

Heterogeneous responses of capital flows to macroprudential policies: Evidence from Central, Eastern, and Southeastern Europe

Lukas Vashold^{1*}

¹ Vienna University of Economics and Business, Vienna, Austria

Abstract

Macroprudential policies are at the heart of the regulatory toolkit available to policy-makers that seek to maintain financial stability. Their effects on target variables such as credit growth have been studied extensively. Yet, empirical research on their impacts on capital flows and structural characteristics that influence them remains scant. We study the dynamic responses to macroprudential shocks in a region that was exposed to pronounced macrofinancial cycles and where countries adopted such measures comparatively early. A macroprudential tightening curbs credit growth and capital inflows but responses are heterogeneous, especially for the latter. We show that structural characteristics such as the exchange rate regime, the level of financial development, or the external openness of countries shape the effects of macroprudential policies. These mediating factors should be considered by policy-makers aiming to preserve financial stability, together with the appropriate choice from the broader set of regulatory measures at their disposal.

Keywords: Macroeconomic policy, financial stability, structural characteristics, panel vector autoregression

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*Correspondence to lvashold@wu.ac.at, Welthandelsplatz 1, 1020 Vienna, Austria. I would like to thank Markus Eller, Maximilian Böck, Florian Huber, Niko Hauzenberger, Helene Schuberth and Reiner Martin for continued support and cooperation in projects leading to this paper. Detailed remarks from Nikolas Kuschnig, Jesús Crespo Cuaresma, Francesco Zanetti, Thomas Zörner, and two anonymous referees were of great help.

1 Introduction

Macroprudential policies (MPPs) have the objective of enhancing financial stability from a systemic perspective. They extend the microprudential perspective, which aims at enhancing the stability of individual banks or financial institutions, and incorporate the broader limiting macroeconomic costs from financial distress in their target-setting (Galati and Moessner, 2018; Forbes, 2021). MPPs may also be suitable tools to prevent or mitigate imbalances resulting from large and volatile capital flows (Aikman et al., 2015; Forbes, 2021) as, even though they are not inherently designed to limit these flows, introducing them preemptively can contain the build-up of systemic vulnerabilities over time. Such precautionary actions could increase the resilience of the financial system to aggregate shocks, including those arising from exuberant capital inflows and their reversals (Aguirre et al., 2019; Takáts and Temesváry, 2019). The structural characteristics of countries are increasingly recognized to be potentially important factors shaping heterogeneous effects of MPPs (Claessens, 2015; IMF, 2017). Identifying those that matter and determining how they influence the effects of MPPs is highly relevant, especially in times of growing financial integration. Yet, empirical evidence on how such structural characteristics shape the link between MPPs and capital flows remains scant.

Countries in Central, Eastern, and Southeastern Europe (CESEE) experienced pronounced credit and housing price growth in the run-up to the global financial crisis (GFC), hand in hand with a surge of international capital inflows (Eller et al., 2010). While country authorities and international institutions initially considered these patterns to be part of the catch-up to more advanced economies, they grew concerned about the potential consequences in case of a slowdown or reversals, especially with respect to cross-border capital flows (Bakker and Klingens, 2012). These concerns led to the implementation of macroprudential measures in a range of CESEE countries, even before the wake of the GFC, making them early adopters in this respect (Vandenbussche et al., 2018; Poghosyan, 2020). The early adoption of MPPs and pronounced boom-bust cycles in macrofinancial quantities spurred efforts to evaluate the effectiveness of MPPs in this region, especially with respect to their primary goals such as taming credit growth or house prices (see

inter alia [Vandenbussche et al., 2015](#); [Kang et al., 2017](#); [Dumičić, 2018](#)). Recent studies also investigate the interplay between these measures and international capital flows in individual countries ([Eller et al., 2021](#)), finding considerable heterogeneity in dynamic responses across them. The role of structural characteristics shaping these heterogeneities however has been neglected so far.

In this paper, we investigate the dynamic effects of MPPs on credit growth and capital inflows in CESEE, with an emphasis on identifying structural characteristics that shape heterogeneities across countries. To assess this question empirically, we modify and extend the hierarchical VAR model proposed by [Jarociński \(2010\)](#) to allow for efficient estimation of both autoregressive and variance parameters in a panel setting, and compute dynamic group-level responses to a tightening macroprudential shock. This framework addresses issues riddling the prevalent literature ([Forbes et al., 2015](#)) and pools information across countries while allowing for deviations between them in a data-driven fashion, which enhances comparability of responses across different country groups. We incorporate an intensity-adjusted index for a broad spectrum of MPPs ([Eller et al., 2020b](#)) as well as country-specific and global factors to model a rich spectrum of interdependencies between MPPs and macrofinancial variables. With this setup at hand, we study the effects of MPPs on typical targets such as credit growth, provide new insights into the scarcely investigated link between MPPs and international capital flows, and put forward novel empirical evidence on structural characteristics of countries that shape the effects of MPPs on these quantities.

We find that MPPs are effective with regards to its goal of taming the domestic leverage cycle in the CESEE region. Credit growth is also curbed in most sub-panels and individual countries investigated. On the contrary, the impact of a tighter macroprudential environment on capital flows is more ambiguous. While there is evidence that MPPs reduce capital inflows in CESEE overall, we observe pronounced heterogeneities in these responses across countries (see also [Eller et al., 2021](#)). Digging deeper, the empirical results suggest that differences in the exchange rate regime, the level of financial development, and the degree of external openness are important factors for the heterogeneity in

the responses to a MPP tightening. These insights are an important impetus for further analyses into the transmission channels of MPPs on capital flows and other targets, both of a theoretical and an empirical nature. Equipped with our results, as well as with findings of concurrent and future research, policy-makers can base their decisions on solid, evidence-based research to achieve their goal of enhanced financial stability.

We proceed as follows. The next section provides an overview of the related literature. Section 3 then introduces the empirical framework employed, gives an overview of MPP activity in CESE, describes the data used, and elaborates on the identification scheme used for identifying a tightening MPP shock. Section 4.1 presents credit and capital flow responses to a macroprudential tightening in CESEE, highlighting heterogeneities across countries. Reflecting on these deviations, Section 4.2 provides insights on some potential structural characteristics that shape them. Section 5 concludes.

2 Related Literature

Taming the domestic leverage cycle in order to enhance financial sector resilience is one major goal of MPPs (ESRB, 2014). Excessive credit growth often precedes major financial crises and can increase the likelihood of (banking) crises to occur (Büyükkarabacak and Valev, 2010; Schularick and Taylor, 2012; Jordà et al., 2016; Greenwood et al., 2022). Large and volatile capital flows in turn are often associated with elevated foreign borrowing, credit booms (and their busts), and ultimately impact systemic financial sector risk as well (Reinhart and Rogoff, 2009; Fratzscher, 2012).

In the aftermath of the global financial crisis (GFC), the link between MPPs and their main objective of enhancing financial stability has become an area of active research. The theoretical literature focuses on the effects of MPPs on credit extension and asset prices (e.g. Korinek, 2018; Jeanne and Korinek, 2019). Optimally set MPPs can significantly reduce the probability of financial crises from excessive over-borrowing of the private sector (Bianchi, 2011; Bianchi and Mendoza, 2018; Krenz and Živanović, 2024) and the volatility of house prices and resulting household debt (Gelain et al., 2013), especially when different measures are used in combination (Goodhart et al., 2013). When designed

appropriately, MPPs can, in combination with aligned monetary policy, also increase social welfare across economic agents (borrowers and savers) that are differentially affected by a pandemic shock (Bratsiotis and Gloria, 2025). Although most MPPs are designed and implemented at a national level, investigating their effects at different levels has also received more attention. In a monetary union, cross-country differences in the degree of indebtedness or design of mortgage markets are important aspects to be considered as they can drive asymmetries of responses to different types of shocks (Malmierca, 2023; Rubio, 2024). On a more granular scale, the introduction of region-specific stabilization policies can also reduce within-country inequalities stemming from regionally differing housing cycles and enhance resilience overall (Suh, 2023).

Most empirical studies focus on the role of MPPs in taming the domestic leverage cycle (Cerutti et al., 2017a; Dumičić, 2018), dampening excessive asset price growth (Vandembussche et al., 2015; Kuttner and Shim, 2016), or both (Akinci and Olmstead-Rumsey, 2018; Alam et al., 2024). Generally, they are found to be effective in reducing exuberant credit growth, as well as stabilizing housing prices (albeit to an attenuated extent) (Araujo et al., 2024) but can also drive a shift towards more borrowing from the (less regulated) shadow bank sector (Hodula and Ngo, 2024). A growing literature also analyzes the impact of macroprudential policies on the bank or credit registry level (Jiménez et al., 2017; Andrieş et al., 2022; Benbouzid et al., 2022; Epure et al., 2024), allowing for a more accurate separation of supply and demand effects. There is ample evidence that the effectiveness of macroprudential measures in curbing credit extension depends on country characteristics. Effects of MPPs vary with developmental status of economies (e.g. Cerutti et al., 2017a; Akinci and Olmstead-Rumsey, 2018), with the chosen exchange rate regime (Kim et al., 2019; Ghosh and Kumar, 2022), the role of the central bank in the setting of MPPs (Kim et al., 2025), a country's financial development, inclusiveness and openness (Cerutti et al., 2017a; Ahamed et al., 2021; Giraldo et al., 2024) or the indebtedness of the private sector (Kim and Mehrotra, 2022). Furthermore, effects vary with the type of policies employed, the state of the country-specific business cycle, and the global financial cycle (see e.g. Cerutti et al., 2017a; Araujo et al., 2024; Epure et al.,

2024). It has also been shown that the effects of MPPs depend on the direction of the intervention, i.e. a tightening versus a loosening, with asymmetric responses being the norm rather than the exception (Benbouzid et al., 2022; Araujo et al., 2024).

Regarding the interplay between MPPs and capital flows, the theoretical literature is comparatively scarce. Actively setting MPPs can mitigate the negative effects of foreign borrowing shocks fueled by large capital inflows, their sudden reversals, and rapid asset price appreciation (Ghilardi and Peiris, 2016). They reduce the amount and the riskiness of financial liabilities financed by domestic and foreign lenders, i.e., those financed by capital inflows. This in turn can decrease the incidence and severity of crises by mitigating contractionary effects of exchange rate depreciations (Korinek and Sandri, 2016) or by stabilizing capital flows from banks in response to an increase in foreign interest rates (Kitano and Takaku, 2020). A priori however, there is no clear indication about the direction and magnitude of the direct effects MPPs can have on capital flows. Foreign exchange (FX)-based MPPs mostly target loans denominated in foreign currencies, impacting cross-border (banking) flows directly (Eller et al., 2021). Borrower-based MPPs such as loan-to-value (LTV) ratios on the other hand often have the primary aim to mitigate excessive and risky borrowing. Given the bidirectional links between capital flows and domestic credit growth (Lane and McQuade, 2014; Igan and Tan, 2017), MPPs can thus indirectly reduce recapitalization needs of bank subsidiaries. Conversely, increasing capital, liquidity or reserve requirements for banks may force foreign-owned subsidiaries to retort to their parent banks for recapitalization. Both of the latter two channels are especially prevalent in countries with high shares of foreign-owned banks, as is the case in CESEE (Eller et al., 2016), and work in opposite directions with regards to their potential impact on capital flows. Last, by strengthening the resilience of the domestic financial system, MPPs could also make it more attractive for international investors and thus increase capital inflows. The direct impacts of MPPs on capital flows is a promulgation of all of these channels and may thus differ across instrument types as well as structural characteristics of countries.

The role of such country characteristics driving country heterogeneities in responses of cross-border capital flows has important implications for the evaluation of the efficacy of MPPs. Both for the extensive and the intensive use of MPPs, characteristics related to the economic structure, institutions and financial markets of a country (henceforth subsumed under its *structural characteristics*) may be important determinants (Claessens, 2015), as is also recognized in the policy debate (IMF, 2017).

