.0263)
Change in unemployment rate	-0.0016**
	(0.0007)
Change in unemployment rate$_{t-1}$	-0.0001
	(0.0001)
Country fixed effects	YES
Time fixed effects	YES
Observations	781
R^2	0.45

*Notes: Robust standard errors in parentheses; ***p<0.01, **p<0.05, *p<0.1.*

5.1.1 Testing the predictability of the monetary policy shocks

As argued above, the new monetary policy shock series should theoretically be exogenous from macroeconomic movements. Before we proceed to the empirical analysis, we test whether these shocks in fact are unpredictable from macroeconomic movements. Following Coibion (2012), Cloyne and Hürtegren, (2016) and Champagne & Sekkel (2017) this is done by performing a panel Granger (1969) causality test by regressing our monetary policy shocks MOP_{it} on a set of lagged macroeconomic variables x_{it-k} :

$$MOP_{it} = \alpha_i + \sum_{k=1}^{K} \beta_{ik} x_{it-k} + \varepsilon_{ik} \quad (4)$$

where we include two measures of output (real GDP growth and industrial production growth), inflation, unemployment growth and the change in money supply (M1 and M3) in our set of macroeconomic variables. The test is performed on quarterly data and the results are presented in Table 2.

Table 2. Predictability of monetary policy shocks

	K = 1 lag		K = 2 lags	
Variable	F-statistics	p-values	F-statistic	p-values
Real GDP growth	0.00775	0.9299	0.64921	0.5227
Industrial production growth	0.37013	0.5431	0.37113	0.6901
Inflation	0.00067	0.9793	0.21777	0.8044
Change in unemployment rate	0.00405	0.9493	2.78418	0.0624
Money growth (M1)	0.4737	0.4915	0.46441	0.6287
Money growth (M3)	0.06886	0.7931	1.40052	0.2471

Notes: The table reports F-statistics and p-values for the null hypothesis that all of the β_{ik} are equal to zero.

The null hypothesis states that our monetary policy shock series is not predictable from lags of these macroeconomic variables, i.e. the β_{ik} are jointly equal to zero. As can be seen, we cannot reject the hypothesis that our monetary policy shock series are exogenous, since p-values are overall large and statistically insignificant. For example, in the 1 quarter lag test, p-values for all variables are high. Many p-values are even higher than 90 percent. Furthermore, p-values in the 2 quarter lag test are also not statistically significant at conventional levels, except for the unemployment growth which is significant at the 10 percent level[28]. Hence, the unpredictable nature confirms that our monetary policy shocks are a suitable measure for our second-stage when we identify the macroeconomic and financial effects.

5.2 Descriptive evidence

Before proceeding to analyse how the interaction between monetary and macroprudential policies affect macroeconomic and financial stability, we present some descriptive evidence on our monetary and macroprudential policy series. To start, Figure 1 shows our monetary policy shock series. Although our data is different, the results are for the most part similar compared to other studies using Romer and Romer's (2004) narrative approach to identify monetary

[28] Champagne and Sekkel (2017) also found some degree of predictability for GDP growth, commodity price changes and the unemployment rate for their exogenous monetary policy shocks.

policy shocks on, for example, the United States (Romer & Romer, 2004; Coibion, 2012), the United Kingdom (Cloyne and Hürtegren, 2016), and Canada (Champagne & Sekkel 2017). That notwithstanding, this is not only one of the few studies to consider Romer and Romer's (2004) method on countries outside of the United States, United Kingdom and Canada, it is also one of the few studies that considers this method to identify monetary policy shocks on a panel of countries.

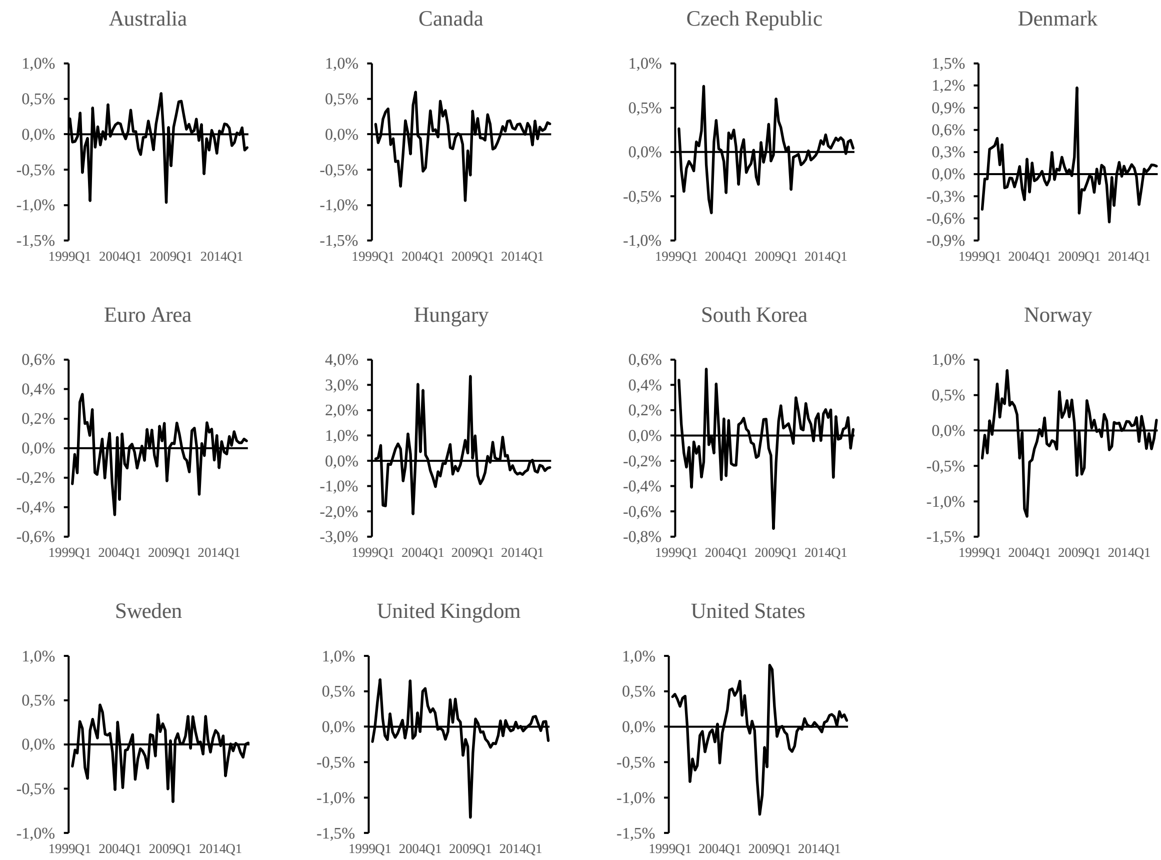

Figure 1. Monetary policy shock series.

As shown in Figure 1, the monetary policy shock series are of similar volatility across the countries, varying mostly between -0.5 percent and 0.5 percent over the sample period. The one exception to this conclusion is Hungary who has seen substantially more volatile expansionary and contractionary monetary policy shocks. Moreover, there is a negative monetary policy shock in most countries at the time of the global financial crisis of 2007-2008. This observation fits with the notion that many central banks conducted expansionary monetary policy to relieve deflationary pressures stemming from the macroeconomic situation at the time and to stimulate aggregate demand.

Figure 2 presents the countries quarterly tightening and easing of macroprudential policy as identified by Alam et al. (2019). As shown in the figure, the usage of macroprudential policy actions differ both in direction and frequency between the countries. The implementation of macroprudential measures also changes across the sample period, since there seems to be an increased usage after the global financial crisis of 2007-2008. Interestingly, while all countries have employed some sort of macroprudential tightening measures, Australia, Sweden and the United States have not employed any sort of easing measure. The country that most frequently used macroprudential policies during the sample period was South Korea (24), while the United States employed the least amount (4).

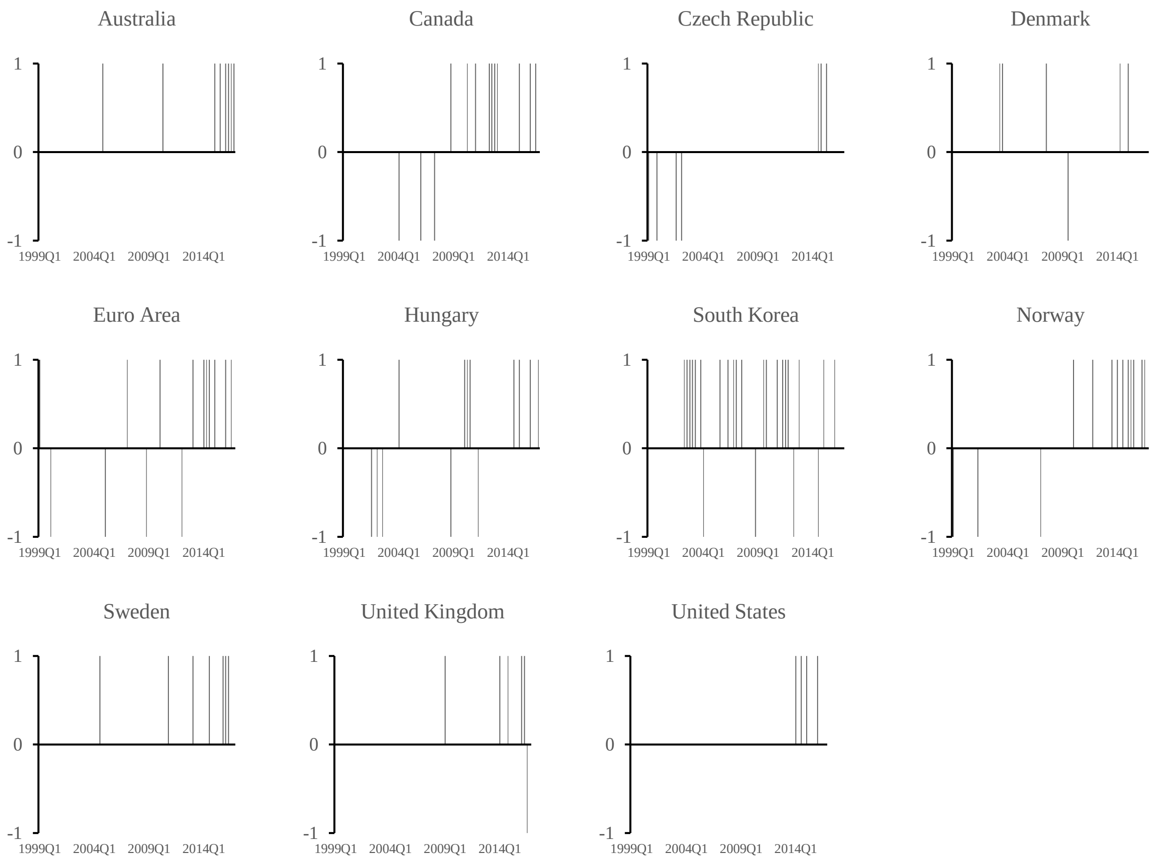

Figure 2. Macroprudential policy actions.

