The impact of macroprudential policies on capital flows in CESEE *

Markus Eller[1], Niko Hauzenberger[2], Florian Huber[2], Helene Schuberth[1], and Lukas Vashold[3]

[1]Oesterreichische Nationalbank (OeNB)
[2]University of Salzburg
[3]Vienna University of Economics and Business

Abstract

In line with recent policy discussions on the use of macroprudential policies (MPPs) to respond to cross-border risks arising from capital flows, this paper tries to quantify which impact MPPs had on capital flows in Central, Eastern and Southeastern Europe (CESEE) – a region that experienced a substantial boom-bust cycle in capital flows amid the global financial crisis and where policymakers had been quite active in adopting MPPs already before that crisis. To study the dynamic responses of capital flows to a tightening in the macroprudential environment, we propose a novel regime-switching factor-augmented vector autoregressive (FAVAR) model and include an intensity-adjusted macroprudential policy index to identify MPP shocks. We find that tighter MPPs translate into negative dynamic reactions of domestic private sector credit growth and gross capital inflow volumes in a majority of the countries analyzed. Level and volatility responses of capital inflows are often correlated positively, suggesting that if MPPs were successful in reducing capital inflows, they would also contribute to lower capital flow volatility. We also provide evidence that the effects of MPP tightening are stronger in an environment characterized by low interest rates, suggesting that MPPs are more effective when conventional monetary policy is at its limits.

Keywords: Capital flows, macroprudential policy, global factors, regime-switching FAVAR, CESEE

JEL Codes: C38, E61, F44, G28.

September 30, 2024

*E-mail: markus.eller@oenb.at, niko.hauzenberger@sbg.ac.at, florian.huber@sbg.ac.at, helene.schuberth@oenb.at and lukas.vashold@wu.ac.at. Opinions expressed by the authors do not necessarily reflect the official viewpoint of the Oesterreichische Nationalbank or of the Eurosystem. The authors would like to thank Zoltan Walko and Michael Wögerer for excellent research assistance and an anonymous referee, Alina Bobaşu, Reiner Martin, Claudia Maurini, Francesco Mazzaferro, Esther Segalla, Ursula Vogel as well as participants of the following events for helpful comments and valuable suggestions: the 4^{th} CESEEnet research workshop (March 2019 in Mauerbach), the 2019 Annual Meeting of the Central Bank Research Association (CEBRA, July 2019 in New York), the OeNB's 2019 Conference on European Economic Integration (November 2019 in Vienna), the 17^{th} ESCB Emerging Markets Workshop (December 2019 at the OeNB), the 2020 Annual Meeting of the Austrian Economic Association (NOeG, February 2020 in Vienna) and seminars held at the OeNB, the ECB, the European Systemic Risk Board (ESRB), the Joint Vienna Institute (JVI), the University of Salzburg and the Austrian Institute of Economic Research (WIFO).

1. INTRODUCTION

Macroprudential policies (MPPs) are primarily prudential measures designed to limit systemic financial risk and thus to avoid macroeconomic costs associated with financial instability, since there is no direct channel for monetary policy to sufficiently guarantee financial stability (see, e.g., Galati and Moessner, 2013; 2018; Svensson, 2018). Volatile capital flows are often seen as a major source for boom-bust cycles in credit or asset prices, eventually impacting financial sector stability (IMF, 2017). The volatility of capital flows, in turn, is apparently strongly affected by global "push" factors, such as the global financial cycle (see, for instance, Calvo et al., 1996; Fratzscher, 2012; Rey, 2015; Lepers and Mercado, 2020; Eller et al., 2020a). Given this link between globally determined capital flow volatility and domestic financial stability, the question arises whether macroprudential policy could improve a country's resilience with respect to external shocks (or, more specifically, have a stabilizing impact on capital flows) and thus contain tail risks to domestic macrofinancial quantities.