However, theoretical contributions on the role that these characteristics play in shaping responses to changes in the macroprudential environment are scant. Unsal (2013) shows in an open-economy DSGE model that under a fixed exchange rate regime, higher levels of macroprudential regulation result in slightly muted responses of capital flows and credit to a financial shock. Compared to a regime with flexible exchange rates however, capital flow responses to a MPP tightening are stronger for both broader and more targeted macroprudential measures, with the absence of exchange rate appreciation effects offered as an explanation for this differential effects. Farhi and Werning (2016) also consider the role of exchange rate regimes for the optimality of monetary and macroprudential policy, showing that the role and effects of macroprudential policies differ across them. For fixed exchange rates, macroprudential policies such as restrictions or taxes on capital inflows and outflows can be a second-best way of regaining some degree of monetary policy autonomy and dampen the effects of capital flows in booms and recessions. Ahnert et al. (2021) offer some theoretical insights for FX-based MPPs, where borrowers substitute from FX lending from banks towards other financial sectors. This insight implies some role of the level of financial development, with more developed markets or deeper financial institutions allowing easier switching towards other sources and thus potentially more muted effects of MPPs on both credit and capital flows. It also implies that the degree of indebtedness of economies and the structure of this debt may play a role for the effects of MPPs. In particular, the financial openness and exposure to external debt sources of countries are important determinants for financial stability and effects of MPPs differ along the spectrum of this dimension (Giraldo et al., 2024). However, providing evidence

on the existence of structural drivers for capital flow response heterogeneities is ultimately an empirical exercise.

Yet, the empirical literature on the relation between MPPs and capital flows in general is also still in its infancy. Recent papers focusing on their effects on the leverage cycle and asset prices shed light on the possible dynamics of MPPs and capital flows (inter alia [Forbes et al., 2015](#); [Fendoğlu, 2017](#); [Aizenman et al., 2020](#)), with some evidence pointing towards a stabilizing effect of MPPs for cross-border banking flows and lending shocks ([Takáts and Temesváry, 2019](#)). Only few papers study the direct response of capital flows to macroprudential policy measures, most of them focusing on the effects of FX-based measures, with mixed findings. Some studies find evidence for MPPs leading to reductions of capital inflows ([Bruno and Shin, 2015](#); [Aguirre et al., 2019](#); [Frost et al., 2020](#)), whereas others point in the other direction, namely that borrower countries with more frequent use of MPPs attract larger capital inflows ([Cerutti and Zhou, 2018](#); [Akdogan, 2018](#)). FX-based MPPs have been shown to meaningfully reduce domestic credit growth and short-term cross-border banking flows ([Aguirre et al., 2019](#); [de Crescenzo et al., 2017](#)), but can have the unintended consequence of banks increasing FX bond issuance as a response to lower FX borrowing, shifting the exposure to other sectors of the economy ([Ahnert et al., 2021](#)). Financial openness as a structural characteristic of countries has been shown to be a double-edged sword by increasing financial vulnerability via cross-border capital flows while also increasing bank liquidity ([Giraldo et al., 2024](#)). Another recent study utilizes a novel quantile regression framework to study capital flows to emerging markets and the impact of several policies, including MPPs ([Gelos et al., 2022](#)). Within this context, MPPs can mitigate the downside risks of adverse global shocks on portfolio inflows. Importantly, institutional frameworks matter for the medium-term bounce-back of foreign flows to the receiving country.

This mixed evidence with regards to the effects of MPPs on capital flows is a strong indication for country heterogeneity, a finding supported by recent studies of the dynamic reactions to MPP shocks. Most notably for our context, [Eller et al. \(2021\)](#) find supporting evidence for the overall effectiveness of MPPs to rein in excessive credit growth and to

reduce capital inflows but their results reveal substantial heterogeneity, especially so for capital inflows. In a related study, [Eller et al. \(2020b\)](#) also find that the effects of MPPs on credit extension differ across types of MPPs, with borrower-based measures affecting credit growth most strongly, and the type of credit, with household credit growth being affected in a more pronounced fashion. Compared to these studies, we introduce a unified modelling framework in the next section that bridges the gap between country-specific VAR estimation, as is done in [Eller et al. \(2021\)](#), and fixed-effects regressions that capture heterogeneity across countries by merely including a country-specific intercept, as is done on [Eller et al. \(2020b\)](#). This allows us to draw inference for country groups that have different structural characteristics and meaningfully compare them, while simultaneously acknowledging and endogenously modelling the heterogeneity across countries within them.

3 Econometric Framework & Data

The early empirical literature on the effects of MPPs mostly relied on simple fixed-effect panel regressions.¹ Such models can be problematic in at least two respects. First, they are generally not able to appropriately capture the endogenous interaction between macroeconomic, financial and policy variables over time ([Galati and Moessner, 2018](#); [Forbes, 2021](#)). Second, they often lack appropriate recognition of cross-country heterogeneity, with differences only captured by unit-specific intercepts. Heterogeneous patterns in the conduct of and responses to MPPs, potentially caused by these factors, highlight the need to go beyond simple fixed-effect panel regressions. Recently, there have been advances in these respects, most notably in the realm of dealing with endogeneity issues. These include [Richter et al. \(2019\)](#); [Rojas et al. \(2022\)](#); [Fernandez-Gallardo \(2023\)](#), who use local projections to investigate the impact of an MPP shock on macroeconomic quantities; [Kim and Mehrotra \(2018\)](#); [Kim et al. \(2019\)](#); [Kim and Mehrotra \(2022\)](#); [Kim et al. \(2025\)](#) that rely on panel vector autoregressions to study the impact of macropruden-

¹See, inter alia, [Claessens et al. \(2013\)](#); [Vandenbussche et al. \(2015\)](#); [Kuttner and Shim \(2016\)](#); [Cerutti et al. \(2017a\)](#); [Dumićić \(2018\)](#); [Alam et al. \(2024\)](#).

tial and monetary policy as well as their interrelation; [Gelos et al. \(2022\)](#) that employ a novel quantile regression framework; and [Chari et al. \(2022\)](#); [Budnik and Rünstler \(2023\)](#) that use an instrumental variable approach to extract exogenous MPP shocks. Country-specific conditions such as financial development, the exchange rate regime or macroeconomic stability are factors that should be considered for an appropriate identification of the effectiveness of MPPs ([IMF, 2017](#)). A host of studies tries to investigate heterogeneities across countries by grouping them according to structural characteristics (e.g. [Cerutti et al., 2017a](#); [Akinci and Olmstead-Rumsey, 2018](#); [Alam et al., 2024](#)) but stays within the simple fixed-effects regression framework.

In this paper, both of these problems are tackled in a unified manner by employing hierarchical Bayesian panel vector autoregressions. The proposed model setup allows for modelling a set of economies jointly, while capturing both local and global economic conditions adequately. It extends the model introduced by [Jarociński \(2010\)](#), allowing for (1) an efficient modeling of dynamic responses to an exogenous MPP shock and (2) identification of country heterogeneities in these responses. It has the advantage of acknowledging and endogenously modelling heterogeneities between countries within a given panel explicitly, making comparisons across panels in which countries share certain characteristics more meaningful.

Specifically, we assume for each country i ($i = 1, \dots, N$) in a given panel, that the M -dimensional vector of endogenous variables, $\mathbf{y}_{i,t}$ ($t = 1, \dots, T_i$), follows a VAR(p) process:

$$\mathbf{y}_{i,t} = \sum_{j=1}^p \mathbf{A}_{i,j} \mathbf{y}_{i,t-j} + \mathbf{B}_i \mathbf{w}_t + \mathbf{a}_i + \boldsymbol{\varepsilon}_{i,t}, \quad \boldsymbol{\varepsilon}_{i,t} \sim \mathcal{N}(0, \boldsymbol{\Sigma}_i), \quad (1)$$

where $\mathbf{y}_{i,t-j}$ denotes the j -th lag of the endogenous variables and the $M \times M$ matrices $\mathbf{A}_{i,j}$ contain the corresponding autoregressive coefficients. $\mathbf{w}_t$ is a $W \times 1$ vector of exogenous variables, with related coefficients collected in the $M \times W$ matrix $\mathbf{B}_i$. Based on the Deviance Information Criterion ([Li et al., 2025](#)), we chose a lag order of $p = 4$ for the endogenous variables as well as including contemporaneous values of the exogenous ones. Finally, $\mathbf{a}_i$ denotes the intercept vector and the vector $\boldsymbol{\varepsilon}_{i,t}$ holds Gaussian VAR innovations

with zero mean and variance-covariance matrix Σ_i . Collecting all coefficients related to lagged endogenous variables, the exogenous variables as well as the country-specific intercepts in $\mathbf{A}_i = [\mathbf{A}_{i,1}, \dots, \mathbf{A}_{i,p}, \mathbf{B}_i, \mathbf{a}_i]^\top$ (with resulting dimension $K \times M$, where $K = Mp + W + 1$), accounting for parameter heterogeneity boils down to treatment of $\mathbf{A}_i$ and Σ_i .

A common choice in the Panel VAR literature is to fully pool information across countries (see [Canova and Ciccarelli, 2013](#), for an excellent survey), akin to country-fixed effects in a panel regression setup. This would imply that almost all coefficients in $\mathbf{A}_i$ are assumed to be identical across countries and heterogeneity across countries is captured only by country-specific intercept terms $\mathbf{a}_i$. Such an approach is restrictive in that a high degree of homogeneity across countries and their parameters is presumed. Instead, we propose using a modeling approach that allows for coefficient heterogeneity in the spirit of hierarchical Bayesian modelling.

Specifically, we follow [Jarociński \(2010\)](#) and assume that country coefficients contained in $\mathbf{A}_i$ arise from a Gaussian distribution with a common mean. Let $\boldsymbol{\alpha}_i = \text{vec}(\mathbf{A}_i)$ for all i . Then

$$\boldsymbol{\alpha}_i | \bar{\boldsymbol{\alpha}}, \Sigma_\alpha \sim \mathcal{N}(\bar{\boldsymbol{\alpha}}, \Sigma_\alpha), \quad (2)$$

where $\bar{\boldsymbol{\alpha}}$ denotes the common mean vector with dimension $m = KM$. This prior setup carries the notion that country coefficients within a panel sharing certain characteristics tend to be similar, but not identical. Implicit in this formulation is the assumption that countries within a certain panel are similar and constitute special cases of the same underlying economic model (as argued by [Jarociński, 2010](#)). Based on the jointly estimated parameters, panel-wide as well as country-specific impulse responses can be recovered.

The prior variance-covariance matrix Σ_α effectively controls the country-specific deviations from the common mean. It is decomposed as $\Sigma_\alpha = \Omega_\alpha(\lambda_1 \otimes \mathbf{I}_m)$, where Ω_α is constructed similar to the well-known Minnesota prior ([Litterman, 1980](#)) (see [Appendix A](#) for a closer description). It imposes some structure by shrinking coefficients associated with endogenous variables towards the common mean, with the degree of shrinkage increasing

in the lag order j , while leaving coefficients of exogenous variables and deterministics unrestricted. The overall tightness parameter λ_1 effectively pushes the country coefficients towards the common mean. To achieve a data-driven balance between the two extreme cases of full pooling across countries and country-specific estimation of the model, we follow Jarociński (2010) and treat λ_1 as an additional parameter to be estimated.²

We further extend the model proposed by Jarociński (2010) by efficiently pooling information across countries for the estimation of the error variances in Σ_i . In particular, a hierarchical Wishart prior (Frühwirth-Schnatter, 2006; Malsiner-Walli et al., 2016) is imposed that carries a similar notion of combining information about the error variances across countries, but allows for deviations where the data deems it necessary. The conditional conjugacy of the whole prior setup implies that the (conditional) posterior distributions are well-known. See Appendix A for a detailed description of the full prior setup as well as hyperparameter choices and Appendix B for derivations of the various resulting posterior distributions. In this way, the degree of information pooling across countries is endogenized for both the autoregressive and variance parameters, and varies between panels, allowing for more meaningful comparisons between panel-wide responses.

The heterogeneity across countries in turn informs both the sampling of the heterogeneity parameters and the common posterior moments for the autoregressive and variance coefficients. As described in Appendix B in more detail, the posterior distribution of the common mean for the autoregressive coefficients depends on the averaged country-specific coefficients, weighted by the updated (inverse) prior variance-covariance matrix Σ_α , and its prior mean. Larger deviations of country-specific coefficients from zero, and across countries, thus also push the common mean further away from its prior mean, which is centered around zero. A similar logic applies to the variance parameters of countries and their common scaling matrix $\mathbf{C}_0$. The posterior draws of the common mean coefficients $\bar{\alpha}$ and the scaling matrix $\mathbf{C}_0$ can then be used to draw inference for the shocks of interest on an aggregate (i.e. panel-wide) level. Thus, based on this model setup, one can draw inference jointly for sets of countries, enabling comparisons between those groups. By treating

²Recent contributions go a step further by allowing for country- and even coefficient-specific heterogeneity parameters using Bayesian shrinkage priors (Boeck et al., 2024).