5.3 Baseline regression results

In Figure 3, we show the results from the impulse response functions of each endogenous variables in our structural panel VAR [29]. Since we are only interested in how our macroeconomic and financial variables respond to macroprudential and monetary policy shocks,

[29] As discussed by Cochrane (1998), interpreting impulse response functions from VAR models is not an easy task. This is because impulse response functions capture the historical average values of the endogenous variables following a shock. What our VAR impulse response functions show is the combined effect of an initial shock in policies and later policy moves that are anticipated based on the initial shock (Romer & Romer, 2004).

we only present results from shocks to these two policy variables. The first column shows how our endogenous variables respond to macroprudential policy actions (MAP) and the second shows responses from monetary policy shocks (MOP). As can be seen, both shocks are contractionary. This entails that the impulse response functions are responses to a macroprudential policy and a monetary policy tightening, respectively. Since the two policy variables are measured in different ways, the nature of the policy shocks is different. This means that we can only compare the relative size of the responses from the policy shocks. The dashed lines represent 90 percent error bands obtained from the standard error of the impulse response estimate.

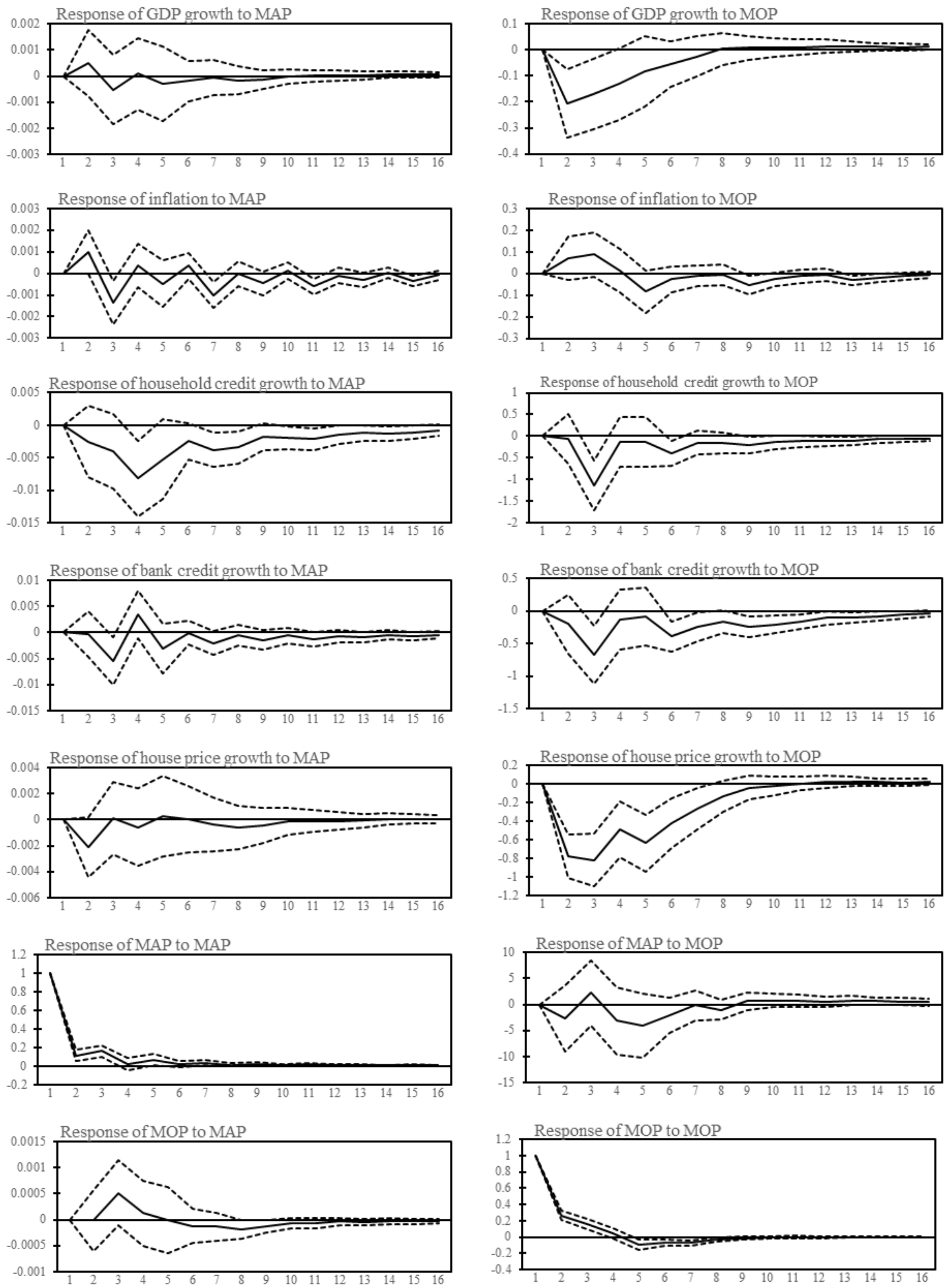

Figure 3. Impulse responses from the panel VAR model.

As the results suggest, contractionary monetary policy has a significant and negative effect on output. Specifically, a 100 basis point increase in our measure of monetary policy shock reduces quarterly real GDP growth by about 0.2 percent after 2 quarters, and 0.1 percent after 5 quarters.

Thereafter, the effect fades out. This is well in line with our prediction from macroeconomic theory. For example, monetary policy affects consumer spending and business expansion through its effect on the money supply. A contractionary macroprudential policy shock on the other hand, does not seem to affect output growth as the impulse response is barely oscillating around zero and its error bands are wide. This is likely due to macroprudential actions being aimed at specific sectors to achieve financial stability, and not to, for example, affect aggregate demand.

Despite a small increase in the beginning, a macroprudential tightening results in a fall in the price level. Hence, there is some evidence that macroprudential policies may have effects on the macroeconomic stability through inflation. In the first 5 quarters, contractionary monetary policy, however, yields a counterintuitive increase in the inflation rate. In other words, a surprise tightening of monetary policy raises the price level. This is known as the "price puzzle", which is an empirical phenomenon common in standard VAR models when estimating the monetary policy effects on inflation[30]. After 5 quarters, however, the inflation rate stays negative and relatively flat following a monetary policy contraction. This entails that monetary policy is effective in achieving price stability, at least after some period.

The impact of macroprudential measures and monetary policy shocks are similar for our two variables of credit. This is true for both the immediate effect as well as persistence on both household and bank credit following contractionary macroprudential and monetary policies. Since the purpose of implementing macroprudential policies is to limit credit growth in specific sectors, this result is in line with our expectations. We can therefore conclude that these policies achieve the goal of financial stability, at least in terms of affecting credit growth. However, for macroprudential policy shocks, household credit growth seems to be more affected than bank credit growth. A potential explanation could be that macroprudential policies are mainly aimed at financial institutions or households and not corporations (Cerutti, Claessens & Laeven, 2017). Given that monetary policy significantly affects credit growth however, important side effects on financial stability need to be considered when conducting these types of policies. Specifically, a peak decline of quarterly credit growth of around 0.5 to 1 percent is reached after 3 to 4 quarters following contractionary monetary policy, and the shock effects then fade over time. Hence, both types of policies can affect credit growth.

[30] See Eichenbaum (1992) and Sims (1992) for discussions about the price puzzle.

The response to house price growth following a macroprudential impulse is negative at first, but is afterwards close to zero. However, the estimated coefficients are not statistically significant. This entails that macroprudential tightening has only a limited effect on curbing house price growth. Perhaps more interesting, however, is the large and statistically significant impact on house price growth following a monetary policy tightening. A monetary policy contraction induces a peak decline in house price growth of almost 0.8 percent after 3 quarters. It then fades and reaches zero after 3 years. Again, this entails that monetary policy has important side effects on the financial system.

The results of the two policy variables show some feedback effects. First, a macroprudential policy tightening induces a contemporaneous monetary policy expansion, which after almost 1 year is followed by a contraction. According to Kim and Mehrotra (2017), this can be interpreted as an endogenous monetary policy action aimed to combat inflationary pressures arising from the macroprudential tightening. This argument is valid, since our results above suggest that contractionary macroprudential measures affect inflation. Similarly, a monetary policy tightening leads to a macroprudential policy easing after about 1 year, which likely is an endogenous response to changes in credit growth following monetary policy measures (Kim & Mehrotra, 2017). These responses are however not statistically significant and should therefore be interpreted with caution.

We also investigate the contribution of macroprudential and monetary policy shocks to the volatility of our macroeconomic and financial variables using a forecasted error variance decomposition. While the impulse responses presented above show the effect of policy shocks to our endogenous variables in the VAR model, the variance decomposition separates the variation for each variable into the component shocks to the VAR. In other words, the forecasted error variance decomposition shows the amount of variation that the policy variables contribute to the other endogenous variables. We measure this at a yearly frequency. The results from this estimation, together with standard errors[31], are presented in Table 3.

[31] The standard errors are obtained from 1000 Monte Carlo repetitions.