Why would we actually expect macroprudential policies having an impact on capital flows and/or contributing to shield a country from external shocks? To give an intuition, at least three different arguments can be mentioned. *First*, several MPPs have a direct cross-border dimension as they target banking sector risks related to the foreign currency denomination of banks' assets and liabilities (so-called FX-based MPPs). *Second*, MPPs can impact capital flows via bank-related flows: by curbing domestic borrowing from domestic banks, tighter MPPs indirectly can also curb external borrowing by banks (if the domestic banking sector relies in its funding considerably on international financial intermediaries, see IMF, 2020). *Third*, MPPs may also more generally strengthen the ability of the domestic financial sector to cope with risks related to foreign exchange or international exposure and thus enhance macroeconomic stability (as documented in Forbes et al., 2015).[1] The related policy debate is already quite advanced, discussing the capability of MPPs in improving the resilience with respect to volatile capital flows and in complementing traditional capital flow management measures (e.g., Beirne and Friedrich, 2017; IMF, 2016; 2017; 2020; Lepers and Mehigan, 2019; Portes et al., 2020).

Quantifying the empirical effects of macroprudential policies is a quickly emerging field – not least thanks to newly available databases that capture the implementation of specific MPP measures across the globe. There is already a large literature on the efficacy of MPP measures to tame domestic credit cycles and some papers establish a link to capital flow dynamics (e.g., Ostry et al., 2012; Forbes et al., 2015; Beirne and Friedrich, 2017; Fendoğlu, 2017; Igan and Tan, 2017; Aizenman et al., 2020). A growing strand of the literature addresses the efficacy of MPPs to stabilize domestic macroeconomic quantities, studying the interactions with monetary policy or capital controls (e.g., Kim and Mehrotra, 2018; Richter et al., 2019; Bergant et al., 2020; Brandao-Marques et al., 2020; Rojas et al., 2020).

Nevertheless, despite the intense policy debate there are only a few papers that have already studied the *direct* response of capital flows to MPP measures. In general, the findings with respect to the effect of MPPs on international capital flows are mixed. Buch and Goldberg (2017) found that cross-border bank lending is influenced by domestic MPP changes but often only to a limited extent, whereby bank characteristics (e.g., banks' balance sheet conditions) are important sources for heterogeneous responses of banks to MPPs. In a similar vein, Beirne and Friedrich (2017) found that the extent of cross-border

[1] For instance, via better capitalization of banks or less risky credit extension.

spillovers of MPPs depends on banking sector conditions both at home and abroad. Aysan et al. (2015) find that cross-border capital flows to Turkey were less sensitive to global factors after the implementation of MPPs in late 2010. For a huge panel of countries over the period 2006–2015, moreover, Cerutti and Zhou (2018) study the joint impact of macroprudential and capital control measures on cross-border banking flows: Tighter MPPs in lender countries apparently reduce direct cross-border banking outflows but are associated with larger outflows via local affiliates. Tighter MPPs in borrower countries, on the other hand, are associated with larger direct cross-border banking inflows, likely due to circumvention motives. In a similar vein, Frost et al. (2020) study a large panel of countries for the time period of 2000–2017 and find that the activation of FX-based MPPs reduces capital inflow volumes by nearly 5 % of GDP and is linked to a lower probability of banking crisis and capital flow surges in the following three years. In Ireland, the introduction of tighter lending restrictions for domestic mortgages in early 2015 led to a subsequent increase in issuance of high-risk loans of Irish banks in the UK mortgage market, indicating risk-shifting behaviour of banks triggering cross-border bank lending (McCann and O'Toole, 2019). Ahnert et al. (2021) show for a sample of 48 countries that spans the period from 1996 to 2014 that FX-based MPPs are effective in reducing banks' FX borrowing but also have the unintended consequence of simultaneously causing firms to increase FX bond issuance and thus shifting FX exposure to other sectors of the economy. In a similar vein, Cizel et al. (2019) show that MPPs targeting the banking sector can lead to leakage especially in financially more developed economies, shifting excessive credit provision and the associated financial stability risks to the nonbank financial sector.