λ_1 , the heterogeneity coefficient, as an additional unknown parameter to estimate and accounting for uncertainty about it within panels, more meaningful comparisons between them become possible. Clustering countries in sub-panels based on different characteristics of them then allows for a closer investigation of different reactions to a macroprudential policy shock. This way, key structural characteristics driving these differences may be identified. Country-specific responses, which shape these group responses and are in turn shaped by them themselves, could also be obtained for each panel but suffer from limited comparability across them. We thus abstain from reporting them in Section 4.2, they are available on request.

3.1 Macroprudential policies in CESEE

The vast majority of studies regarding the effectiveness of MPPs relies on simple metrics to quantify such measures and their intensity. Most commonly, macroprudential activity is tracked by translating any tightening (loosening) incident into an increase (decrease) of one point in the respective country index and cumulatively summing up over time (e.g. [Shim et al., 2013](#); [Ahnert et al., 2021](#); [Alam et al., 2024](#)). These approaches come with the detriment that only the extensive margin of MPPs is captured, neglecting the strength of these adjustments — their intensity. As an example, a decrease in the loan-to-value (LTV) ratio by ten percentage points is treated identically to a lowering by one percentage point. The index used in this paper, introduced in [Eller et al. \(2020b\)](#), represents another approach for integrating the intensity of measures into an encompassing macroprudential policy index (MPPI) for eleven EU member states in CESEE.³ By applying a set of different weighting rules for the various incorporated measures, differences in the intensity of the adjustments are reflected in the index. However, it should also be noted that by aggregating across MPPs that target different aspects of financial institutions, heterogeneities across instruments may be concealed. We explore this issue in Appendix F.1. This way changes in the macroprudential environment are captured more precisely, allowing for a more accurate investigation of the effects of MPPs. A detailed description of the

³These countries are: Bulgaria (BG), the Czech Republic (CZ), Croatia (HR), Estonia (EE), Hungary (HU), Latvia (LV), Lithuania (LT), Poland (PL), Romania (RO), Slovenia (SI), and Slovakia (SK).

construction of the index, the underlying datasets, as well as the included instruments and exact weighting rules can be found in [Eller et al. \(2020b\)](#).

Figure 1 gives an overview of the MPPI for the given time period. It reveals, as previously mentioned, that a number of countries already implemented and tightened MPPs well before the GFC. Overall a substantial tightening in the region can be discerned from the CESEE-11 aggregate (constructed as a simple average across countries) in the top left panel. However, it also reveals heterogeneous patterns across countries. Some countries have been more active prior to the GFC, while others tightened their macroprudential stance only its aftermath and to a lesser extent. Figure C.1 in Appendix C gives closer insights in the composition of the overall MPPI and provides a more detailed overview of the most important developments.

3.2 Macrofinancial data

Alongside the intensity-adjusted index for macroprudential policies, we include several macrofinancial and macroeconomic quantities. The variables of primary interest in terms of responses to a macroprudential policy shock are credit growth and capital inflows. While the former is modelled as the quarterly change in total claims on the domestic private sector, the latter is measured in four-quarter moving sums of either gross total capital or gross other investment inflows as percentage of GDP. Other investment flows consist to a major part of flows originating from direct foreign lending to domestic banks ([Hahm et al., 2013](#)), and thus act as a proxy for banking flows. As most MPPs are targeted at the banking sector, the reactions of such flows are of particular interest. Further macroeconomic variables included in the empirical specification are GDP growth, the inflation rate, as measured by quarterly changes the (harmonized) consumer price index, and the short-term interest rate in order to control for interdependencies with monetary policy. German GDP growth and the German money market rate enter the model as exogenous variables as a means to account for leading role of Germany for the CESEE region (similar to the role of the US in global financial markets, see [Rey, 2015](#)).

Furthermore, a factor that captures the financial cycle for CESEE countries is included as an additional exogenous control to alleviate concerns with regards to a potential omitted variable bias. It is constructed by extracting the first principal component from a set of financial variables (in the spirit of [Eller et al., 2020a](#)). Compared to other global financial cycle indicators often used in macroeconomic studies (e.g. [Miranda-Agrippino and Rey, 2015](#)), the factor used here is more tailored to the context of CESEE countries with respect to the sample of countries. We also opted for choosing a more narrow set of financial variables than [Eller et al. \(2020a\)](#) that is more appropriate for the MPP context, namely the growth of credit and deposit stocks of banks as well as equity price returns. Results using other indicators for the global financial cycle are qualitatively similar and available upon request.

The period under investigation ranges from Q1 1997 until Q4 2018, thus covering the global financial crisis but excluding the COVID-19 pandemic. The end of the sample period is due to the availability of the intensity-adjusted MPPI and other indicators as well as to keep up comparability with [Eller et al. \(2021\)](#) that report more country-specific results. Table D.1 in Appendix D gives an overview of the variables included in the analysis for each country with a short description, their transformations pre-estimation and the main sources used to obtain them.

3.3 Identification of a MPP shock

To identify a tightening macroprudential shock, variables included in the model are ordered recursively and short-term zero restrictions are imposed. The identified shock is scaled to represent an one-unit increase in the MPPI. This corresponds, for example, to a decrease of the LTV ratio by five percentage points or an increase of the capital adequacy ratio for banks by one percentage point. We assume that the policy instrument for MPPs is contemporaneously exogenous to the macroeconomic variables included in the model. This carries the notion that changes in the macroprudential policy stance are lagging behind changes in economic conditions for a quarter. Other studies employing vector autoregressive models impose similar identifying assumptions ([Kim and Mehrotra,](#)

2017; Kim et al., 2019, 2025), but presume that macroprudential policy is instantaneously reactive to changes in economic conditions. We consider these identifying assumptions as somewhat problematic as there is typically a legislative process involved in setting MPPs, at least for their initial introduction. While policy-makers do observe economic conditions, their ability to react within the same quarter by proposing and implementing new macroprudential measures based on them is thus often hindered by a need for coordination with lawmakers (see e.g. Meeks, 2017). The existence of such decision lags has been exploited for the identification of fiscal policy shocks in a VAR framework (Blanchard and Perotti, 2002; Giordano et al., 2007; Ilzetzi and Jin, 2021), in a setting related to ours. Nonetheless, we also consider cases where the macroeconomic variables are assumed to be contemporaneously exogenous to the macroprudential policy instrument as well as interchanging the reaction function of monetary and macroprudential policy. The main results obtained by such alternative identification schemes are qualitatively similar, as reported in Appendix E. The use of data on quarterly frequency also alleviates some of the concerns regarding endogeneity of policy responses. Recently, alternative identification schemes of MPP shocks have been proposed (see e.g. Rojas et al., 2022; Chari et al., 2022; Budnik and Rünstler, 2023), lack of comparable data for most of the CESEE countries prevented us to follow similar strategies.

An additional concern when analyzing the effects of MPPs are potential anticipation effects. With a legislative process behind them, there may be a considerable lag between the date of announcement and the date of actual implementation of MPPs. The index used in this study accounts for such discrepancies by utilizing information on both the announcement and the implementation date of MPPs. In particular, for a tightening MPP the announcement date is taken into account, while for a loosening one the actual date of its implementation is used. This carries the notion that banks or other relevant actors react to a tightening in the macroprudential environment as soon as it is announced, e.g. by building up additional capital reserves. On the contrary, for loosening MPPs, banks have to adhere to the applicable regulations until the day of actual implementation. This

way anticipatory effects are factored in and identification concerns stemming from them are mitigated.

4 Results & Discussion

4.1 Effects of macroprudential policy in CESEE

Before focusing on the effects of MPPs on typical targets like reining in excessive credit growth and more unconventional ones such as dampening volatile capital inflows, a brief examination of reactions for all endogenous variables to a tightening in the macroprudential environment may prove insightful. Figure 2 shows the impulse responses of all endogenous variables to a tightening macroprudential policy shock corresponding to an unexpected one-unit increase in the MPPI.

It shows that MPP has significant effects on real as well as macrofinancial variables. GDP growth and price inflation fall in response to an unexpected tightening in the macroprudential environment. The decrease in inflation is of a prolonged nature, indicating persisting effects of MPPs on inflation. There is also suggestive evidence for interdependencies between macroprudential and monetary policy. The short-term interest rate decreases three quarters after the MPP shock and shows some erratic behaviour in the following quarters. The expansionary reaction of monetary policy in the beginning is in accordance with theoretical contributions ([Alpanda and Zubairy, 2017](#)) and empirical analyses ([Kim and Mehrotra, 2018](#)).

Turning to macrofinancial variables, our results suggest that credit growth is significantly reduced for an extended period of time in response to a tightening MPP shock. Within the first quarters following such a shock the decrease is sizable and dissipates only slowly. This indicates that, in general, MPPs are effective with respect to their target of taming excessive credit growth in the CESEE region, in line with theoretical predictions ([Bianchi and Mendoza, 2018](#)) and previous empirical studies ([Vandenbussche et al., 2015](#); [Dumičić, 2018](#)). For gross total capital and other investment inflows (CAP and OI inflows henceforth) the emerging picture is less clear. For both types of capital inflows there is no

significant effect on impact. However, about two years after the MPP shock, both types of capital inflows are lowered significantly with some persistence. This delayed decrease can be rationalized with lower demand for capital inflows, e.g. in the form of reduced refinancing needs of banks, that results from substantially lower credit growth. Results for the variables discussed are qualitatively robust to the inclusion of additional economic variables, such as equity price growth, changes in the real effective exchange rate and capital outflows (see Figure E.1 in the Appendix). As discussed in Appendix F.1, effects of MPPs also depend on the main aspect they are targeting. Figure F.1 provides some insights into the effects of different types of MPPs, operationalized as subindices of the MPPI, on macrofinancial variables. It provides further evidence that different types of MPPs affect macrofinancial quantities differently. Borrower-based measures such as LTV ratios having the strongest effects, in line with the prevalent literature (Cerutti et al., 2017b; Richter et al., 2019). They also corroborate recent findings that these effects may differ with the considered horizon (Andrieş et al., 2022), further research in the dynamic effects of different MPP types is thus warranted.

Table 1 reports the values of a forecast error variance decomposition of the MPP shock for the three variables of main interest. This allows for inference regarding the relative importance of MPP shocks in explaining variation in these variables over time. It appears that the explanatory power of macroprudential policy for fluctuations in credit growth and capital inflows is rather limited. A little more than five percent of the variance of credit growth is explained by a shock in the macroprudential environment. This value is even smaller for the capital inflows, with a maximum of 2.18% and 1.66% for CAP and OI inflows, respectively. This discrepancy is not surprising, considering that taming the leverage cycle is an explicit goal of MPPs while capital flows are no primary targets and they are strongly driven by global financial factors, with regional and local conditions only of secondary importance (Eller et al., 2020a). Yet, perceptions about the regulatory quality of countries are important determinants for decisions of private investors, especially in the post-crisis period Boonman (2023), offering a potential explanation for the

slightly higher explained variance of CAP inflows, which also include portfolio inflows, as opposed to OI inflows.

Up to now, the obtained results referenced to the overall effects of MPPs in the CESEE region. However, the nature of the proposed model allows for heterogeneities regarding country parameters. This in turn permits country-specific deviations of the responses from the regional results and a more granular view with respect to the effects of MPPs in the individual countries. Figure 3 provides an overview of country-specific impulse responses for credit growth and capital inflows to a tightening MPP shock. It reveals that impulse responses to a macroprudential tightening vary substantially between countries. Credit growth is reduced significantly in a majority of countries, but peak responses differ in magnitude. The reactions of both CAP and OI inflows are much more diverse. While the peak responses in the individual countries are also often negative, some remain insignificant or even indicate an increase in inflow levels.

These findings of pronounced heterogeneity between countries regarding the impact of a tightening MPP shock on capital inflows are in line with previous research on the effectiveness of MPPs in the CESEE region (Eller et al., 2021). They also underline the potential importance of country-specific characteristics as determinants of capital flows and the effects of MPPs as already stressed by policy-makers (IMF, 2017). The next section investigates a series of such structural characteristics that might be possible drivers of heterogeneities in the responses to a change in the macroprudential environment.