Table 3. Forecasted error variance decomposition of macroprudential and monetary shocks

Horizon	GDP growth		Inflation		Household credit growth		Bank credit growth		House price growth	
	MAP	MOP	MAP	MOP	MAP	MOP	MAP	MOP	MAP	MOP
1	0.1040	1.5634	1.0649	0.4140	0.9346	1.2766	0.7242	0.8072	0.1625	5.4582
	(0.3825)	(0.9907)	(0.7760)	(0.5273)	(0.7221)	(0.8124)	(0.6888)	(0.6550)	(0.4392)	(1.8842)
2	0.1263	1.6913	1.2616	0.5519	1.4638	1.3958	0.8704	1.0928	0.1706	7.2815
	(0.4815)	(1.1000)	(0.8679)	(0.5414)	(0.9729)	(0.8710)	(0.7930)	(0.7782)	(0.6514)	(2.5930)
3	0.1295	1.6904	1.3702	0.6218	1.5728	1.4533	0.9188	1.2717	0.1780	7.2544
	(0.4910)	(1.1027)	(0.9212)	(0.5658)	(1.0799)	(0.9004)	(0.8337)	(0.8469)	(0.6943)	(2.5851)
4	0.1314	1.6962	1.4136	0.6536	1.6126	1.4649	0.9413	1.2980	0.1783	7.2501
	(0.4911)	(1.1053)	(0.9458)	(0.5749)	(1.1267)	(0.9094)	(0.8513)	(0.8579)	(0.6979)	(2.5821)

Notes: Standard errors in parentheses.

The results from the forecasted error variance decomposition show that monetary policy shocks are more important in explaining fluctuations in GDP, bank credit and house price growth, while macroprudential policies explain to a greater extent fluctuation in inflation. Fluctuations in household credit growth is explained to a relatively high degree by both policies. At the 4-year horizon for example, monetary policy shocks explain 1.7 percent of fluctuations in quarterly GDP growth, while macroprudential actions can only explain 0.13 percent. Similarly, substantially more of the volatility in quarterly house price growth is explained by monetary policy shocks (7.3 percent) compared to macroprudential actions (0.2 percent) at the 4-year horizon. Overall, this suggests that the role of monetary policy shocks is greater than macroprudential measures in explaining macroeconomic and financial stability.

These results can be broadly compared with previous research. Using a similar measure of monetary policy shocks for the US, Romer and Romer (2004) find that output, as measured by industrial production, decreases by around 0.2 percent after 12 months in a VAR framework. Cloyne and Hürtegren (2016) and Sekkel and Champagne (2017) also find evidence of large price puzzles using narrative measures of monetary policy in VAR models. Furthermore, while Kim and Mehrotra (2017) found that macroprudential policies affects inflation, they did also find that macroprudential policy significantly affects real GDP, which contrasts with our findings. Zdzienicka et al. (2015) found that bank credit is reduced by 0.5 percent after 7 quarters following a monetary policy contraction, and by 1.6 percent after 6 quarters following a macroprudential tightening measure. The limited impact of macroprudential measures on house price growth is also highlighted by Cerruti, Claessens and Laeven (2017). In fact, the authors argue that it is more difficult to moderate house price growth than credit growth using macroprudential policies. At the same time, the empirical evidence that monetary policy can affect house price growth is concordant with previous studies (Zhu, Betzinger & Sebastian, 2017; Walentin, 2014; Jordà, Schularick & Taylor, 2015).

In sum, both contractionary macroprudential and monetary policies have similar effects on our macroeconomic and financial variables, leading to reduced inflation, household- and bank credit growth. Real GDP growth and house price growth are only affected by monetary policy and not by macroprudential actions. In other words, monetary policy achieves its goal of macroeconomic stability by affecting output growth and inflation, while macroprudential policy can achieve financial stability by affecting credit growth. However, the conduct of monetary policy can have side effects on financial stability by affecting the growth of credit and house prices. Similarly, macroprudential policies may affect price stability through its effect on inflation. Hence overall, the two policies seem to be working through related mechanisms. Moreover, the results imply that since both policies can have an impact on price and financial stability, their simultaneous effect on both targets needs to be considered. As argued by Kim and Mehrotra (2017) in such instances, the conduct of both type of policies at the same time may, in an environment of low inflation and strong credit growth, be challenging since the two instruments are working at cross purposes. Furthermore, monetary policy shocks can explain much more of the fluctuations in our macroeconomic and financial variables compared to macroprudential policy shocks. In conclusion, the coordination between monetary and macroprudential policies is important considering their similar effect on the real economy and the financial system.

5.3.1 Macroprudential and monetary policy interaction

Considering that our baseline results showed signs of significant interaction effects between the policy variables, in this section we re-estimate the model by also including an interaction term between the policies. In other words, we analyse the response coming from a simultaneous tightening in macroprudential and monetary policy. The results are presented in Figure 5.

As can be seen from the results, conducting both macroprudential and monetary policies at the same time may yield confounding results. Considering the error bands, the results however show that the endogenous macroeconomic and financial variables are only somewhat significantly affected by the interaction term. For example, it seems that the simultaneous conduct of contractionary macroprudential and monetary policies may have an offsetting effect on the GDP and household credit growth. Some similar interaction effects can be seen for the other variables. Since, they are statistically insignificant, we revert to the baseline specification.

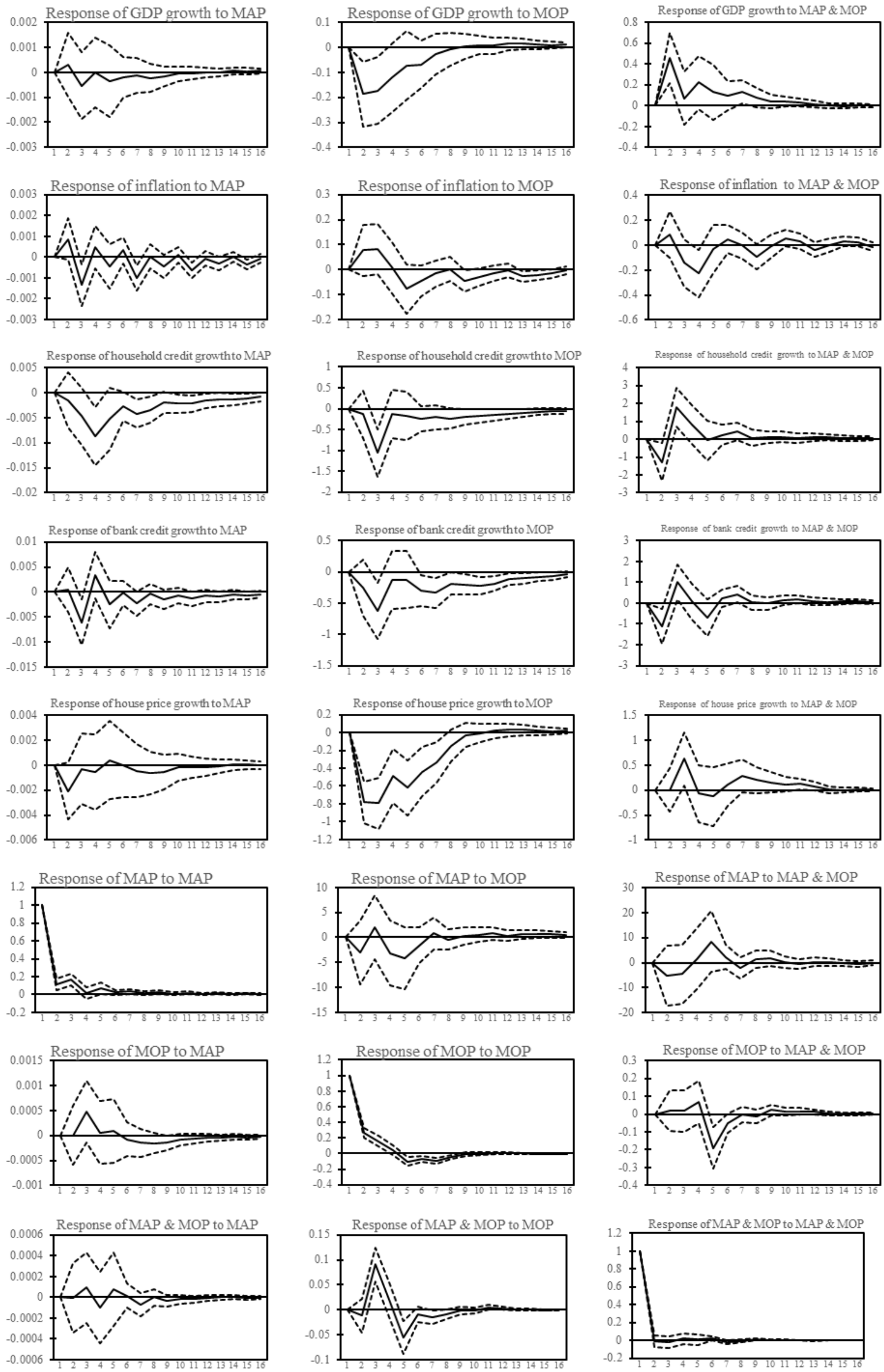

Figure 4. Impulse responses from the panel VAR with policy interaction.

5.3.2 Extended model

To investigate further side effects of macroprudential and monetary policies, we extend our baseline specification by also including unemployment, consumption and investment growth as endogenous variables in our panel VAR model. These can be considered as side effects since they typically are not the main policy action of either macroprudential or monetary policies[32]. Unemployment, for example, can be affected by economic policies through aggregate supply and demand. Moreover, since consumption and investments are components of GDP, we can also infer the transmission mechanism of the two policy shocks. Principally, these policies can in the short run affect these components for several reasons. First, macroprudential policies can, through credit, affect consumption and investment (Kim & Mehrotra, 2017). Second, wealth effects following a reduction in asset price growth from macroprudential policies can reduce consumption and investment. Third, some macroprudential measures may make households save more, thereby reducing consumption (Alam et al., 2019). The results from our extended model are presented in Figure 5. Again, these added variables are assumed to be contemporaneously exogenous to the macroprudential and monetary policies.