This paper aims to contribute to the existing literature along the following dimensions. *First*, in terms of regional focus, we investigate the countries from Central, Eastern, and Southeastern Europe (CESEE). As small open economies, they show considerable external vulnerabilities – among others due to a large share of public and private sector debt being denominated in foreign currency – and are therefore susceptible to global risk fluctuations that often result in sudden shifts in international capital flows. As a striking example, because of the large reversal of flows (in particular related to bank flows) during the 2008/2009 crisis, the CESEE region suffered stronger output declines than any other region in the world (Berglöf et al., 2010). On the other hand, several CESEE countries had been quite active in implementing MPPs already before the global financial crisis (GFC), mostly to rein in extraordinarily strong credit growth at the time, which was fueled by a surge in capital inflows (Hegerty, 2009). This contrasts with countries in Western Europe which mostly became active only in the aftermath of the GFC. As mentioned before, MPPs are expected to have a measurable effect on cross-border banking flows, which are of particular importance in CESEE given the prominent role of foreign parent banks. For these reasons, the investigated sample provides an appealing case for studying the impact of MPPs on capital flows. *Second*, in terms of econometric methodology, while most of the previous cross-country studies have relied on simple fixed-effects panel regressions, we propose a regime-switching factor-augmented vector autoregression (FAVAR) framework. Our model allows studying country-specific capital flow responses to MPP shocks, capturing the dynamics in a closed economy and accounting at the same time for global factors – such as the global financial cycle – in a parsimonious framework. Moreover, we allow for nonlinearities in the form of regime switches to capture potential macroprudential policy shifts (e.g., in the wake of high- and low-interest rate episodes). To enrich this novel econometric setup also on the data side, we utilize a recently developed intensity-adjusted macroprudential policy index (MPPI, documented in Eller et al., 2020b). In contrast to most of the literature that captures only the occurrence of MPPs using rather simple indices, this index allows us to track not only if, but also to what extent a measure was implemented.[2] Next to the intensity adjustment, this index covers a comparatively long time span, captures a large variety of instruments and differentiates between the announcement and implementation date of measures to account for possible anticipation effects.

Our empirical results may be summarized as follows. In the majority of countries, we find that contractionary macroprudential policy translates into declining growth rates of private sector credit. This is accompanied by declining levels of gross capital inflows. Countries which display more variation in their capital flow series tend to react stronger to MPP shocks. Considering the volatility of capital flows, we find that volatility reactions typically trace the corresponding level reaction. Specifically, most countries which display a reduction in capital inflows in response to tighter MPP conditions also tend to exhibit decreasing capital flow volatility. Moreover, we find evidence that the effects of MPPs are more pronounced in an environment characterized by low interest rates. In periods where interest rates approach the zero lower bound, both credit growth and volumes of capital inflows are reduced more strongly compared to periods characterized by high interest rates.

The remainder of the paper is structured as follows: Section 2 discusses more details on the transmission channels through which macroprudential measures can affect capital flows. Section 3 describes the applied nonlinear FAVAR framework as well as the prior specification. Section 4 describes the macroeconomic data and provides more details on the macroprudential policy index used. Section 5 explains how we identify an MPP shock. Finally, Section 6 provides an overview of the related dynamic structural responses to a tightening MPP shock and Section 7 concludes.

2. TRANSMISSION CHANNELS THROUGH WHICH MACROPRUDENTIAL POLICIES CAN AFFECT CAPITAL FLOWS

Even though MPPs typically do not directly target the capital and financial account, they can nevertheless have an impact on capital flows (for a policy-oriented overview, see IMF, 2017). To motivate the focus of our analysis on the direct response of capital flows to MPPs, we review the related transmission channels as discussed in the literature more closely in this section.

First, as the closest link, several MPPs have a direct cross-border dimension insofar as they address the foreign currency-denomination of banks' assets and liabilities. Such FX-based MPPs have often been designed with the explicit aim to limit capital flows, complementing or substituting traditional capital flow management measures such as capital controls (for the substitutability and complementarity between MPPs and capital controls, see Ostry et al., 2012). There are already a few papers that found that FX-based MPPs can reduce the volumes of capital inflows or the probability of capital flow surges (e.g., Forbes and Warnock, 2012; Frost et al., 2020; Ahnert et al., 2021).

Second, there is another direct link via bank-related capital flows. Tighter MPPs are expected to curb in one way or another the borrowing of domestic agents from domestic banks. Especially borrower-based MPPs (e.g., tighter lending requirements) can be seen as taxes on consumer and housing loans to

[2] To give an example, it should make a difference for any impact assessment of macroprudential policy tightening if we treated a lowering of the maximum loan-to-value (LTV) ratio from 100 % to 60 % in a different way than a reduction from 100 % to only 90 %. Many existing investigations would just use a dummy approach and would treat both cases identically.

discourage excessive borrowing. But also lender-based MPPs (e.g., higher capitalization requirements for banks) can act as a factor limiting credit supply. As a consequence, cross-border funding from parent banks, or generally from financial institutions and financial investors abroad, are less needed for domestic credit extension. Direct foreign lending to resident banks would thus experience a decline in the case of a tighter MPP environment.[3] The funding of substantial credit booms, mostly in foreign currency, via bank flows was particularly pronounced in most of the CESEE countries in the run-up to the GFC whereby a large share of inflows consisted of flows from large global banks to their local subsidiaries (see Eller et al., 2016). There is also a strong correlation between capital flows and the share of foreign currency lending to households, non-financial corporations and banks in almost all of the CESEE countries (see Bakker and Klingen, 2012).