4.2 Structural differences driving heterogeneous MPP responses

As described in Section 3, the model approach taken in this paper allows for more meaningful comparisons between panels consisting of different countries. In such a way the responses of groups that share specific structural characteristics can be compared and possible determinants that shape the effects of MPPs can be examined. In what follows, we use the average of the splitting variable across countries as a splitting rule to distinguish between “high” and “low” categories of countries, where applicable. Applying this rule splits countries in similarly large country groups. While the exact thresholds that

are used as splitting criteria are thus somewhat arbitrary, there is typically a clear divide around them, with countries being either clearly above or clearly below them. In a first step, we analyze how institutional differences might affect the effectiveness of MPPs. For this, we focus on the exchange rate regime as well as the overall level of financial development. Next, we consider the debt structure and financial openness of economies, in particular their degree of external indebtedness and the share of loans denominated in foreign currency on total private sector loans.

As discussed in Section 2, there is ample evidence from theoretical and empirical studies that the effects of MPPs are dependent on country characteristics, the economic cycle, and their direction of change. Further, the state of the regulatory framework and changes therein are important determinants for capital flows, especially for countries where the banking sector consists largely of subsidiaries of internationally acting banks, as is the case in CESEE (Eller et al., 2016). Our choice of structural characteristics to examine is guided by the relevance attributed to them in the policy debate (e.g. IMF, 2017).

The exchange rate regime a country adopts is one of the most widely discussed determinant of capital inflows and the effects of MPPs. Economies with a flexible exchange rate may absorb external shocks through currency adjustments. In contrast, countries with a fixed or tightly managed exchange rate are more vulnerable to capital flow volatility, implying a stronger reliance on MPPs and potentially stronger effects of them (Obstfeld et al., 2010). The sign and magnitude of the capital flow response may depend on the type and direction of the MPP intervention. The overall financial development of an economy can also condition policy effectiveness. In more advanced financial systems, the complexity and depth of markets can blunt the impact of MPPs, while in less developed systems, they may have more immediate and pronounced effects for credit growth (Claessens et al., 2013), with potentially delayed impacts for capital flows. This dimension captures the regulatory capacity of countries but also potential for circumvention of MPPs via other lending channels, which can shape outcomes by influencing market perceptions and compliance (Cerutti et al., 2017b).

The debt structure, particularly the level of external indebtedness and the share of foreign currency (FX) loans in total lending, can also significantly influence policy transmission. High external debt or widespread issuance of FX-denominated loans increases exposure to exchange rate volatility and capital flow reversals, thereby magnifying financial fragility. In such contexts, macroprudential tools need to be carefully tailored to manage currency mismatches and systemic risks, ensuring stability in credit markets and resilience to global financial shocks ([Galati and Moessner, 2018](#)). The responses of credit growth and capital flows to MPP shocks may thus also deviate between countries with different debt structures and external openness, as evidenced by previous studies (see e.g. [Kim and Mehrotra, 2022](#)). Differences for capital flows can stem from the refinancing needs of banks in financially more open countries, especially when subsidiaries of foreign-owned banks play a larger role in the banking sector. A tightening of the macroprudential environment is also likely to have stronger contractionary effects on credit growth and capital inflows in countries where the share of loans denominated in foreign currency is already high. This is the case as certain MPPs are specifically designed to regulate such positions in the balance sheet of banks (for example, FX mismatch limits or FX-specific lending restrictions) ([Ahnert et al., 2021](#)). Thus, in countries with higher initial levels of FX exposure, we would expect stronger reactions of macrofinancial quantities to MPP adjustments.

The first and second columns of Figure 4 refer to results corresponding to sample splits based on the exchange rate regime. A majority of countries in the CESEE region have some sort of fixed exchange rate, most often pegged to the Euro, or adopted the Euro itself at some point in the observation period. The Czech Republic, Hungary, Poland and Romania on the other hand have (semi-)floating exchange rates. For both regimes a significant reduction in credit growth is observable, albeit the impact for countries with a fixed exchange rate regime is a bit more pronounced. Considering the reactions of capital inflows some striking differences are revealed. Countries with flexible exchange rates exhibit a tendency of reduced capital influxes but none of the responses is significant. This is in contrast with the significant increase of such inflows for countries with fixed exchange rates together with a slight, but insignificant tendency for rising CAP inflows. These

results are in line with theoretical contributions that relate these differences to the inability of countries with a fixed exchange rate regime to conduct adjustments in their exchange rate to counteract effects of MPP changes (Unsal, 2013). They also provide evidence that MPPs can be a more effective way of dampening the adverse effects of excessive capital in- and outflows at different stages of the economic cycle in these economies (Farhi and Werning, 2016). Taken together, these results highlight that transmission channels of MPPs are different for countries with differing exchange rate regimes, as previously reported for credit extension (Kim et al., 2019). Our results provide evidence for similarly heterogeneous responses of capital flows, an aspect policy-makers should consider in their choice and design of regulatory instruments, including MPPs.

Another possible determinant for the effectiveness of MPPs is the level of overall financial development of countries. Based on average values of the index developed by Svirydzenka (2016) that captures several dimensions of financial development for the analyzed period, we differentiate countries by their relative financial development, with Czechia, Estonia, Hungary, Poland and Slovenia belonging to the financially more developed group, i.e. with “high” financial development. The third and fourth columns in Figure 4 show impulse responses for these country groups. The insignificant impact of MPPs on credit growth in financially more developed countries, together with the significant decrease for financially less developed countries, is in line with previous results (Kim and Mehrotra, 2022). These differences likely stem from the complicated enforcement of MPPs in economies with more complex financial systems and a larger shadow banking economy (Hodula and Ngo, 2024). However, other studies have found significant negative effects on credit growth in advanced economies (see Richter et al., 2019; Fernandez-Gallardo, 2023), implying that the degree of financial development might not correlate perfectly with economic development. Turning to the reactions of capital inflows there are also substantial differences. For CAP inflows there is a slight reduction of inflow levels in financially more developed countries while there is an upwards tendency, only marginally significant, for economies with less developed financial systems within the first year after a MPP tightening that is followed by slight reductions after about two years. A similar pattern with more pronounced

reductions in the medium-term horizon emerges for OI inflows. Whereas there is no significant reaction for countries with a higher level of financial development, OI inflows reduce in countries with a less developed financial system after seven to eight quarters. These results can be reconciled with recent findings that increased regulatory quality is an important determinant for the investment decision of investors ([Boonman, 2023](#)). MPPs might be perceived as being advantageous to the resilience of the financial system and can lead to higher portfolio investment inflows, that are part of CAP inflows. The reduction at later horizons might again be due to the pronounced decrease in credit extension, reverberating into lower refinancing needs of foreign-owned subsidiaries from their parent banks. For countries that are already financially more developed this effect seems to be absent, potentially as the perception of the regulatory quality is higher a priori and additional measures reduce the attractiveness for investors. We investigate alternative measures for the financial development of countries in [Appendix F.2](#), including the private debt-to-GDP ratio and the subindex for the depth of financial institutions from [Svirydzenka \(2016\)](#). [Figure F.2](#) shows that results are qualitatively similar. Countries with lower private debt levels and shallower financial institutions show larger reduction in credit growth, consistent with previous studies ([Kim and Mehrotra, 2022](#)). For capital flows, a tightening macroprudential shock leads to slight delayed decreases in capital inflows, more pronounced so for OI inflows, potentially due to the lower credit demand.

The degree of financial openness of an economy is another aspect that might be influencing the reaction of macrofinancial variables to a tightening MPP shock, especially so for cross-border capital flows ([Giraldo et al., 2024](#)). Two measures that can be considered for this aspect, among others, are the degree of external indebtedness and the share of loans extended to the private sector denominated in foreign currencies.

Impulse responses for countries with a high and low level of external debt are depicted in the first and second columns of [Figure 5](#).⁴ Comparing the impulse responses of these

⁴Economies in the high external indebtedness sub-sample have had an average external debt-to-GDP ratio of more than roughly 80% in the observation period, the mean across countries in that period. Data on gross external debt in percent of GDP was obtained from the [annual database](#) of the Vienna Institute for International Economic Studies (wiiw). Bulgaria, Estonia, Croatia, Hungary, Latvia and Slovenia are considered to be countries with high external indebtedness.

country groups with each other, differences in the capital flow responses again catch the eye. Countries with a high foreign debt exposure show a tendency of increased inflows in the first year after such a shock, with OI inflows even rising significantly. In contrast, for capital inflows in countries with a low external debt-to-GDP ratio a tightening in the macroprudential environment has no effect for an extended period of time followed by marginal decreases. This is in line with studies that show that MPPs in countries with higher external exposure lead to increases of bank flows into the country (Reinhardt and Sowerbutts, 2015; Avdjiev et al., 2019). They also corroborate recent empirical evidence that countries with a higher degree of financial openness (as can also be proxied by their level of external debt) may be more financially stable but also more susceptible to capital flow volatility (Giraldo et al., 2024). The negative responses of credit growth are quite similar for these two country groups, however in countries with low external debt the reduction is a tad more prolonged. This indicates, together with the observed differences in capital inflow responses, that MPPs are affecting their target variables differently in these regimes, more strongly so in countries with a lower degree of external indebtedness or financial openness.

A number of MPPs target, either directly or indirectly, the exposure of banks to foreign currencies. For example, this can take the form of higher risk weights for FX loans or stricter lending restrictions for loans in foreign currencies. Thus, the share of FX loans on total loans as a proxy for the reliance of the economy on such loans may prove as an important factor for the efficacy of MPPs (see also Ahnert et al., 2021). The last two columns in Figure 5 show impulse responses of credit growth and capital inflows for countries grouped by their share of FX loans.⁵ In terms of reducing these variables, MPPs are found to be more effective in those countries that feature a high share of loans in foreign currencies. Credit growth is decreasing sharply following a tightening MPP shock and is remaining at a lower level quite persistently. Capital inflows are diminishing slightly with a bit of a delay for these countries, with OI inflows being a bit more affected. Whereas

⁵Data on FX loans to total loans obtained from the wiiw database. Countries with a share of less than roughly 35% form the group defined as having a low FX loans share based on the mean across countries. These were the Czech Republic, Poland, Slovenia and Slovakia.

these responses can be seen as evidence for the effectiveness of MPPs, their use has also been shown to shift exposure by substituting FX lending from banks to other sectors of the financial system that might be less regulated (Hodula and Ngo, 2024). On the other hand, for countries with a low share of FX loans, both CAP and OI inflows exhibit no significant reaction to an unexpected tightening shock in the macroprudential environment, neither on impact nor afterwards. Furthermore, the response of credit growth is also more muted for this country group, although a short-lived reduction is observable. These differences indicate that a tightening in the macroprudential stance, which often involves stricter regulations for foreign exposures, has a larger effect in countries that exhibit a high share of FX loans, corroborating previous studies (Ahnert et al., 2021).

We also investigate differences with regards to the timing of macroprudential activity in Figure F.3, showing that macrofinancial quantities in countries that adopted MPPs earlier showed stronger credit growth responses in lines with the primary mandate to rein in excessive credit growth in this period. Capital inflows on the other hand are only marginally impacted in both country groups and exhibit different reactions. Last, we also conduct a sample split by time period rather than by country characteristics, considering the periods before and after the GFC. Though the impulse responses are estimated less precisely due to the low numbers of available time periods, Figure F.3 reveals stronger effects on credit growth in the pre-crisis period and mixed evidence for capital inflows.

5 Conclusion

The mediating impact of country characteristics on the effects of MPPs are important factors to consider for policy-makers. This pertains to the effectiveness of MPPs to achieve their direct targets, such as reining in exuberant credit growth, but also for their effects on cross-border capital flows, which are typically not considered to be directly targeted by MPPs. However, the interaction of capital flows with domestic financial variables makes the analysis of the effects of MPPs on capital flows, and the impact of structural characteristics, highly relevant. Yet, the heterogeneous effects of MPPs, especially with

regards to capital flows, remains an understudied issue in the empirical literature; with few exceptions (Gelos et al., 2022).

In this paper, we investigate the effects of MPPs on private sector credit growth and capital inflows in CESEE. The region experienced a pronounced leverage cycle, boom-bust periods of cross-border capital flows, and adopted macroprudential regulations comparatively early on and frequently, making it an ideal research subject for the effects of MPPs. We use an intensity-adjusted index that captures such policies in a more accurate way and employ a hierarchical Bayesian panel vector autoregressive model to efficiently pool information across countries while still allowing for parameter heterogeneity. This unified framework explicitly acknowledges and endogenously models country-specific heterogeneity, making comparisons across country panels more meaningful.