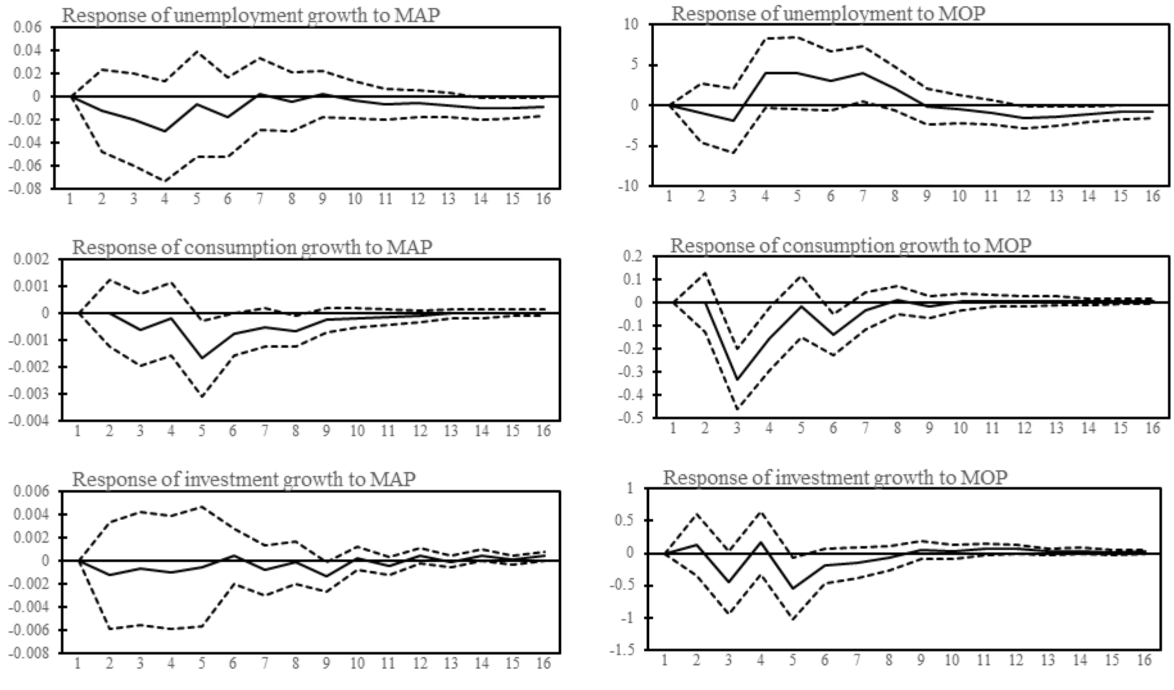

Figure 5. Impulse responses from the extended panel VAR model.

Figure 5 shows that macroprudential policies do not significantly affect unemployment, consumption or investment growth, since the impulse response function is close to zero and the 90 percent error bands are wide. This is in line with Alam et al. (2019) who find that

[32] Unless in the case of a dual mandate of monetary policy, where unemployment could also be the policy objective.

consumption growth is only mildly affected by macroprudential policies. Regarding monetary policy shocks, the three variables seem to be affected in the expected directions. Unemployment increases, while consumption and investment decrease following a monetary policy contraction. As argued by Kim and Mehrotra (2017), the lack of statistical significance may stem from the fall in degrees of freedom when adding additional variables to the VAR model.

5.4 Robustness

We assess the robustness of our baseline specifications by changing model specification and identifying assumptions. This is done by estimating our structural panel VAR model using Bayesian inference instead, including commodity prices as an additional exogenous regressor, changing the nature of the policy shocks, changing the variable order, and changing the lag length. The estimation results from these robustness tests are provided in Appendix 2.

Given the moderate size of standard macroeconomic datasets, regular VARs may suffer from over-parametrisation if the model consists of many parameters. To overcome this problem, Bayesian methods to estimate VARs have become increasingly popular (Koop & Korobilis, 2010). Hence, to check for the robustness of our baseline model, we estimate our structural panel VAR with Bayesian inference[33]. We use the same set of endogenous variables as our baseline specification and order the policy variables last. The effects on our macroeconomic and financial variables are qualitatively similar to our baseline panel VAR model when using Bayesian inference. Specifically, there is only little difference in the direction or magnitude of the response from shocks in the two policy variables while the peak effects remain largely the same.

As already discussed, our baseline results are indicative of a price puzzle between monetary policy and inflation. Hence, we test if the price puzzle is removed when we include commodity prices as an exogenous regressor in our structural panel VAR model[34]. The results show that the inflation response to macroprudential policy shocks changes slightly. However, the price puzzle remains between monetary policy shocks and inflation even after controlling for commodity prices.

[33] As is typical in the macroeconomic literature, we set the shrinkage prior in accordance with the Minnesota priors (see Doan, Litterman & Sims, 1983; Litterman, 1986).

[34] As discussed by Giordani (2004), previous research has shown that this stems from the policy makers' information set including variables useful in forecasting future inflation that is not available to the econometrician. Because of this, many studies have attempted to overcome the price puzzle by controlling for commodity prices (see e.g. Sims, 1992). Including commodity prices however changes the interpretation of monetary policy. As a result, this may lead to a misspecification of the VAR model (Giordani, 2004).

Several studies use the cumulative sum of e.g. monetary policy to evaluate its effect on macroeconomic variables (see e.g. Romer & Romer, 2004). As such, we also cumulate our two policy variables and estimate responses from shocks to these variables. The impact of the cumulative shocks, in terms of direction and magnitude, is broadly the same as in our baseline specification. However, one difference can be seen for the responses from the policy shocks, since the error bands are now slightly narrower.

In our baseline specification, we assumed that the macroprudential and monetary policies respond to, but do not affect the non-policy variables contemporaneously[35]. Here we relax this assumption by changing the Cholesky ordering of our endogenous variables. Specifically, we allow our two policy variables to be contemporaneously exogenous by ordering our monetary policy shocks first, our macroprudential policy actions second, and then the rest of our macroeconomic and financial variables. The results when changing the assumption of the timing of the policy actions are almost identical to our baseline. Specifically, all endogenous variables respond similarly to when the policy actions are assumed to be contemporaneously exogenous to the other variables. Hence, this suggests that the effects of macroprudential and monetary policies are very prolonged and become bigger over time.

As an additional robustness test to our panel VAR model, we change the lag length. In our baseline specification, we used a lag length of $P = 4$ quarters, because traditionally a lag length of 1 year is common in the VAR literature (Coibion, 2012). Similar studies have however used different lag lengths, such as 2 quarters (Kim & Mehrotra, 2017) or even 2 years (Cloyne & Hürtegren, 2016; Champagne & Sekkel, 2017). As such, we estimate our model using a lag length of 2 quarters and 2 years, respectively. The results suggest that the peak effect from policy shocks is robust to changes in the lag specification. Some increased persistence is noted however, at least for the credit growth variables, when the lag length increases.

[35] If we successfully capture the information set that policymakers have when choosing monetary policy stance in the first stage regressions, our monetary policy shocks should be contemporaneously exogenous. As a result, we should be able to relax the assumption that, at least, our monetary policy shocks do not contemporaneously affect the other variables in the VAR (Cloyne & Hürtegren, 2016).

6 Conclusion

The global financial crisis of 2007-2008 showed that the objective of price stability is not enough to also ensure financial stability for monetary policy. This led to a renewed interest into economic policies with the sole purpose of limiting systemic risk to the financial system, namely macroprudential policies. This study explores the interaction between monetary and macroprudential policies in affecting the macroeconomy and financial system. The analysis is conducted on a sample of 11 OECD countries over the quarterly period of 1999Q1 to 2016Q4. The estimation strategy is carried out using a structural panel VAR model with impulse responses from the two economic policies. Following Romer and Romer (2004), we construct our own exogenous measure of monetary policy shocks using quantitative data in a first-stage regression. Macroprudential policy actions are taken from a new and updated dataset.

There are several contributions from this paper. First, to our knowledge, our method of measuring monetary policy shocks has not been used before on panel data. We show that not only is it viable to apply this method on panel data, it also yields reasonable effects when regressed on various macroeconomic and financial variables compared to related studies. Second, we use a dataset on macroprudential policy actions that has previously not been used in a similar setting. In fact, next to the creators of the dataset, this is one of the first studies to use this data to evaluate the effect of macroprudential policies. Hence third, we can shed light on how monetary and macroprudential policies interact to affect the macroeconomy and financial system by studying it in a new setting.

We find that the two policies are effective at achieving their respective targets. Specifically, a contractionary monetary policy reduces output growth and inflation. As a result, this suggests that monetary policy contributes to the macroeconomic stability and price stability. Similarly, it is found that a macroprudential policy tightening reduces the growth of household credit and bank credit, suggesting that they can contain financial imbalances. While the two policies achieve their targets, they do however have significant spillovers on other parts of the economy which they do not explicitly target. For example, monetary policy shocks significantly affect the growth in household credit, bank credit and house prices, while macroprudential actions significantly affect inflation. This is indicative of monetary and macroprudential policies working through related channels by indirectly influencing other parts of the economy. Hence, we also find a notable interaction between monetary and macroprudential policies in affecting macroeconomic and financial stability.

Given that monetary and macroprudential policies interact, our results have important policy implications. In particular, our findings corroborate the need for coordination between monetary and macroprudential policies since both policies can affect price and financial stability. This implies that economic authorities cannot conduct one type of economic policy without accounting for its simultaneous impact on the other type of economic policy. In other words, financial sector spillovers may arise from monetary policy aimed too narrowly at price stability. As argued by Kim and Mehrotra (2017), this context could prove difficult if inflation is low and credit growth is strong because monetary and macroprudential policies may then work against each other. They should therefore be used as complements and coordination thus becomes especially important.