Third, as a more indirect channel, by limiting systemic financial risk at home, MPPs can enhance resilience of the domestic financial system to cope with shocks and vulnerabilities created at the global level (IMF, 2020). Excessive capital inflow episodes may be limited by MPPs containing the procyclical interplay between asset prices, private credit and wholesale funding (IMF, 2017). By restricting increases in leverage and volatile funding, the resilience with regard to fluctuations in the global financial cycle may be enhanced and capital flow volatility may eventually decline. In addition, the frequency of disruptive capital outflows could be reduced by MPPs during episodes of financial stress; examples are (countercyclical capital) buffers that help maintain the ability to provide credit under adverse conditions or liquidity requirements that mitigate susceptibility to abrupt capital outflows. The literature studying the role of MPPs in improving a country's resilience to international shocks has grown in recent years (for a recent literature review see Forbes, 2020). Cesa-Bianchi et al. (2018) found that countries featuring lower loan-to-value (LTV) ratios and stricter limits on foreign currency borrowing are less vulnerable to global credit supply shocks. Similarly, Coman and Lloyd (2019) found that tighter LTV limits and reserve requirements appear to be particularly effective measures to shield emerging markets from negative spillover effects of US monetary policy. Bergant et al. (2020) show that tighter levels of macroprudential regulation can considerably dampen the sensitivity of GDP growth in emerging markets with respect to global financial shocks.

Based on the transmission channels discussed above, there is a case for studying more closely the impact of MPPs on bank-related capital flows. In the empirical analysis we will approximate them by other investment flows (for a more detailed reasoning see Section 4). Given the more indirect effects as mentioned in the third channel, we will also have a focus on total capital flows as a proxy for a country's overall external exposure. Besides other investment (OI), total capital flows consist also of direct investment (FDI) and portfolio investment (PI). The share of bank-related PI flows is fairly smaller than in the case of OI and the share of bank-related FDI cannot be identified based on balance of payment statistics. Other sources based on annual data indicate that the financial sector accounts for quite a high share of the total inward FDI stock in CESEE (with about 20 % before the GFC, see Eller et al., 2006). For similar reasons as mentioned above for bank flows in general, also bank-related FDIs may decline as a consequence of tighter macroprudential regulation. On the other hand, the need for capitalizing

[3]Even if the impact of MPPs on bank-related capital inflows were negative, the effectiveness of macroprudential tools in reining in a domestic credit boom could be weakened by direct cross-border borrowing, as shown by Cerutti and Zhou (2018). This was particularly the case prior to the GFC, when large foreign banks extended direct cross-border credit to non-financial corporations in several CESEE countries.

local subsidiaries of foreign banks may have a positive impact on FDI inflows. Concerning PI flows, as a consequence of tighter MPPs, firms may substitute borrowing from banks by issuing corporate bonds (recall the results of Ahnert et al., 2021) that are likely sold to a considerable extent abroad given the still comparatively underdeveloped local capital markets in CESEE (Reininger and Walko, 2020). In this case we would observe a positive impact of MPP tightening on PI inflows due to cross-sectoral spillovers. On the other hand, to the extent that wholesale funding of banks is contained by MPPs, the issuance of bank bonds (that are likely also sold to foreign investors) may decline, yielding a negative link between tighter MPPs and PI inflows. On balance, the effects of MPP tightening on FDI and PI are less clear than in the case of cross-border loans to banks as captured by OI flows.

3. ECONOMETRIC FRAMEWORK

In this section we propose a novel factor-augmented vector autoregressive (FAVAR) framework (Bernanke et al., 2005) with regime-switching in order to assess the effects of macroprudential policy actions for several CESEE countries over time, while controlling for the impact of co-movement in international financial series. After describing key model features, we discuss prior specification and implementation.