The empirical results suggest that macroprudential policy curbs credit growth and reduced capital inflows, albeit to a lesser extent and with some delay, in CESEE. However, they also reveal substantial heterogeneities in response to a tightening in the macroprudential stance, especially so for capital inflows. Investigating these differences, we find that the effects of macroprudential regulation hinge on different country characteristics such as the exchange rate regime, the level of financial development or the financial openness and debt structure of an economy. These results are robust to a multitude of specification variations and highlight the importance of these determinants for the efficacy of macroprudential policies. Yet, it should be kept in mind that there remains substantial cross-country heterogeneity within panels of countries that share specific structural characteristics. Hence, specific policy choices should take the domestic and international macroeconomic environment, the broader prudential environment, and the state of the banking sector into account.

Considering the heterogeneities uncovered in the present study is of importance for policy-makers in order to make well-informed decisions. Yet, further research is needed to trace the influence of such country characteristics, the differential effects of MPPs targeting different aspects of financial institutions, and the interaction thereof. Aggregating across macroprudential instruments that differ in their target-setting in a single index, as

is done for most results presented here, may conceal heterogeneous responses. As explored in Appendix F.1, there are heterogeneities across different types of MPPs, and examining their interplay with country characteristics more closely is a promising avenue for future research. In a similar vein, the extension of the index to cover a broader sample of countries could be a valuable starting point for more in-depth analyses to increase external validity beyond CESEE countries. Such analyses could also include approaches for an endogenous clustering of countries (see e.g. Huber et al., 2023), the subsequent use of cluster analyses to examine the importance of structural characteristic more closely, and the exploration of interactions between macroprudential and monetary policy.

6 Data and Code Availability

The data, code and results underlying this study can be accessed at Mendeley Data (<https://doi.org/10.17632/3p7frzss8x.1>). Additionally, code and data can be accessed on Github (https://github.com/oDNAudio/macropru_heterogeneity_cesee) and data binaries containing the results are available from Zenodo (<https://doi.org/10.5281/zenodo.15463643>).

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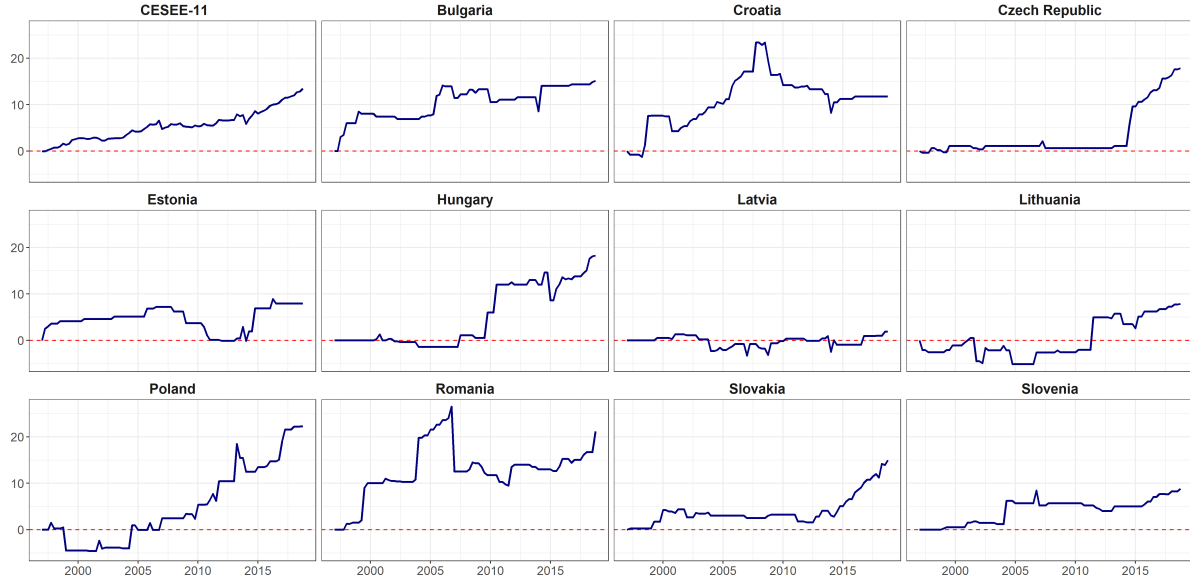
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Figures & Tables

Figure 1: Intensity-adjusted macroprudential policy index (MPPI) for the time period Q1 1997 to Q4 2018 using announcement (implementation) dates of MPPs for tightening (loosening) measures.



Note: Authors' own calculations based on [Eller et al. \(2020b\)](#).

Figure 2: Impulse responses of macroeconomic quantities to a tightening MPP shock

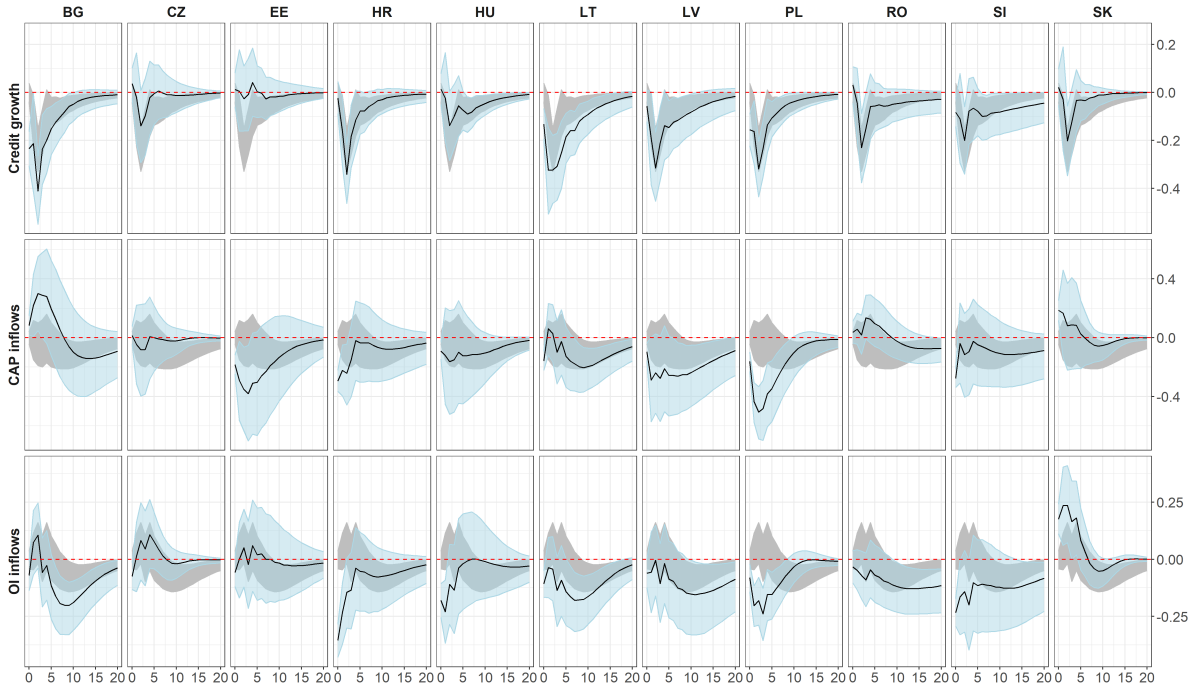


Note: Impulse responses for all included endogenous variables (except the MPPI) following a tightening macroprudential policy shock modeled as an unexpected one-unit increase in the MPPI for the CESEE region. Black lines denote the posterior median response, blue shaded areas refer to the 68% credible set.

Table 1: Forecast error variance decomposition for a tightening MPP shock

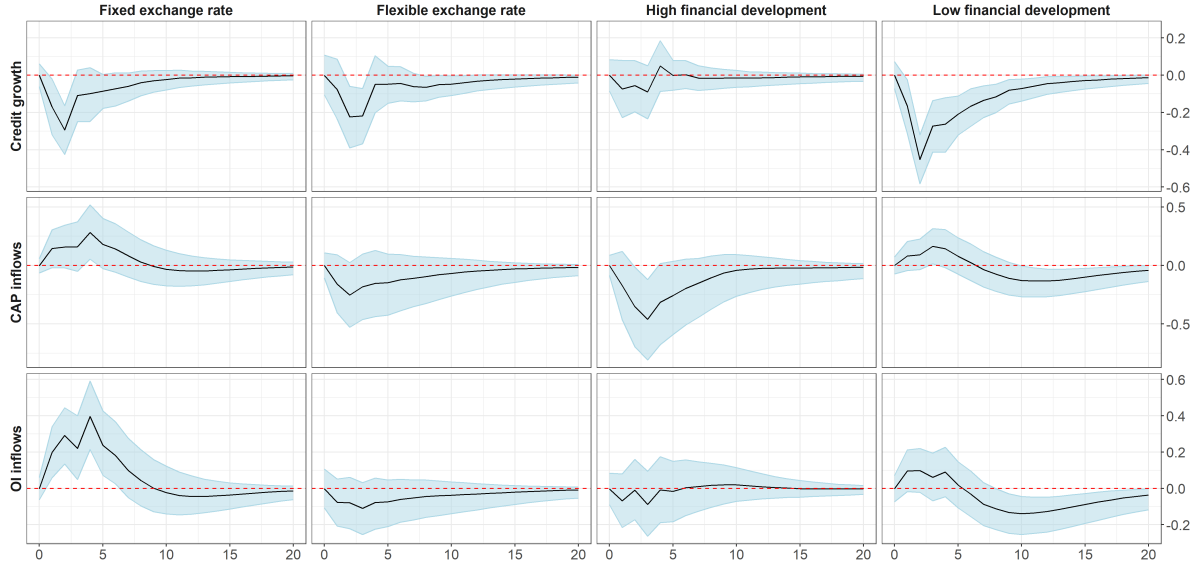
Horizon	1-year	2-year	3-year	4-year	5-year
Credit growth	5.22 [2.50-9.20]	5.27 [2.45-9.45]	5.24 [2.43-9.40]	5.22 [2.42-9.37]	5.22 [2.41-9.35]
CAP inflows	1.13 [0.34-3.61]	1.55 [0.51-4.34]	1.95 [0.72-4.93]	2.12 [0.81-5.21]	2.18 [0.83-5.28]
OI inflows	0.67 [0.24-1.96]	1.04 [0.42-2.39]	1.47 [0.59-3.01]	1.61 [0.65-3.30]	1.66 [0.67-3.39]

Note: Table shows forecast error variance decomposition of credit growth, gross total capital inflows and other investment inflows following a tightening macroprudential shock. The 68% credible intervals are in brackets. All values in percentage points.

Figure 3: Country-specific impulse responses of macrofinancial quantities to a tightening MPP shock

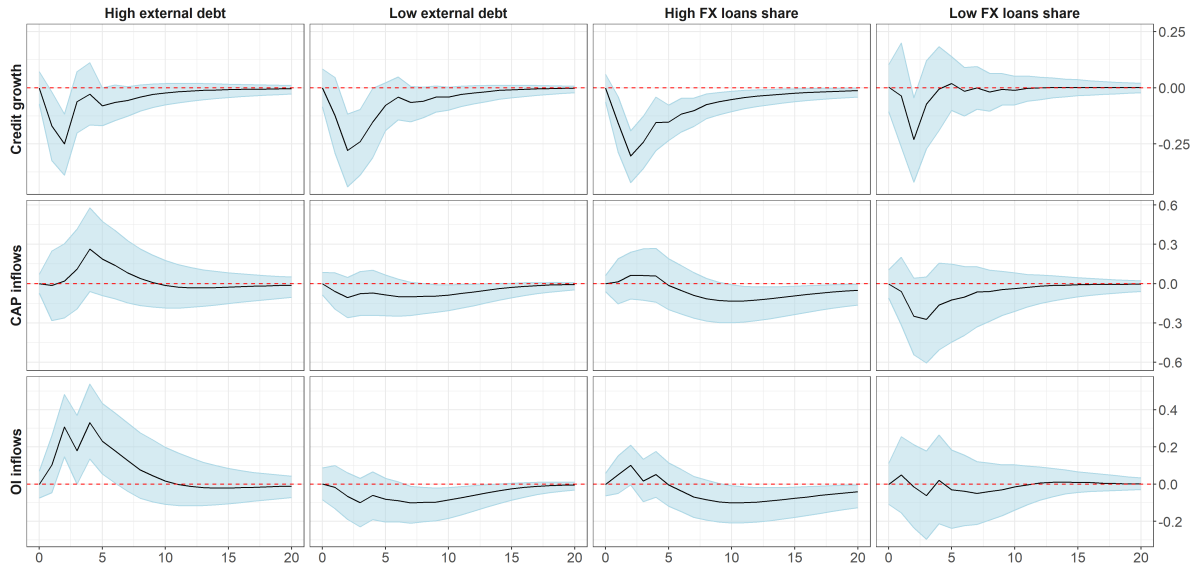
Note: Impulse responses for credit growth, gross total capital inflows and other investment inflows following a tightening MPP shock modeled as an unexpected one-unit increase in the MPPI. Black lines denote the posterior median response, blue shaded areas refer to the 68% credible set. Grey shaded area refers to the 68% credible interval of the impulse responses for the CESEE region.