Future research is still warranted on this topic considering that macroprudential policies are still in its infant stage of theoretical and empirical development (Galati & Moessner, 2012). For example, we considered only developed countries in this study. Developing countries have however actively used macroprudential policies to a larger extent than developed countries. Hence, a natural extension of our paper would be to apply this method to the context of strictly developing countries. The implementation of macroprudential policies is also relatively novel. As more data becomes available, another potential direction of future research is therefore to investigate whether there exists a long run relationship between macroprudential policies and macroeconomic and financial variables using cointegration methods. Furthermore, many studies on monetary policy find evidence of asymmetric regional effects in terms of output, inflation and unemployment. It is therefore important to also highlight whether the effects of macroprudential policies differ between countries, but also within regions of the same country.

References

Akinci, O., & Olmstead-Rumsey, J. (2018). "How Effective are Macroprudential Policies? An Empirical Investigation", *Journal of Financial Intermediation,* Vol. 33, pp. 33-57.

Angelini, P., Neri, S., & Panetta, F. (2012). "Monetary and Macroprudential Policies", *ECB Working Paper,* No. 1449.

Antipa, P., & Matheron, J. (2014): "Interactions Between Monetary and Macroprudential Policies", *Banque de France Financial Stability Review,* No. 18, pp. 225-239.

Bank of England. (2015). "One Bank Research Agenda", *Bank of England Discussion Paper*.

Bean, C., Paustian, M., Penalver, A., & Taylor, T. (2010). "Monetary Policy After the Fall", *paper presented at the Federal Reserve Bank of Kansas City Economic Symposium, Jackson Hole, Wyoming.*

Beau, D., Clerc, L., & Mojon, Benoit. (2017). "Macro-prudential Policy and the Conduct of Monetary Policy", *Banque de France Occasional Papers,* No. 8.

Bernanke, B. S., Boivin, J., & Eliasz, P. (2005). "Measuring the Effects of Monetary Policy: A Factor_Augmented Vector Autoregressive (FAVAR) Approach", *The Quarterly Journal of Economics*, Vol. 120, Issue 1, pp. 387-422.

Bernanke, B., & Blinder, A. (1992). "The Federal Funds Rate and the Channels of Monetary Transmission", *American Economic Review,* Vol. 82(4), pp. 901-921.

Bernanke, B., Gertler, M., & Gilchrist, S. (1996). "The Financial Accelerator and the Flight to Quality", *The Review of Economics and Statistics,* Vol. 78, No. 1, pp. 1-15.

Blinder, A., Ehrmann, M., Fratzscher, M., De Haan, J., & Jansen, D. (2008). "Central Bank Communication and Monetary Policy: A Survey of Theory and Evidence", *Journal of Economic Literature,* Vol. 46, Issue 4, pp. 910-945.

Borio, C. (2014). "Monetary Policy and Financial Stability: What Role in Prevention and Recovery?", *BIS Working Papers,* No. 440.

Borio, C. E. V., & Shim, I. (2007). "What Can (Macro-)prudential Policy Do to Support Monetary Policy?", *BIS Working Papers No. 242.*

Borio, C., & Drehmann, M. (2009). "Assessing the Risk of Banking Crises – Revisited", *BIS Quarterly Review, March*, pp. 29-46.

Budnik, K., & Kleibl, J. (2018). "Macroprudential Regulation in the European Union in 1995-2014: Introducing a New Data Set on Policy Actions of a Macroprudential Nature", *ECB Working Paper Series,* No. 2123.

Cerutti, E., Claessens, S., & Laeven, L. (2017). "The Use and Effectiveness of Macroprudential Policies: New Evidence", *Journal of Financial Stability,* Vol. 28, pp. 203-224.

Cerutti, E., Correra, R., Fiorentino, E., & Segalla, E. (2016). "Changes in Prudential Policy Instruments – A New Cross-Country Database", *IMF Working Paper,* No. 110.

Cerutti, E., Dagher, J., & Dell'Ariccia, G. (2015). "Housing Finance and Real-Estate Booms: A Cross-Country Perspective", *IMF Staff Discussion Note,* No. 12.

Chadwick, M. G. (2018). “Effectiveness of monetary and Macroprudential Shocks on Consumer Credit Growth and Volatility in Turkey”, *Central Bank Review,* Vol. 18, Issue 2, pp. 69-83.

Champagne, J., & Sekkel, R. (2017). “Changes in Monetary Regimes and the Identification of Monetary Policy Shocks: Narrative Evidence from Canada”, *Bank of Canada Staff Working Paper No. 39.*

Christiano, L. J., Eichenbaum, M. & Evans, C. L. (1996). “The Effects of Moentary Policy Shocks: Evidence from the Flow of Funds”, *The Review of Economics and Statistics,* Vol. 78(1), pp. 16-34.

Christiano, L. J., Eichenbaum, M. & Evans, C. L. (1999). “Monetary Policy Shocks: What Have We Learned and to What end?”, *Handbook of Macroeconomics,* ed. By J. B. Taylor and M. Woodford, Amsterdam: North-Holland, Vol. 1A, pp. 65-148.

Christiano, L. J., Eichenbaum, M., & Evans, C. L. (2005). “Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy”, *Journal of Political Economy,* Vol. 113, No. 1, pp. 1-45.

Claessens, S., Ghosh, S. R., & Mihet, R. (2014). “Macro-prudential Policies to Mitigate Financial System Vulnerabilities”, *IMF Working Paper 14/155.*

Cloyne, J., & Hürtegren, P. (2016). “The Macroeconomic effects of Monetary Policy: A New Measure for the United Kingdom”, *American Economic Journal: Macroeconomics,* Vol. 8, No. 4, pp. 75-102.

Cochrane, J. H. (1998). “What do the VARs Mean? Measuring the Output Effects of Monetary Policy”, *Journal of Monetary Economics,* Vol. 41, pp. 277-300.

Coibion, O. (2012). “Are the effects of Monetary Policy Shocks Big or Small?”, *American Economic Journal: Macroeconomics,* Vol. 4, No. 2, pp. 1-32.

Crocket, A. (2000). “Marrying the Micro- and Macro-Prudential Dimensions of Financial Stability”, *Remarks before the Eleventh International Conference of Banking Supervisors, held in Basel, 20-21 September 2000.*

De Paoli, B., & Paustian, M. (2013). “Coordinating Monetary and Macroprudential Policies”, *Federal Reserve Bank of New York Staff Reports,* No. 653.

Dell’Ariccia, G., Rabanal, P., & Sandri, D. (2018). “Unconventional Monetary Policies in the Euro Area, Japan, and the United Kingdom”, *Journal of Economic Perspectives,* Vol. 32, No. 4, pp. 147-172.

Doan, T., Litterman, R., & Sims, C. A. (1983). “Forecasting and Conditional Projection Using Realistic Prior Distributions”, *NBER Working Paper Series,* No. 1202.

Dumičić, M. (2018). “Effectiveness of Macroprudential Policies in Central and Eastern European Countries”, *Public Sector Economics,* Vol. 42(1), pp. 1-19.

Eichenbaum, M. (1992). “Interpreting the Macroeconomic Time Series Facts: The Effects of Monetary Policy: Comments”, *European Economic Review,* Vol. 36, pp. 1001-1011.

Gadanecz, B., & Jayaram, K. (2009). "Measures of Financial Stability – A Review", *IFC Bulletin No. 31 (Bank for International Settlements).*

Galati, G., & Moessner, R. (2012). "Macroprudential Policy – A Literature Review", *Journal of Economic Surveys,* Vol. 27, No. 5, pp. 846-878.

Gambacorta, L., & Murcia, A. (2017). "The Impact of Macroprudential Policies and Their Interaction with Monetary Policy: An Empirical Analysis using Credit Registry Data", *BIS Working Papers,* No. 636.

Gerba, E., & Macchiarelli, C. (2015). "Interaction Between Monetary Policy and Bank Regulation: Theory and European Practice", available at SSRN: https://ssrn.com/abstract=2668723 or http://dx.doi.org/10.2139/ssrn.2668723.

Giordani, P. (2004). "An Alternative Explanation of the Price Puzzle", *Journal of Monetary Economics,* Vol. 51, Issue 6, pp. 1271-1296.

Gourinchas, P-O., & Obstfeld, M. (2012). "Stories of the Twentieth Century for the Twenty-First", *American Economic Journal: Macroeconomics,* Vol. 4(1), pp. 226-265.

Granger, C. W. J. "Investigating Causal Relations by Econometric Models and Cross-spectral Methods", *Econometrica,* Vol. 37, No. 3, pp. 424-438.

Guibourg, G., Jonsson, M., Lagerwall, B., & Nilsson, C. (2015). "Macroprudential Policy – Effects on the Economy and the Interaction with Monetary Policy", *Sveriges Riksbank Economic Review,* Vol. 2.

IMF. (2013). "The Interaction of Monetary and Macroprudential Policies", *Policy Papers.*

Issing, O. (2011). "Lessons for Monetary Policy: What Should the Consensus Be?", *CFS Working Paper*, No. 13.

Jiménez, G., Ongena, S., Peydró, J-L., & Saurina, J. (2017). "Macroprudential Policy, Countercyclical Bank Capital Buffers, and Credit Supply: Evidence from the Spanish Dynamic Provisioning Experiments", *Journal of Political Economy,* Vol. 125, No. 6, pp. 2126-2177.

Jordà, O., Schularick, M., & Taylor, A. M. (2011). "Financial Crises, Credit Booms, and External Imbalances: 140 Years of Lessons", *IMF Economic Review,* Vol. 59, pp. 340-378.

Jordà, O., Schularick, M., & Taylor, A. M. (2015). "Betting the House", *Journal of International Economcs,* Vol. 96, Supplement 1, pp. S2-S18.

Kaminsky, G. K., & Reinhart, C. M. (1999). "The Twin Crises: The Causes of Banking and Balance-of-Payments Problems", *American Economic Review,* Vol. 89, No. 3, p. 473-500.

Kim, S., & Mehrotra, A. (2017). "Effects of Monetary and Macroprudential Policies – Evidence from Inflation Targeting Economies in the Asia-Pacific Region and Potential Implications for China", *BOFIT Discussion Papers 4.*

Koop, G., & Korobilis, D. (2010). "Bayesian Multivariate Time Series Methods for Empirical Macroeconomics", *Foundations and Trends in Econometrics, Vol.* 3, No. 4, pp. 267-358.