3.1. *The nonlinear factor-augmented VAR model*

Our approach is based on modeling a set of macroeconomic and financial quantities specific to country $i = 1, \ldots, N$ while capturing international movements in financial quantities. For country i, we assume that a set of m endogenous variables $\boldsymbol{y}_{it}$, including our measure of macroprudential activity (the MPPI), domestic macroeconomic and financial variables as well as a capital flow series c_{it} and its volatility proxy v_{it}, depend on their own lags plus lags of a single global financial factor $\boldsymbol{F}_{it}$, that accounts for most of the variation in international financial variables (for details, see Section 4). Global co-movement in financial sector variables might have triggered similar macroprudential policy decisions across countries. The inclusion of the global financial factor thus allows to control for global (unidirectional) spillovers.[4] Defining $\boldsymbol{x}_{it} = (\boldsymbol{F}'_{it}, \boldsymbol{y}'_{it})'$ allows us to establish a relationship between the observed quantities (a set of international macroeconomic and financial quantities stored in an S-dimensional vector $\boldsymbol{Z}_{it}$) and the observed and unobserved factors in $\boldsymbol{x}_{it}$,

$$\begin{pmatrix} \boldsymbol{Z}_{it} \\ \boldsymbol{y}_{it} \end{pmatrix} = \begin{pmatrix} \boldsymbol{\Lambda}_{iS_{it}} & \boldsymbol{0} \\ \boldsymbol{0} & \boldsymbol{I} \end{pmatrix} \begin{pmatrix} \boldsymbol{F}_{it} \\ \boldsymbol{y}_{it} \end{pmatrix} + \begin{pmatrix} \boldsymbol{\eta}_{it} \\ \boldsymbol{0} \end{pmatrix}. \tag{1}$$

Here, $\boldsymbol{\Lambda}_{iS_{it}}$ denotes an $(S \times q)$-dimensional matrix of regime-specific factor loadings with $S \gg q$, and S_{it} is an endogenous regime indicator. We assume that $S_{it} \in \{0, 1\}$ follows an endogenous Markov switching

[4]As highlighted in several works of the ESRB (e.g., Portes et al., 2020), cross-border spillovers and leakages of domestic macroprudential measures provide a rationale for stronger cross-border coordination of macroprudential policies (including reciprocation of measures). Let us assume that country i implements a macroprudential tightening; if other important partner countries responded reciprocally, this could also have an impact on capital flows to country i. As a caveat, though, we cannot account for such bilateral spillovers, since we are estimating country-specific VARs. A global VAR or a panel VAR could be a solution to account for bilateral cross-border linkages; at the same time, it would be quite challenging to properly identify the policy shock and to account for different effects over time in these settings.

process that is driven by the country-specific short-term interest rate i_{it}, with transition probabilities discussed in Sub-section 3.2. This model feature allows us to study whether responses to MPP shocks differ over time and distinguish between high- and low-interest rate episodes. Finally, $\boldsymbol{\eta}_{it}$ represents an S-dimensional vector of measurement errors that follow a Gaussian distribution with mean zero and diagonal variance-covariance matrix $\boldsymbol{\Sigma}_i = \text{diag}(\sigma^2_{i1}, \ldots, \sigma^2_{iS})$.

Equation (1) constitutes the measurement equation that relates observed to latent quantities. A few features are worth discussing. *First*, we need an identifying assumption on $\boldsymbol{\Lambda}_{iS_{it}}$. In what follows, we assume that the upper $q \times q$ block of $\boldsymbol{\Lambda}_{iS_{it}}$ is set to an identity matrix $\boldsymbol{I}_q$. Estimating the latent factors by means of principal components (PCs) then corresponds to extracting PCs from the corresponding set of observed quantities. *Second*, we assume that the factor loadings are regime-specific. This implies that the sensitivity of elements in $\boldsymbol{Z}_{it}$ with respect to movements in $\boldsymbol{F}_{it}$ is time-varying and changes across two economic regimes. *Third*, any comovement in $\boldsymbol{Z}_{it}$ stems exclusively from the latent factors $\boldsymbol{F}_{it}$.