Figure 4: Impulse responses of macrofinancial quantities for countries split by exchange rate regime and degree of financial development



Note: Impulse responses for credit growth, gross total capital inflows and other investment inflows following a tightening macroprudential policy shock modeled as an unexpected one-unit increase in the MPPI. The first and second columns refer to responses for countries with different exchange rate regimes. The third and fourth columns present responses for country groups differing in their degree of financial development. Black lines denote the aggregate posterior median response, blue shaded areas refer to the corresponding 68% credible set.

Figure 5: Impulse responses of macrofinancial quantities for countries split by external indebtedness and FX loans share



Note: Impulse responses for credit growth, gross total capital inflows and other investment inflows following a tightening macroprudential policy shock modeled as an unexpected increase of one unit in the MPPI. The first and second columns refer to countries with high and low degrees of external indebtedness, respectively. The third and fourth columns present responses for countries with high and low ratios of FX loans to total loans, respectively. Black lines denote the aggregate posterior median response, blue shaded areas refer to the corresponding 68% credible set.

Appendix A Full prior setup

Here, we specify the full prior setup for the hierarchical Bayesian VAR setup introduced in Section 3. First, for the common mean $\bar{\alpha}$, we elicit a Gaussian prior, $\bar{\alpha} \sim \mathcal{N}(\mathbf{b}_0, \mathbf{B}_0)$, with prior parameters set to relatively uninformative values, i.e. $\mathbf{b}_0 = \mathbf{0}$ and $\mathbf{B}_0 = 10^2 \mathbf{I}_m$.

Next, on Σ_α we impose a structure that resembles the specification of the covariance matrix of the well-known Minnesota prior (Litterman, 1980). For that, we rely on a fixed diagonal covariance matrix Ω_α , with $\Sigma_\alpha = \Omega_\alpha(\lambda_1 \otimes \mathbf{I}_m)$. The variance parameters of Ω_α that correspond to elements in α_i , i.e. relating endogenous variables to the lags of themselves and other endogenous variables, are given by:

$$\omega_{\alpha_{kl}} = \left(\frac{\sigma_k^2}{\sigma_l^2} \right) \left(\frac{\lambda_2}{j^{\lambda_3}} \right)^2,$$

where σ_k^2 and σ_l^2 are pooled OLS residual variances obtained from running M autoregressive models on the pooled data to control for relative coefficient sizes. λ_2 denotes a parameter relating to cross-variable lag coefficients specified as $\lambda_2 = 1$ for $k = l$ and 0.5 otherwise. λ_3 controls the degree of shrinkage for higher lags. Following large parts of the literature it is set equal to 1. For the coefficients regarding the exogenous variables and the intercept terms, the variance is given by:

$$\omega_{\alpha_{c_k}} = \sigma_k^2 \lambda_4^2,$$

where λ_4 is the variance parameter controlling prior tightness on these parameters. Setting λ_4 to a high value (e.g. 10^2) implies leaving these parameters almost unrestricted.

The full covariance matrix can then be constructed as $\Sigma_\alpha = \Omega_\alpha(\lambda_1 \otimes \mathbf{I}_m)$. λ_1 is the overall tightness parameter and effectively pushes the country coefficients towards the common mean. $\lambda_1 = 0$ implies that the country coefficients will all be equal to the common mean, i.e., full pooling of the data is achieved. For $\lambda_1 \rightarrow \infty$ the prior becomes uninformative, i.e. there is no information pooling across countries.

Jarociński (2010) achieves a balance between these two cases by treating λ_1 as an additional parameter to be estimated, in the spirit of hierarchical modeling. This way, the degree of information pooling across countries is endogenized and varies between panels. Deviating slightly from Jarociński (2010), who elicits a inverted Gamma prior on λ_1 , we impose a Gamma prior on this parameter:

$$\lambda_1 \sim \mathcal{G}(v, s).$$

Combining this with the prior density of α_i for all i (see Equation 2), it is easy to show that the conditional posterior distribution of λ_1 is of a generalized inverse Gaussian form. Specifying the prior in this way mitigates the problem of results being sensitive to prior parameter choices, as pointed out by Jarociński (2010) and Gelman (2006) for the inverted Gamma hierarchical prior setup. Given λ_1 , it is then possible to construct Σ_α and draw the country-specific coefficients in turn. We specify $v = s = 0.01$, implying a relatively uninformative prior for this parameter.

We extend the model proposed by Jarociński (2010) by also pooling information across countries for the error variances Σ_i for each country i . A hierarchical Wishart prior (Frühwirth-Schnatter, 2006; Malsiner-Walli et al., 2016) of the following form is imposed on Σ_i^{-1} :

$$\begin{aligned}\Sigma_i^{-1} &\sim \mathcal{W}(C_0, c_0), \\ C_0 &\sim \mathcal{W}(Q_0, q_0),\end{aligned}$$

The hyperparameters c_0 , q_0 and Q_0 are specified to achieve regularization of the variance-covariance matrices as:

$$\begin{aligned}c_0 &= 2.5 + \frac{M-1}{2}, \\ q_0 &= 0.5 + \frac{M-1}{2}, \\ Q_0 &= \frac{100q_0}{c_0} \Sigma_0,\end{aligned}$$

where $\Sigma_0 = \text{diag}(\sigma_1^2, \dots, \sigma_M^2)$ is a scaling matrix containing the same pooled OLS residual variances as mentioned above.

This completes the introduction of the hierarchical prior setup used in this study. Appendix B provides details about the resulting (conditional) posterior distributions of the various quantities as well as the sampling scheme used to draw from them.

Appendix B Posterior simulation

The model proposed relies on a Markov chain Monte Carlo (MCMC) algorithm that consists of several blocks to simulate the posterior quantities of interest. In this section, we briefly summarize the conditional posterior distributions of the various quantities as well as an efficient sampling scheme to draw from them. The generic notation $|\bullet$ indicates conditioning on all remaining parameters as well as the data. As initial values, we use OLS estimates of $\hat{\alpha}_i$ and $\hat{\Sigma}_i$ for all i , set $\bar{\alpha} = N^{-1} \sum_{i=1}^N \hat{\alpha}_i$ and define $\lambda_1 = 0.1$. Conditional on these starting values, the algorithm cycles through the following steps:

1. Draw the country-specific coefficients from a multivariate Gaussian posterior distribution, i.e. $\alpha_i|\bullet \sim \mathcal{N}(\bar{\alpha}_i, \bar{V}_i)$ with posterior mean and variance given by:

$$\begin{aligned}\bar{V}_i &= (\Sigma_i^{-1} \otimes \mathbf{X}_i^\top \mathbf{X}_i + \Sigma_\alpha^{-1})^{-1}, \\ \bar{\alpha}_i &= \bar{V}_i [(\Sigma_i^{-1} \otimes \mathbf{X}_i^\top) \mathbf{y}_i + \Sigma_\alpha^{-1} \bar{\alpha}],\end{aligned}$$

where $\mathbf{y}_i = \text{vec}(\mathbf{Y}_i)$.

2. The posterior distribution of the common mean is also multivariate normal, $\bar{\alpha}|\bullet \sim \mathcal{N}(\bar{\mathbf{b}}, \bar{\mathbf{B}})$ with:

$$\begin{aligned}\bar{\mathbf{B}} &= (N \Sigma_\alpha^{-1} + \mathbf{B}_0^{-1})^{-1}, \\ \bar{\mathbf{b}} &= \bar{\mathbf{B}} \left(\Sigma_\alpha^{-1} \sum_{i=1}^N \alpha_i + \mathbf{B}_0^{-1} \mathbf{b}_0 \right).\end{aligned}$$

3. Derive the updated prior variance-covariance matrix for the country-specific coefficients, Σ_α , by first drawing the heterogeneity coefficient λ_1 from a generalized inverse Gaussian distribution:

$$\lambda_1|\bullet \sim \mathcal{GIG}\left(-\frac{NMK}{2} + v, \sum_{i=1}^N (\alpha_i - \bar{\alpha})^\top \Omega_\alpha (\alpha_i - \bar{\alpha}), 2s\right).$$

Then obtain Σ_α from $\Sigma_\alpha = \Omega_\alpha(\lambda_1 \otimes \mathbf{I}_m)$.

4. Simulating the posterior draws of the country-specific variance-covariance matrix Σ_i within the hierarchical Wishart setup proceeds in two steps:

- (a) The common scaling matrix $\mathbf{C}_0$ has a Wishart posterior distribution, $\mathbf{C}_0|\bullet \sim \mathcal{W}(\bar{\mathbf{Q}}, \bar{q})$ with:

$$\bar{\mathbf{Q}} = \mathbf{Q}_0 + \sum_{i=1}^N \Sigma_i^{-1}$$

$$\bar{q} = q_0 + Nc_0$$

- (b) Draw Σ_i^{-1} (for $i = 1, \dots, N$) from its Wishart conditional posterior distribution:

$$\Sigma_i^{-1}|\bullet \sim \mathcal{W}(\bar{\mathbf{C}}_i, \bar{c}_i)$$

$$\bar{\mathbf{C}}_i = \mathbf{C}_0 + \frac{1}{2} \sum_{t=1}^{T_i} (\mathbf{y}_{i,t} - \mathbf{A}_i \mathbf{x}_{i,t}^\top)(\mathbf{y}_{i,t} - \mathbf{A}_i \mathbf{x}_{i,t}^\top)^\top$$

$$\bar{c}_i = c_0 + T_i/2$$

This algorithm is repeated 20,000 times with the first 5,000 draws being discarded as burn-in. From the remaining draws every third is stored and used for inference purposes. The convergence of the sampled parameters was assessed visually as well as with the aid of convergence diagnostics. Results confirm successful convergence toward their stationary distribution and are available on request.