Kuttner, K. N., & Shim, I. (2016). “Can Non-Interest Rate Policies Stabilize Housing Markets? Evidence from a Panel of 57 Countries”, *Journal of Financial Stability,* Vol. 26, pp. 31-44.

Lim, C. H., Columba, F., Costa, A., Kongsamut, P., Otani, A., Saiyid, M., Wezel, T., & Wu, X. (2011). “Macroprudential Policy: What Instruments and How to Use Them?”, *IMF Working Paper 238.*

Lim, C. H., Krznar, I., Lipinsky, F., Otani, A., & Wu, X. (2013). “The Macroprudential Framework: Policy Responsiveness and Institutional Arrangements”, *IMF Working Paper No. 166.*

Lim, C., Columba, F., Costa, A., Kongsamut, P., Otani, A., Saiyid, M., & Wu, X. (2011). “Macroprudential Policy: What Instruments and how to Use Them? Lessons from Country Experiences”, *IMF Working Paper 11/238.*

Litterman, R. B. (1986). “Forecasting with Bayesian Vector Autoregressions: Five Years of Experience, *Journal of Business & Economic Statistics,* Vol. 4, No. 1, p. 25-38.

Lütkepohl, H. (2008). “Impulse Response Function”, *in Palgrave Macmillan (eds) The New Palgrave Dictionary of Economics.* Palgrave Macmillan, London.

Mishkin, F. S. (1996). “The Channels of Monetary Transmission: Lessons for Monetary Policy”, *NBER Working Paper Series,* No. 5646.

Mishkin, F. S. (2001). “The transmission Mechanism and the Role of Asset prices in Monetary Policy”, *NBER Working Paper Series,* No. 8617.

N’Diaye, P. (2009). “Countercyclical Macro Prudential Policies in a Supporting Role to Monetary Policy”, *IMF Working Paper 257.*

Neuenkirch, M., & Nöckel, M. (2018). “The Risk-Taking Channel of Monetary Policy Transmission in the Euro Area”, *Journal of Banking & Finance,* Vol. 93, pp. 71-91.

Ng, S., & Perron, P. (2005). “A Note on the Selection of Time Series Models”, *Oxford Bulletin of Economics & Statistics,* Vol. 67, Issue 1, pp. 115-134.

Nickell, S. (1981). “Biases in Dynamic Models with Fixed Effects”, *Econometrica,* Vol. 49, No. 6, pp. 1417-1426.

Nier, E., & Kang, H. (2016). “Monetary and Macroprudential Policies – Exploring Interactions”, *BIS Papers,* Vol. 86, p. 27-38.

Nier, E., Kang, H., Mancini, T., Hesse, H., Columba, F., Tchaidze, R., & Vandembussche, J. (2012). “The Interaction of Monetary and Macroprudential Policies – Background Paper”, *International Monetary Fund, December*.

Olivei, G., & Tenreyo, S. (2007). “The Timing of Monetary Policy Shocks”, *American Economic Review,* Vol. 97(3). Pp. 636-663.

Praet, P. (2018). “The interaction Between Monetary Policy and Macroprudential Policy”, *Speech at the Money, Macro and Finance Research Group Conference on the Resilience of the Global, Financial Architecture,* London, 27 September.

Quint, D., & Rabanal, P. (2013). “Monetary and Macroprudential Policy in an Estimated DSGE Model of the Euro Area”, *IMF Working Paper 209.*

Ramey, V. A. (2016). “Macroeconomic Shocks and Their Propagation”, *NBER Working Paper Series,* No. 21978.

Richter, B., Schularick, M., & Shim, I. (2018). “The Costs of Macroprudential Policy”, *NBER Working Paper No. 24989.*

Romer, C. D., & Romer, D. H. (2004). “A New Measure of Monetary Shocks: Derivation and Implications”, *American Economic Review,* Vol. 94, p. 1055-1084.

Rubio, M., & Carrasco-Gallego, J. A. (2016a). “The New Financial Regulation in Basel III and Monetary Policy: A Macroprudential Approach”, *Journal of Financial Stability,* Vol. 26, pp. 294-305.

Rubio, M., & Carrasco-Gallego, J. A. (2016b). “Coordinating Macroprudential Policies Within the Euro Area: The Case of Spain”, *Economic Modelling,* Vol. 59, pp. 570-582.

Schinasi, G. J. (2004). “Defining Financial Stability”, *IMF Working Paper No. 187.*

Schularick, M., & Taylor, A. M. (2012). “Credit Booms Gone Bust: Monetary Policy, Leverage Cycles, and Financial Crises, 1870-2008”, *American Economic Review,* Vol. 102, No. 2, pp. 1029-1061.

Shim, I., Bogdanova, B., Shek, J., & Subelyte, A. (2013). “Database for Policy Actions on Housing Markets, *BIS Quarterly Review,* September 2013.

Shin, H. S. (2015). “Macroprudential Tools, Their Limits and Their Connection with Monetary Policy”, *Panel remarks at IMF Spring Meeting event: “Rethinking macro policy III: progress or confusion?* Washington, DC, 15 April 2015.

Sims, C. A. (1980). “Macroeconomics and Reality”, *Econometrica,* Vol. 48, No. 1, pp. 1-48.

Sims, C. A. (1992). “Interpreting the Macroeconomic Time Series Facts: The Effects of Monetary Policy”, *European Economic Review,* Vol. 36, pp. 975-1011.

Söderström, U., & Westermark, A. (2009). “Monetary Policy When the Interest Rate is Zero”, *Economic Review,* Vol. 2, pp. 5-30.

Svensson, E. (2012)- “Regional Effects of Monetary Policy in Sweden”, *Working Paper 2012:9,* Department of Economics, Lund University, Lund.

Svensson, L. E. O. (2017a). “The Relation Between Moentary Policy and Financial-Stability Policy”, *Prepared for the XXI Annual Conference of the Central Bank of Chile,* November 16-17.

Svensson, L. E. O. (2017b). “Leaning Against the Wind: The Role of Different Assumptions About the Costs”, *NBER Working Paper Series,* No. 23745.

Svensson, L. E. O. (2018). “Monetary Policy and Macroprudential Policy: Different and Separate?”, *Forthcoming in Canadian Journal of Economics.*

Tinbergen, J. (1952). “On the Theory of Economic Policy”, *North-Holland, Amsterdam.*

Uhlig, H. (2005). "What are the Effects of Monetary Policy on Output? Results from an Agnostic Identification Procedure", *Journal of Monetary Economics,* Vol. 52, Issue 2, pp. 381-419.

Wallentin, K. (2014). "Housing Collateral and the Monetary Transmission Mechanism", *Scandinavian Journal of Economics,* Vol. 116, Issue 3, pp. 635-668.

Yellen, J. L. (2010). "Macroprudential Supervision and Monetary Policy in the Post-Crisis World", *Business Economics,* Vol. 46, No. 1, pp. 3-12.

Zdzienicka, A., Chen, S., Kalan, F. D., Laseen, S., & Svirydzenka, K. (2015). "Effects of Monetary and Macroprudential Policies on Financial Conditions: Evidence from the United States", *IMF Working Paper,* No. 288.

Zhang, L., & Zoli, E. (2014). "Leaning Against the Wind: Macroprudential Policy in Asia", *IMF Working Paper,* No. 22.

Zhou, S. (2013). "Nonlinearity and Stationarity of Inflation Rates: Evidence from the Euro-Zone Countries", *Applied Economics,* Vol. 45, Issue 7, pp. 849-856.

Zhu, B., Betzinger, M., & Sebastian, S. (2017). "Housing Market Stability, Mortgage Market Structure, and Monetary Policy: Evidence from the Euro Area", *Journal of Housing Economics,* Vol. 37, pp. 1-21.

Appendix 1: Data

Table 4. Variables and data sources

Variable	Description	Measurement	Source
MOP	Monetary policy shocks	Percentages	Own calculations
MAP	Macroprudential policy actions	Dummy: 1 equals a tightening action, -1 equals an easing action, 0 otherwise	Alam et al. (2019)
Interest rates	Central bank policy rates	Percentages	BIS policy rate statistics
LTV	Change in the average loan-to-value (LTV) limit ratios	Percentages	Alam et al. (2019)
GDP growth	Quarterly real GDP growth rate (S.A)	Percentages	OECD
Inflation	Quarterly change in the consumer prices index	Percentages	OECD
Unemployment	Quarterly harmonised unemployment rate growth rate (all persons, S.A)	Percentages	OECD
Household credit	Quarterly credit to households and NPISHs from all sectors growth rate (national currency, adjusted for breaks)	Percentages	BIS total credit statistics
Bank credit	Quarterly credit to private non-financial sector from banks growth rate (domestic currency, adjusted for breaks)	Percentages	BIS total credit statistics
House price	Quarterly house price growth rate	Percentages	OECD, Oxford Economics
Consumption	Quarterly private consumption growth rate (S.A)	Percentages	OECD
Investment	Quarterly private investment growth rate (S.A)	Percentages	OECD
Industrial production	Quarterly industrial production growth rate (S.A)	Percentages	OECD
M1	Quarterly money supply (narrow money) growth rate	Percentages	OECD
M3	Quarterly money supply (broad money) growth rate	Percentages	OECD
Commodity prices	Quarterly change in the commodity price index	Percentages	IMF

Table 5. Macroprudential policy instruments

Number	Instrument
1	Countercyclical Buffers
2	Conservation
3	Capital Requirements
4	Leverage Limits
5	Loan Loss Provisions
6	Limits on Credit Growth
7	Loan Restrictions
8	Limits on Foreign Currency
9	Limits on the Loan-to-Value Ratio
10	Limits on the Debt-Service-to-Income Ratio
11	Tax Measures
12	Liquidity Requirements
13	Limits on the Loan-to-Deposits Ratio
14	Limits on Foreign Exchange Positions
15	Rserve Requirements
16	SIFI
17	Other

Source: Alam et al. (2019).