The latent states and observed quantities in $\boldsymbol{x}_{it}$ are then assumed to follow a regime-switching VAR model of order P,

$$\boldsymbol{x}_{it} = \boldsymbol{a}_{0,iS_{it}} + \sum_{p=1}^{P} \boldsymbol{A}_{p,iS_{it}} \boldsymbol{x}_{it-p} + \boldsymbol{\epsilon}_{it}, \quad \text{with} \quad \boldsymbol{\epsilon}_{it} \sim \mathcal{N}\left(\boldsymbol{0}, \boldsymbol{\Omega}_{iS_{it}}\right), \tag{2}$$

whereby $\boldsymbol{a}_{0,iS_{it}}$ denotes a K-dimensional vector of state-specific intercepts ($K = m + q$), $\boldsymbol{A}_{p,iS_{it}}$ ($p = 1, \ldots, P$) are $(K \times K)$-dimensional matrices of state-specific coefficients, while $\boldsymbol{\epsilon}_{it}$ is a set of Gaussian shocks with zero mean and regime-specific variance-covariance matrix $\boldsymbol{\Omega}_{iS_{it}}$.

Up to this point, we remained silent on how to obtain the volatility estimates. In what follows, we simply assume that v_{it} is obtained by first estimating autoregressive models of order $r (= 4)$ on the corresponding capital flow series c_{it},

$$c_{it} = \sum_{m=1}^{r} \rho_m c_{it-m} + e_{it} \tag{3}$$

with e_{it} being a zero-mean Gaussian shock with time-varying variance $\exp(v_{it})$. The (log) variance then follows an AR(1) process,

$$v_{it} = \mu_i + \phi_i (v_{it-1} - \mu_i) + \varsigma_{it}, \tag{4}$$

with μ_i denoting the unconditional mean of the log-variance, ϕ_i reflecting the persistence parameter and ς_{it} being a Gaussian shock to the log-volatility with zero mean and variance $\sigma^2_{i,v}$. After obtaining point estimates of these measures (i.e., the posterior mean), we include the time-varying log-variances v_{it} as a volatility proxy in our model.

3.2. *An endogenous mechanism for the state allocation*

So far, we remained silent on how the state allocation S_{it} is obtained. We assume that S_{it} follows a Markov switching process with time-varying transition probabilities.[5]

[5]For robustness, we also consider S_{it} to be specified deterministically. Here, S_{it}, for $i = 1, \ldots, N$, equals zero in the period before the GFC (up to 2008Q4) while being equal to unity in its aftermath (starting from 2009Q1).

The transition probability matrix reads as

$$\boldsymbol{P}_{it} = \begin{pmatrix} p_{00,it} & p_{01,it} \\ p_{10,it} & p_{11,it} \end{pmatrix}, \tag{5}$$

with $\sum_{l=0}^{1} p_{kl,it} = 1$ for $k \in \{0, 1\}$.

The transition probabilities of S_{it}, $\Pr(S_{it} = l | S_{it-1} = k, \gamma_i, i_{it}) = p_{kl,it}$, are linked to the country-specific short-term interest rate i_{it} through a probit model (see, inter alia, Filardo, 1994; Kim and Nelson, 1998; Amisano and Fagan, 2013; Huber and Fischer, 2018). This captures the notion that MPPs are more likely to be adopted when conventional monetary policy reaches its limit. The probit specification is given by

$$p_{kl,it} = \Phi(c_{0,ki} + \gamma_i i_{it}), \tag{6}$$

with $c_{0,ki}$ denoting a regime-specific intercept, and Φ refers to the cumulative distribution function of the standard normal distribution. γ_i measures the sensitivity of the transition probabilities with respect to the country-specific interest rate i_{it}.[6] Similar to Amisano and Fagan (2013), we assume that γ_i is fixed across regimes while we allow the intercept to be defined by the previous state S_{it-1}.

It is again worth stressing that the corresponding regime allocation determined by S_{it} is stochastic, with the interest rate determining the transitions between states in a stochastic manner. This implies that if there is substantial evidence in the likelihood that a regime change takes place (not driven by changes in policy rates), our model is capable of detecting this shift.

3.3. *A pooling prior*

Since the VAR coefficients are state-specific and we are interested in the effects of macroprudential policy shocks in different interest rate regimes, we encounter several issues. Most prominently, the length of the time series in the subperiods may be small while the number of parameters to estimate is large. Shrinkage priors in the spirit of Sims and Zha (1998) would offer a feasible solution. However, the corresponding impulse responses would be dominated by the prior, which is centered on a multivariate random walk.