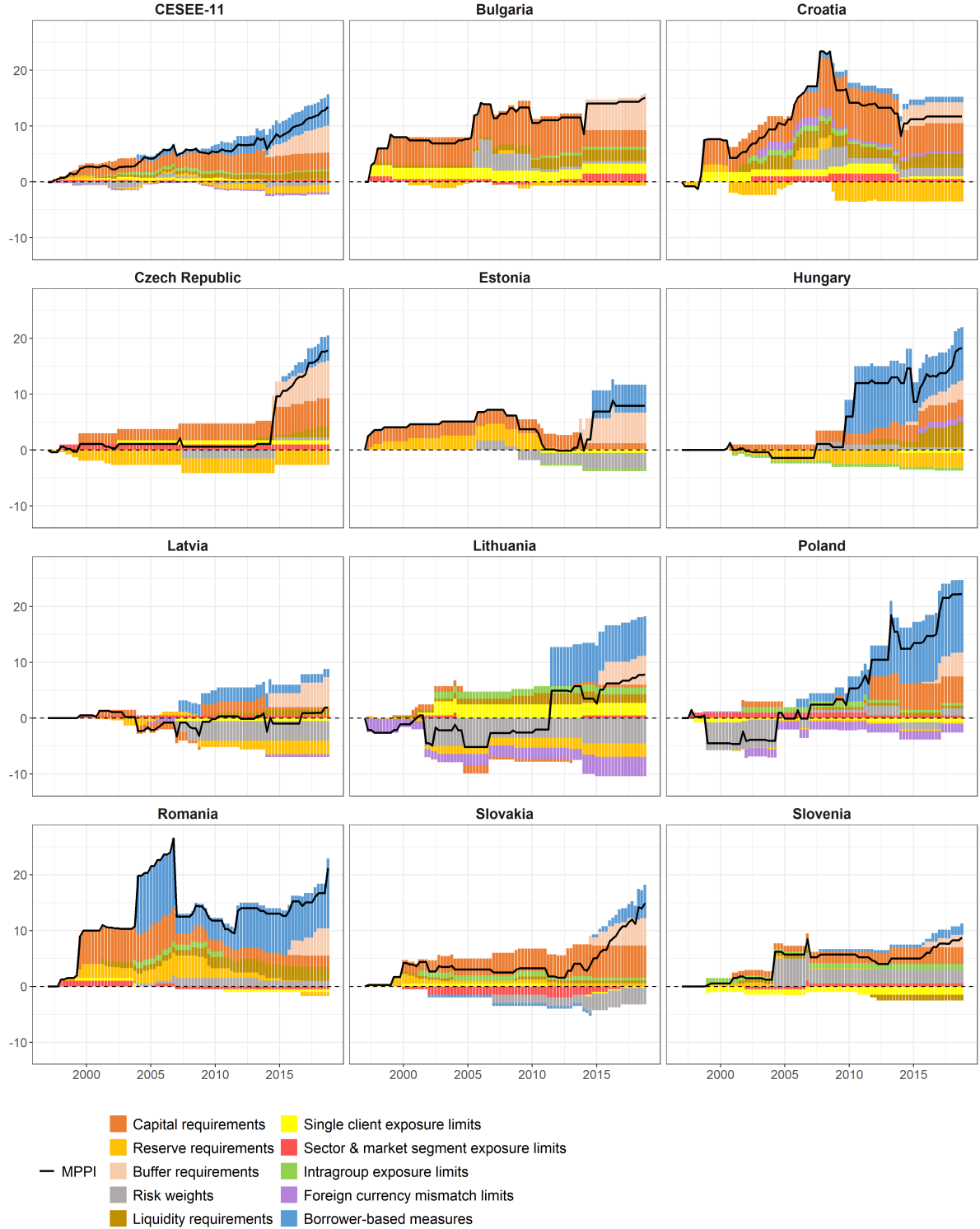
Appendix C Detailed MPP activity in CESEE

This Section gives a more detailed overview about the MPP activity of the eleven EU member countries in CESEE. These countries are: Bulgaria (BG), the Czech Republic (CZ), Croatia (HR), Estonia (EE), Hungary (HU), Latvia (LV), Lithuania (LT), Poland (PL), Romania (RO), Slovenia (SI), and Slovakia (SK).

While Figure 1 in the main part of this paper gives an overview of total macroprudential activity in CESEE, Figure C.1 allows for a more granular consideration. It depicts the individual instruments and subindices constituting the overall MPPI. With regards to the employment of macroprudential policies there are striking patterns. First, there are some countries, like Bulgaria, Croatia, Estonia, Romania and Slovenia, that tightened their macroprudential stance substantially already before the GFC. Other countries such as the two remaining Baltic states and Poland also showed considerable usage of MPPs prior to the GFC, however the actions taken did not lead to a pronounced tightening until after the GFC. On the contrary, Hungary and the Czech Republic implemented rather few changes to the macroprudential environment prior to the GFC, but tightened substantially in its aftermath.

Second, in terms of composition, the types of instruments used is varying over time. In the pre-crisis period capital-based measures like minimum capital or reserve requirements in combination with risk weights were used most actively. This contrasts with the increased implementation of borrower-based measures like LTV or DSTI limits which is a post-crisis phenomenon. Romania constitutes the only case that shows considerable changes prior to the GFC for these measures. [Poghosyan \(2020\)](#) also notes that regarding the implementation of lending restrictions the CESEE region again has a pioneering role. In the more recent past, buffer requirements are the group of measures that have been implemented most actively.

Figure C.1: Detailed composition of the MPPI



Note: Different subindices (bars) of the intensity-adjusted MPP index using announcement (implementation) date for tightening (loosening) measures and their respective contribution to the overall index (black line) for the time period 1997Q1-2018Q4. Authors' own calculations based on (Eller et al., 2020b). Time series have been rescaled to start at 0.

Appendix D Data

Table D.1: Variable description

Variable	Description	Main source(s)
<i>Main variables</i>		
MPPI	Intensity-adjusted macroprudential policy indicator, first differences	Eller et al. (2020b); own calculations
GDP growth	GDP volume, 2005=100, seasonally adjusted, in logarithms, quarter-on-quarter changes	IMF-IFS
Inflation rate	(Harmonized) consumer price index, 2005=100, seasonally adjusted, quarter-on-quarter changes	IMF-IFS; Eurostat
Credit growth	Claims on domestic private sector, (H)CPI deflated, seasonally adjusted, in logarithms, quarter-on-quarter changes	IMF-IFS; BIS
Short-term interest rate	Typically, three-month money market rate (per annum), first differences	IMF-IFS; ECB; Eurostat
Capital inflows	Cumulative four-quarter moving sums of gross total capital or gross other investment (BPM6 definition) inflows as percentage of GDP	IMF-IFS
<i>Exogenous variables</i>		
German GDP growth	GDP volume, 2010=100, seasonally adjusted, in logarithms, quarter-on-quarter changes	IMF-IFS
German short-term interest rate	Three-month money market rate (per annum), first differences	OECD
Global financial factor	First principal component extracted from a set of equity price, credit and deposit growth rates for a global sample of 45 countries, no further transformations	Eller et al. (2020a); Eller et al. (2021); own calculations
<i>Additional variables</i>		
Equity price growth	Equity price index, 2005=100, seasonally adjusted, in logarithms, quarter-on-quarter changes	IMF-IFS; OECD
REER	Real effective exchange rate, CPI-based index, seasonally adjusted, in logarithms, quarter-on-quarter changes	IMF-IFS
Capital outflows	Cumulative four-quarter moving sums of gross total or gross other investment (BPM6 definition) outflows as percentage of GDP	IMF-IFS

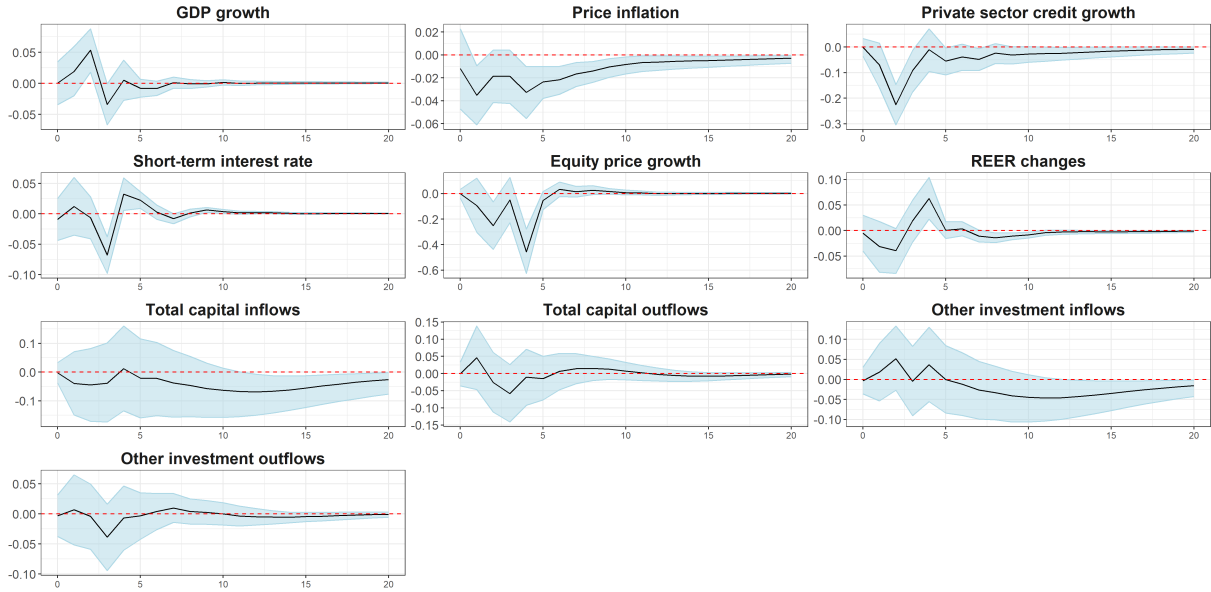
Notes: Table shows included variables for each country under investigation, a short description with their corresponding transformations for estimation as well as sources from where they are gathered. Seasonal adjustment was conducted using the Census X12 method. For Poland capital flow series were not satisfactorily available at quarterly frequency at the beginning of the sample; corresponding annual figures and the quarterly dynamics of the available sample were used for data interpolation. Missing equity price data was interpolated using either dynamics of similar OECD series (where available) or of GDP growth. Moreover, if the short-term interest rate was not available, dynamics of the deposit rate for data interpolation were used. In the case of few remaining missing observations at the beginning or the end of the sample, averages of the subsequent or previous four quarters to fill these gaps were used. All variables were transformed to be (approximately) stationary.

Appendix E Robustness checks

The baseline results discussed in Section 4.1 are fairly robust to a number of changes in the model specification. As a first robustness check the baseline model is extended with information about equity price growth, quarterly changes in the real effective exchange rate (REER) and capital outflows. The estimated impulse responses (see Figure E.1) are qualitatively similar and indicate strong reductions in credit growth together with more moderate decreases in capital inflows, although the effects are a bit more muted than in the baseline specification.

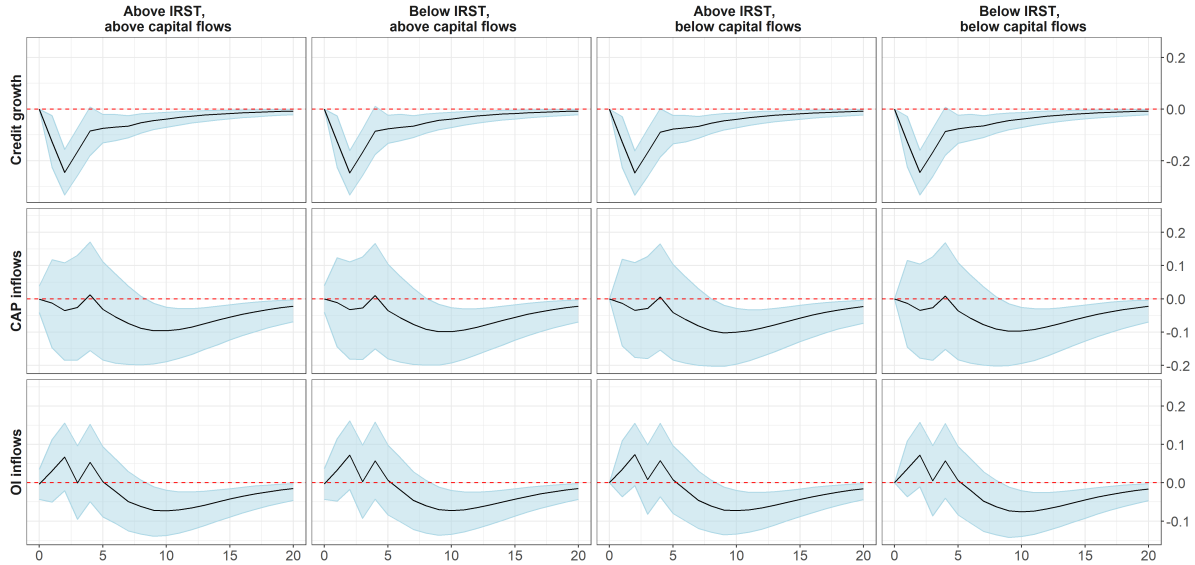
Furthermore, as already argued in Section 3.3, ordering of variables used to achieve identification might be challenged. Figure E.2 shows impulse responses for the macrofinancial variables of main interest under alternative identifying assumptions. It can be observed that results are largely unchanged by different orderings of variables corresponding to these alternatives. This is true for the cases where MPPs are assumed to be contemporaneously exogenous to capital flows, but not to real variables, and also holds for the cases where all variables are assumed to be contemporaneously exogenous to MPPs. As an additional robustness check we also change the ordering between the macroprudential and the monetary policy instrument. The obtained results are again qualitatively similar to the baseline results. Finally, changes in the lag order of variables, both regarding endogenous and exogenous ones, as well as using different sets of exogenous variables yield similar results and are available on request.