Appendix 2: Robustness tests

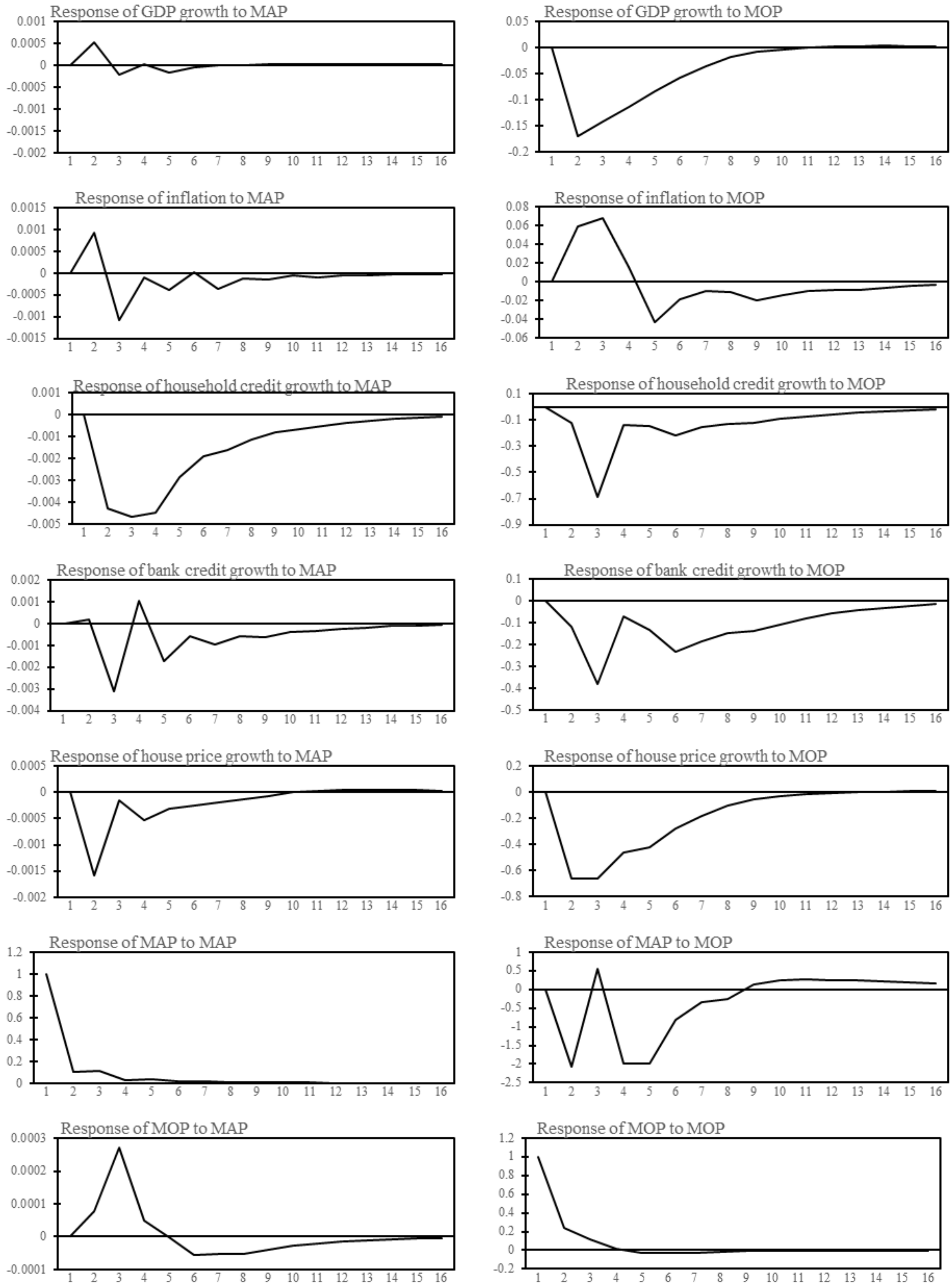

Figure 6. Impulse responses from the Bayesian VAR model. The shrinkage prior is set in accordance with the Minnesota priors (see Doan, Litterman & Sims, 1983; Litterman, 1986).

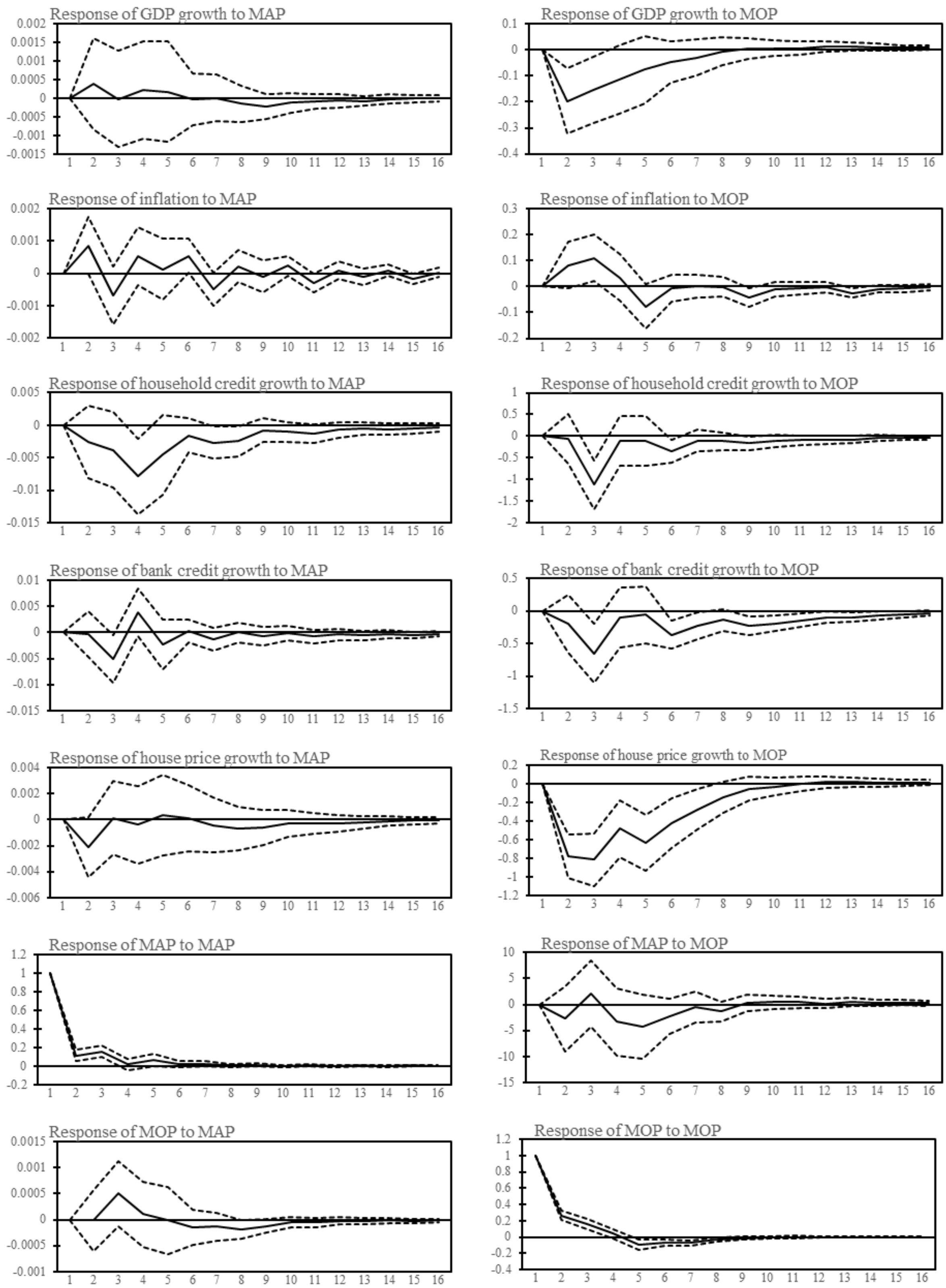

Figure 7. Impulse responses from the panel VAR model with commodity prices.