In the present paper, we follow a different approach and borrow strength from coefficient pooling. More specifically, we stack all regime-specific coefficients in a k-dimensional vector $\boldsymbol{\beta}_{iS_{it}} = vec\left\{\left(\boldsymbol{a}_{0,iS_{it}}, \boldsymbol{A}_{1,iS_{it}}, \dots, \boldsymbol{A}_{P,iS_{it}}\right)'\right\}$, with $k = K(KP + 1)$. In the next step, we assume that the state-specific regression coefficients arise from a common Gaussian distribution given by

$$\boldsymbol{\beta}_{iS_{it}} \sim \mathcal{N}(\boldsymbol{\beta}_{i0}, \boldsymbol{\Xi}_i), \tag{7}$$

with $\boldsymbol{\beta}_{i0}$ denoting a common mean vector of dimension k and $\boldsymbol{\Xi}_i = \text{diag}(\xi_{i1}, \dots, \xi_{ik})$ being a $(k \times k)$-dimensional variance-covariance matrix with ξ_{ij} denoting a coefficient-specific variance. The size of ξ_{ij} effectively controls whether a given coefficient should be pushed towards the common mean across both regimes. If ξ_{ij} is large, the jth element in $\boldsymbol{\beta}_{iS_{it}}$, $\beta_{ij,S_{it}}$, is allowed to differ strongly across regimes (heterogeneity), whereas in the opposite case, $\beta_{ij,0} \approx \beta_{ij,1}$ and thus only little differences across regimes

[6] With more than two regimes, an alternative would be a logit specification (Kaufmann, 2015; Billio et al., 2016; Hauzenberger and Huber, 2020).

are possible (homogeneity).[7] To achieve this behavior we use a Gamma prior on $\xi_{ij} \sim \mathcal{G}(0.1, 0.1)$. This choice reflects the notion of strongly pushing little differences towards homogeneity and, at the same time, ensuring that larger differences across regimes are not altered by any prior information (via heavy tails of the marginal prior distribution). The common mean $\boldsymbol{\beta}_{i0}$ is assumed Gaussian with zero mean and a variance-covariance matrix $0.1 \times \boldsymbol{I}$. This value ensures sufficient shrinkage of the common coefficients towards zero while, if the data permits, enabling non-zero elements in $\boldsymbol{\beta}_{i0}$.

Similarly to the VAR coefficients, we also pool across error variance-covariance matrices in the VAR state equation. This is achieved by placing a conjugate hierarchical Wishart prior on $\boldsymbol{\Omega}_{iS_{it}}^{-1}$ for $S_{it} \in \{0, 1\}$:

$$\begin{aligned} \boldsymbol{\Omega}_{iS_{it}}^{-1} &\sim \mathcal{W}(\boldsymbol{\Psi}_i, \psi_i) \quad \text{and} \\ \boldsymbol{\Psi}_i &\sim \mathcal{W}(\boldsymbol{S}_i, s_i), \end{aligned} \tag{8}$$

with hyperparameters $\psi_i = 2.5 + (K-1)/2$, $s_i = 0.5 + (K-1)/2$, and $\boldsymbol{S}_i = 100 s_i/\psi_i \times \text{diag}(\hat{\sigma}_{i1}, \ldots, \hat{\sigma}_{iK})$ specified according to Malsiner-Walli et al. (2016) and Hauzenberger et al. (2021). $\hat{\sigma}_{ij}$ simply denotes OLS variances of univariate AR(1) processes to consider the original scale of the data.

For the remaining coefficients of the model (i.e., the factor loadings, coefficients of the state equation of the log-volatilities, measurement error variances), our prior setup closely follows the existing literature and is specified to be only weakly informative, if possible. Specifically, we use standard normally distributed priors on the free elements of the factor loadings, inverted Gamma priors that are loosely informative on the measurement error variances, Gaussian prior with mean zero and variance ten on the unconditional mean μ_i of the log-volatility process v_{it} and a Gamma prior with scale and shape parameter equal to $1/2$ on $\sigma_{i,v}^2$. Finally, we use a Beta distributed prior on $\frac{\phi_i + 1}{2} \sim \mathcal{B}(25, 5)$ that captures the notion that the log-volatility process is quite persistent.

We estimate the model using a Markov chain Monte Carlo (MCMC) algorithm that consists of standard steps (for details, see Hauzenberger et al., 2021).