Figure E.1: Impulse responses for model with increased set of endogenous variables



Note: Impulse responses following a tightening macroprudential policy shock modeled as an unexpected one-unit increase in the MPPI for model with an increased set of endogenous variables. Model includes equity price growth, changes in the real effective exchange rate and capital outflows (both for gross total capital and other investment) as additional variables. Black lines denote the aggregate posterior median response, blue shaded areas refer to the 68% credible set.

Figure E.2: Impulse responses of macrofinancial quantities under varying identifying assumptions



Note: Impulse responses for credit growth, gross total capital inflows and other investment inflows following a tightening macroprudential policy shock modeled as an unexpected one-unit increase in the MPPI for different identifying assumptions. The first column reports results for the specification where macroprudential policy is assumed to be reactive to real variables and credit growth but to be exogenous to the short-term interest rate and capital flows. The third column depicts results for the specification where all variables are assumed to be contemporaneously exogenous to both policy instruments. The second and fourth columns refer to specifications where the interest rate is assumed to be contemporaneously exogenous to macroprudential policy i.e. the order of the policy instruments is switched. Black lines denote the aggregate posterior median response, blue shaded areas refer to the corresponding 68% credible set.

Appendix F Additional results

F.1 Effects of different MPPs

As depicted in Figure C.1 and described in more detail in Section C, the intensity-adjusted MPPI captures a multitude of macroprudential measures that aim at different aspects regarding the financial soundness of banks and other financial institutions. While the overall MPPI thus is an accurate representation of changes in the broader (macro)prudential environment, it is also likely that the effects of MPPs differ with respect to the main aspects they target. Figure F.1 presents responses of the main macrofinancial variables of interest following a tightening shock for different subindices of the MPPI. It can be discerned that there are indeed differences in the responses across MPP types. For capitalization- and liquidity-based MPPs (CAP-MPPI and LQ-MPPI; upper and middle panel in Figure F.1), effects on credit growth and capital flows show an overall tendency to increase after a tightening of these measures. The increases in capital flows could be indicative for increased refinancing needs of subsidiary banks in CESEE countries that are met with transfers from abroad. On the contrary, for the borrower-based subindex (BB-MPPI; lower panel of Figure F.1), that captures measures such as loan-to-value or debt-service-to-income ratios, pronounced and long-standing decreases in the investigated macrofinancial quantities can be observed. This underscores the effectiveness of these measures for macroprudential goals that has also been identified in the recent empirical literature (Cerutti et al., 2017b; Richter et al., 2019). While the results presented here provide suggestive evidence of effect heterogeneity of MPPs with respect to their primary targets, more research in this direction is warranted.

Figure F.1: Impulse responses of macrofinancial quantities for CESEE countries for different subindexes of MPPI



Note: Impulse responses for credit growth, gross total capital inflows and other investment inflows following a tightening macroprudential policy shock modeled as an unexpected increase of one unit in different subindexes of the MPPI. The upper panel reports results for the subindex comprising capitalization-based measures such as capital buffers or reserve requirements. The middle panel reports results for the subindex comprising MPPs targeting the liquidity of financial institutions such as liquidity requirements or single client exposure limits. The lower panel reports results for the subindex comprising borrower-based measures such as loan-to-value (LTV) or debt-service-to-income (DSTI) ratios. Black lines denote the aggregate posterior median response, blue shaded areas refer to the corresponding 68% credible set.

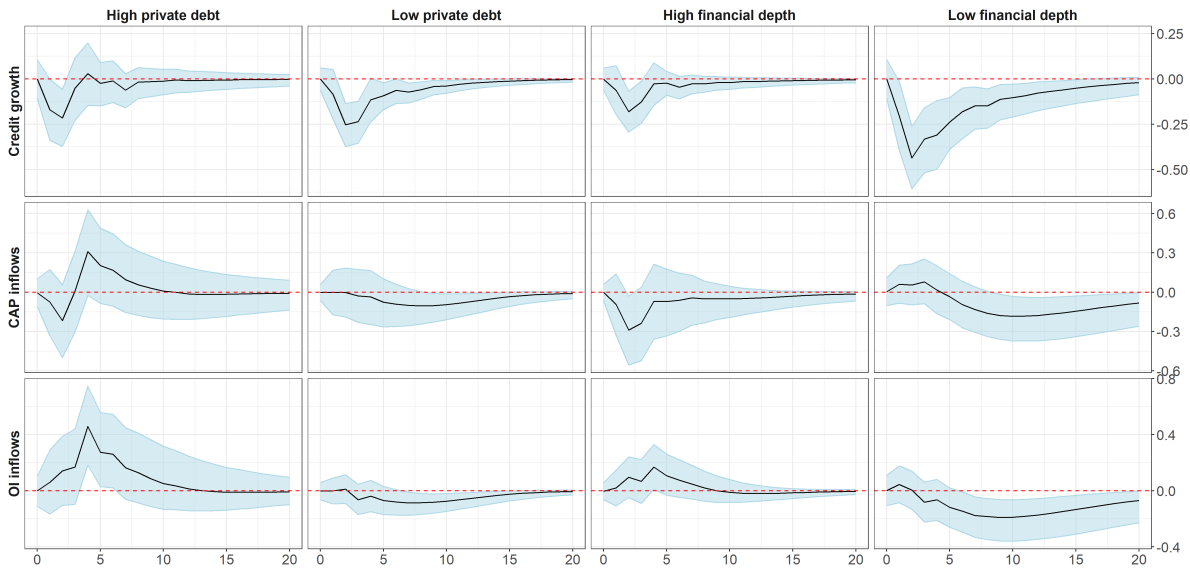
F.2 Additional structural characteristics

Going into more detail regarding the financial characteristics of countries, the sample is split according to the level of private debt as measured by the average ratio of loans extended to the non-financial private sector relative to GDP. The first and second columns of Figure F.2 report impulse responses for countries with high and low degrees of private sector debt, respectively. Credit growth is reduced stronger for an extended period of time in economies that exhibit a lower level of debt, in line with findings by [Kim and Mehrotra \(2022\)](#). A mixed picture emerges for capital inflows in countries with high debt levels. While CAP inflows do not show a significant reaction, OI inflows are rising about one year after impact. This pattern could reflect the need for banks to recapitalize when MPPs involving for instance stricter rules regarding their capitalization are implemented. This would be a less pressing issue in countries with a lower level of private indebtedness.

Indeed, both OI as well as CAP inflows are generally less affected from a tightening in the macroprudential environment and exhibit a small, but significant decrease as can be seen in the second column of Figure F.2.

As another measure of financial development, we split countries by the depth of their financial institutions as measured by the respective subindex of [Svirydzenka \(2016\)](#). The results, shown in the third and fourth columns of Figure F.2, are qualitatively similar to the ones derived for the overall index reported in Figure 4. Countries with lower financial depth show more pronounced and longer persisting responses to a macroprudential tightening for credit growth as well as capital inflows. More integrated financial institutions seem to increase the effects of leakage, with OI inflows not decreasing significantly but rather showing an upwards tendency within the first year after the macroprudential tightening. For countries with financially shallower institutions on the other hand, both overall capital inflows as well as OI inflows are reduced with a certain lag compared to credit growth, potentially caused by reduced financing needs of subsidiary banks.

Figure F.2: Impulse responses of macrofinancial quantities for countries split by total private indebtedness and depth of financial institutions

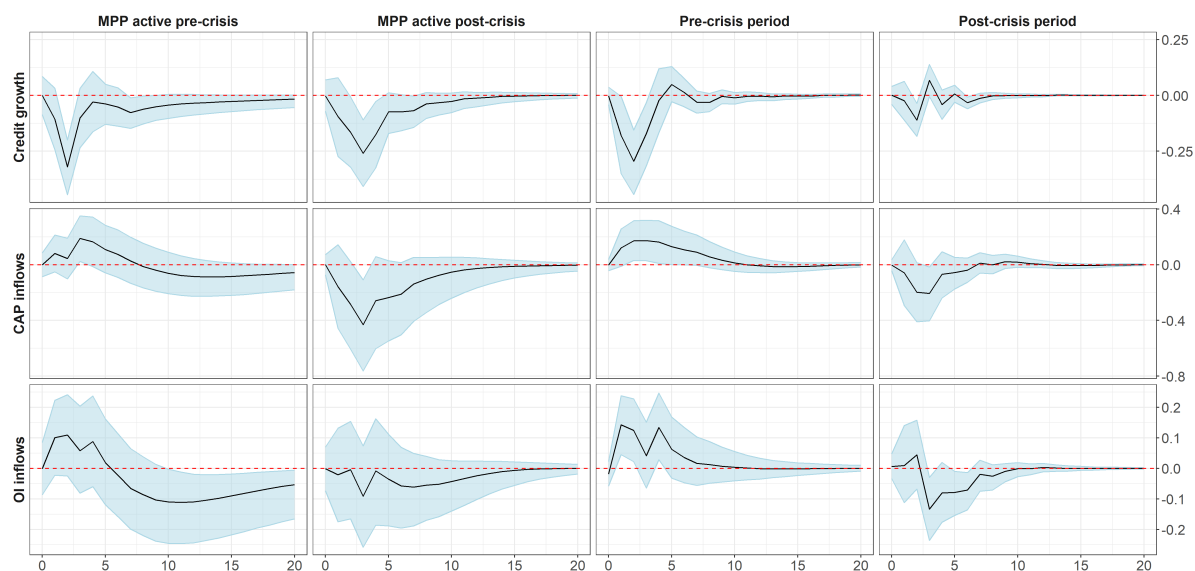


Note: Impulse responses for credit growth, gross total capital inflows and other investment inflows following a tightening macroprudential policy shock modeled as an unexpected increase of one unit in the MPPI. The first and second columns report results for countries with high and low levels of private debt (measured by the ratio of total loans to GDP), respectively. The third and fourth columns report results for countries with a high and low degree of financial depth (as measured by [Svirydzenka \(2016\)](#)), respectively. Black lines denote the aggregate posterior median response, blue shaded areas refer to the corresponding 68% credible set.

As mentioned in Section 3.2, and elaborated in Appendix C, there are heterogeneous patterns in the conduct of macroprudential measures across countries. Some countries started adopting MPPs earlier and have been more active in this respect than others. This implies that the respective authorities in these countries already incorporated the goal of financial stability in their policy function to a greater extent and makes a comparison between these two groups of countries interesting. The first column of Figure F.3 thus shows the impulse responses for countries that have already been active prior to the GFC, while the second column presents them for countries that tightened their stance rather in its aftermath. Considering credit growth, both groups exhibit significant reductions of this variable following a tightening in the macroprudential environment. The short-term effect for countries that were already active in the pre-crisis period is stronger but also dissipates faster. Regarding capital inflows there are some discrepancies. While for OI inflows MPPs tend to have a stronger decreasing effect for countries active in the pre-crisis period the opposite is observable for CAP inflows. This could reflect the prevailing focus on taming the leverage cycle – that was often fueled by cross-border banking inflows – of authorities in these countries at the time. Countries more active in the aftermath of the GFC often put more focus on increasing the resilience of the financial system more generally.

To investigate the effects of the global financial crisis (GFC), we consider a split of the observation period instead of forming subpanels of countries. The third and fourth columns of Figure F.3 show results for the period before and after the GFC, respectively. Credit growth is reduced in both periods but more strongly in the pre-crisis one, in line with the focus of authorities on taming the leverage cycle in this time as mentioned before. Responses of capital inflows differ between periods, with a tendency of increasing in the pre-crisis period, whereas decreasing after the crisis. However, it should be noted that in both periods the precision of the estimated impulse responses suffers from the rather short observation periods available. For a more detailed investigation of the effects of MPPs in different interest rate environments, roughly corresponding to periods preceding and subsequent to the GFC, see [Eller et al. \(2021\)](#).

Figure F.3: Impulse responses of macrofinancial quantities for countries split by MPP activity and observation period split by onset of the GFC



Note: Impulse responses for credit growth, gross total capital inflows and other investment inflows following a tightening MPP shock modeled as an unexpected increase of one unit in the MPPI. The first and second columns presents results for countries that were already active in conducting MPPs prior to the GFC or became active only in its aftermath, respectively. The third and fourth columns present results for splits in the observation period, respectively for the period prior to the GFC (i.e. before 2009Q1) and thereafter. Black lines denote the aggregate posterior median response, blue shaded areas refer to the corresponding 68% credible set.