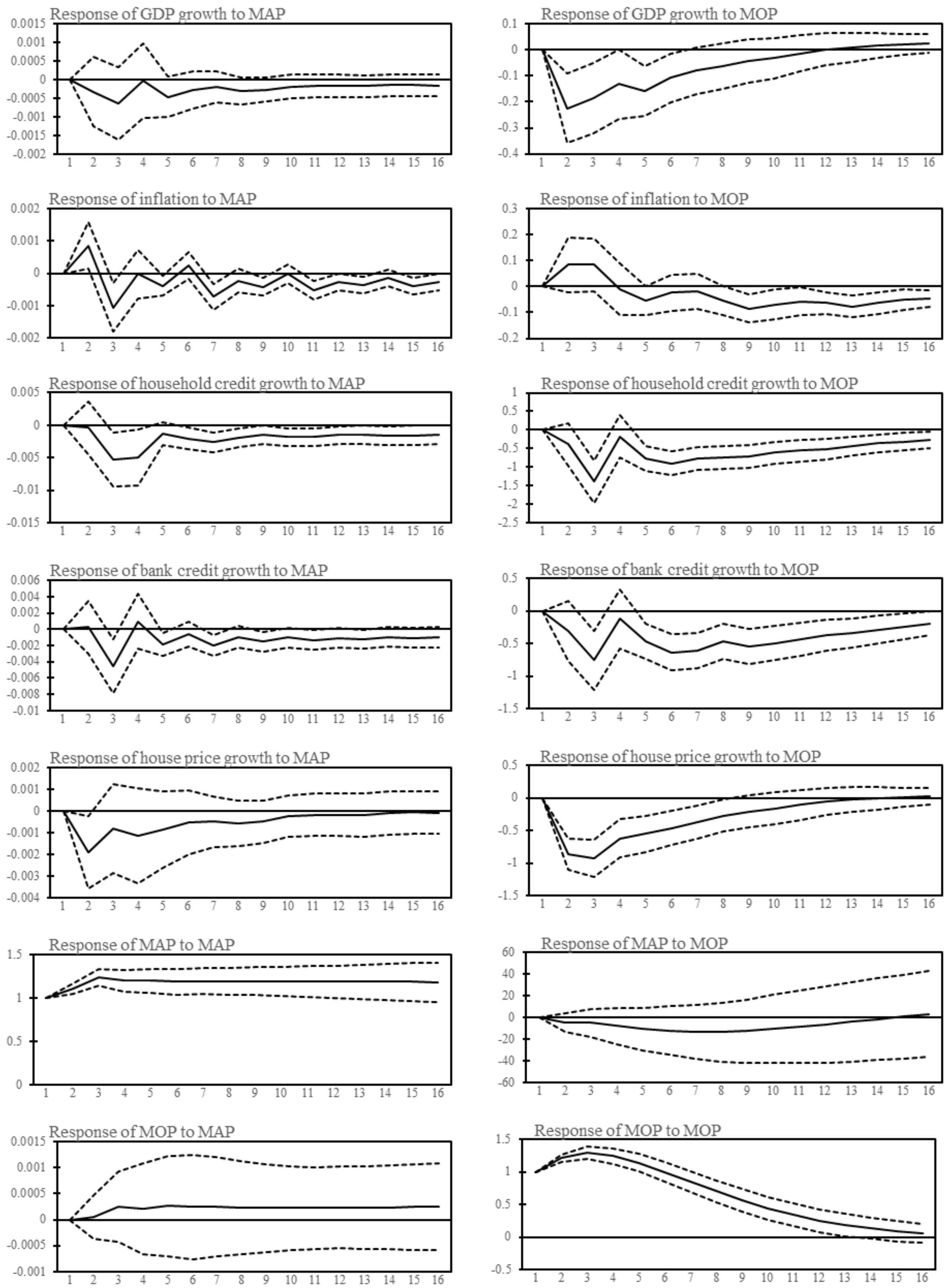

Figure 8. Impulse responses from the panel VAR model using cumulative macroprudential and monetary policies.

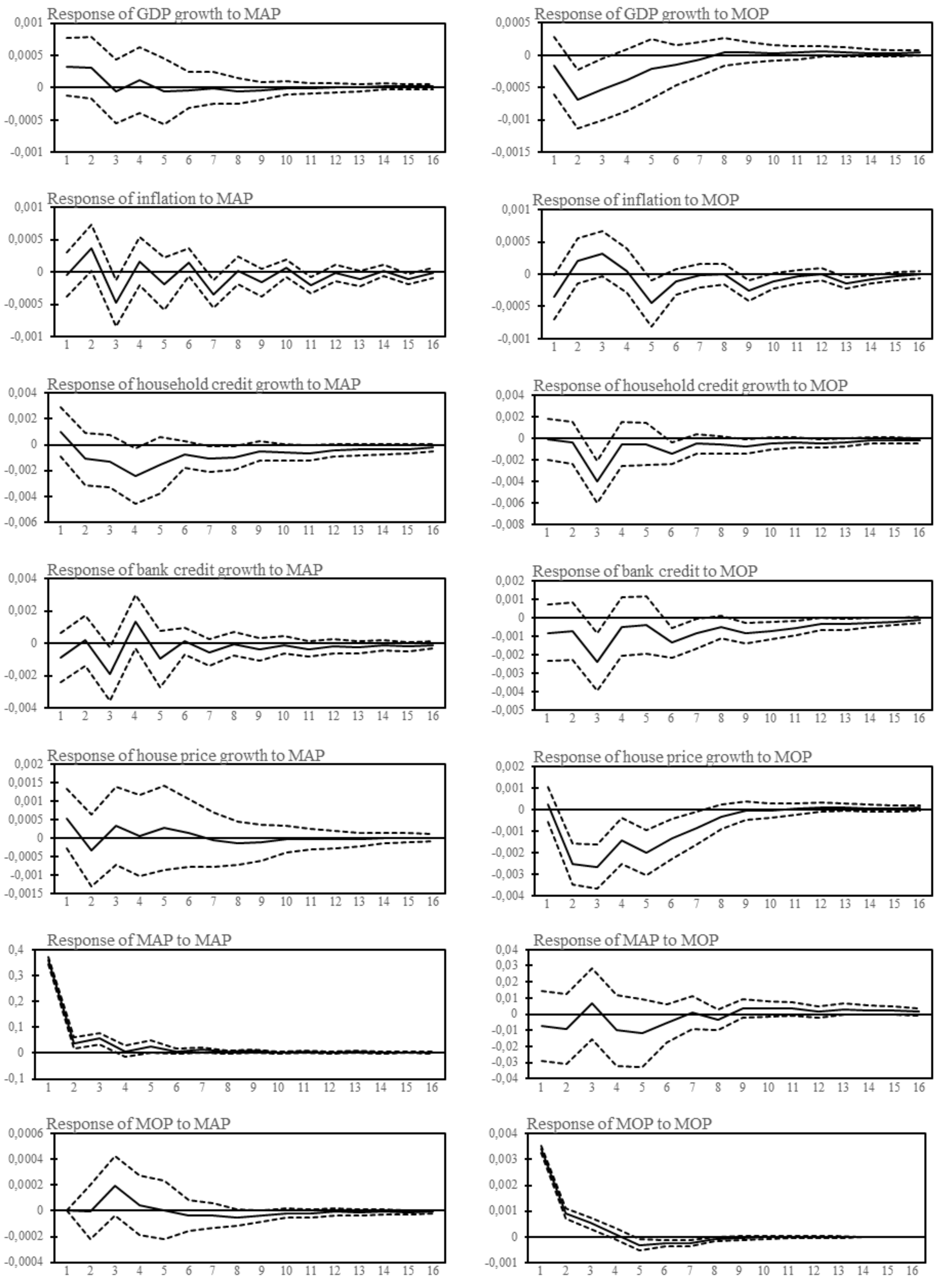

Figure 9. Impulse responses from the panel VAR model when changing the order of the endogenous variables.

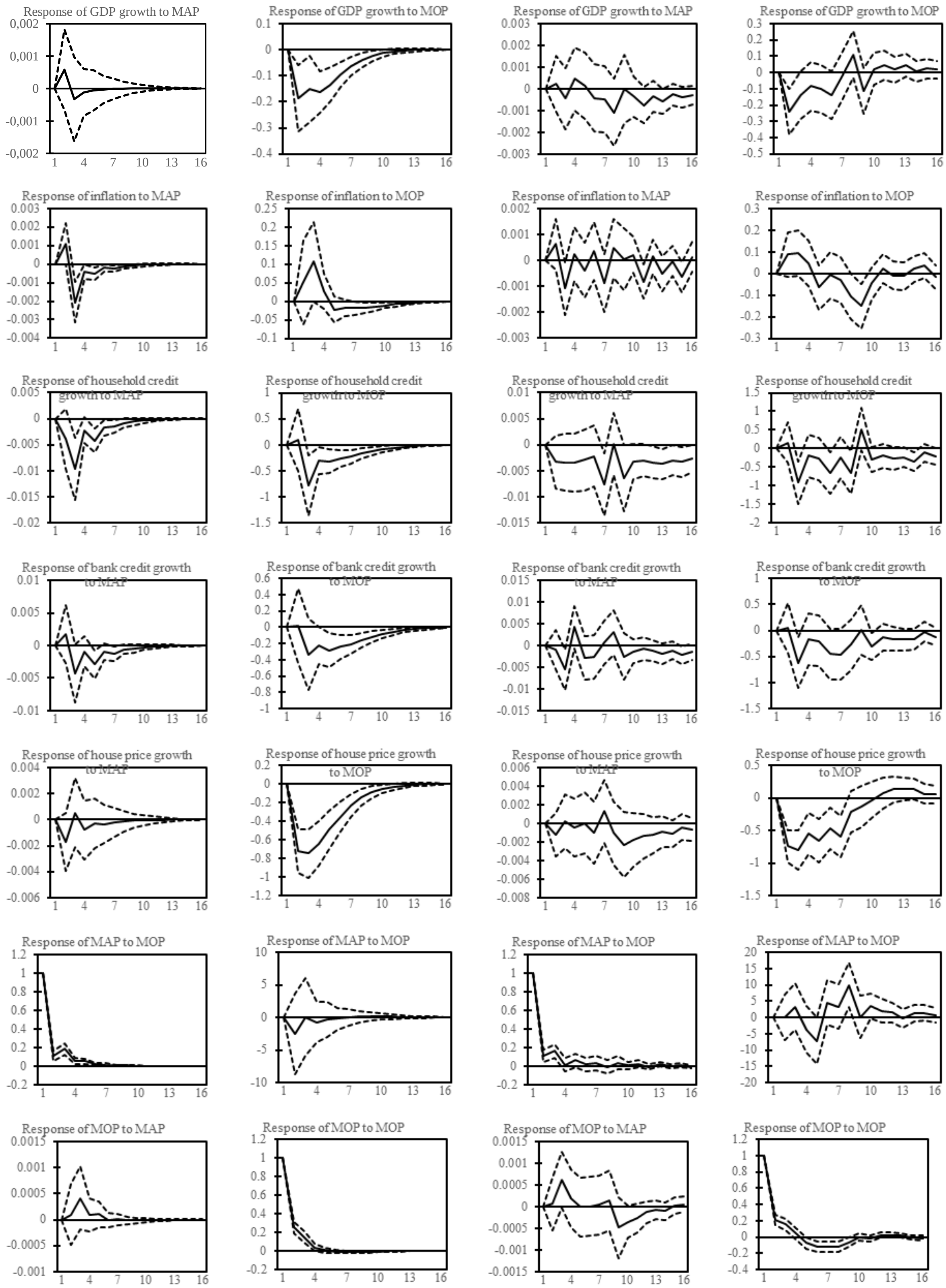

Figure 10. Impulse responses from the panel VAR model with different lag lengths (P). P = 2 in columns 1 and 2, and P = 8 in columns 3 and 4.