4. DATA

Our investigated sample covers the 11 EU member states in CESEE with data available at quarterly frequency from 2000Q1 until 2018Q4.[8] For each country, we include the following variables: (1) the global financial factor, (2) the macroprudential policy index (MPPI), (3) domestic macroeconomic and macrofinancial quantities (real GDP growth, CPI inflation, private sector credit growth, short-term interest rate, equity price growth, (real effective) exchange rate volatility) and (4) the levels and volatilites of gross capital inflows *and* outflows. Thus, the number of endogenous variables is $m = 12$. Table A.1 gives an overview of the used variables, their respective transformations and the main sources they were obtained from.

[7] This specification is closely related to Verbeke and Lesaffre (1996), Allenby et al. (1998) and Frühwirth-Schnatter et al. (2004) and has been applied in the VAR framework in Hauzenberger et al. (2021).

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

4.1. *Macrofinancial data*

Before providing more details on the intensity-adjusted MPPI, let us briefly stress a few issues related to other important system variables. *First*, as regards *capital flows* as the main variable of interest, gross inflows and gross outflows enter simultaneously the model to control for potential dependencies since parts of the inflows are often flowing out of the economy again (inter alia due to special purpose entities or round-trip investment). We include both their levels (percentage of nominal GDP, cumulative four-quarter moving sums) and their volatilities, with the latter being computed as described in Subsection 3.1. As functional categories we include either total capital flows (i.e., totaled direct, portfolio and other investment flows) or other investment (OI) flows only. Given that most MPPs are targeted at banks, the reaction of bank-related capital flows (e.g., direct foreign lending to resident banks) to MPP changes would be of particular interest. However, we are confronted with data limitations for (a) providing a sectoral breakdown for all functional categories (e.g., not available for FDI) and (b) getting satisfactorily long sectoral time series for all investigated countries. Thus, given that OI reflects to a large extent bank-related flows and in fact mostly bank loans,[9] we decided to study OI flows separately as the best-available proxy for cross-border bank flows (in line with other papers, e.g., Bussière et al., 2018; McQuade and Schmitz, 2017). Moreover, OI flows often include more volatile funding sources, such as short-term funding sourced on wholesale markets, and there is evidence that OI is more sensitive with respect to an increase in global risk aversion (McQuade and Schmitz, 2017) and has a more robust relationship with domestic credit extension than other functional categories (Blanchard et al., 2016). The likelihood of surging gross capital inflows leading to a systemic crisis is considerably higher when predominantly funded by OI flows (Hahm et al., 2013). Therefore, in terms of macrofinancial risks, this capital flow category is of special interest and the way macroprudential policies can affect it deserves special attention. That said, also total capital flows deserve attention given not only the fact that OI flows constitute a considerable share of them, as shown in Fig. 1, but also because of indirect effects of MPPs that could affect other types of capital flows, as discussed in Section 2.

Second, to account for the impact of comovement in global financial series and thus to proxy for the impact of the global financial cycle, we extract by means of principal components a *global financial factor* from a set of equity prices, private sector credit growth and private sector deposit growth across a global sample of 45 countries, always excluding the respective domestic economy (by following Eller et al., 2020a).[10] To a certain extent, this makes the global factor country-specific since the domestic variables are not included when the factors are estimated. We opt to focus on the first principical component as a global factor exclusively (i.e., $q = 1$) since results in Eller et al. (2020a) suggest that regional factors

[9]Taking a simple average over the 11 CESEE countries, bank-related international investment position (IIP) stocks constitute nearly 40 % of total OI stocks in the observation period. In the case of portfolio investment (PI), the average share of bank-related IIP stocks is considerably lower (only about 12 %), except for in a few countries. The same picture is also confirmed by bivariate correlations between OI or PI inflows and their bank-related component: it is generally very high in the case of OI (more than 80 %) but rather weak in the case of PI (about 25 %).

[10]Other papers (e.g., Forbes et al., 2015; Avdjiev et al., 2019; Aizenman et al., 2020) include the volatility index (VIX) of the Chicago Board Options Exchange (CBOE) and/or the TED spread as financial risk/uncertainty measures to capture the global financial cycle. However, these proxies are very US-centric and do only cover narrow aspects of the financial cycle, which is why we prefer the specification of a global factor extracted from a broad range of countries and variables for our sample.

only explain a small fraction of variation in domestic quantities. Moreover, adding regional factors would increase the dimensionality of the model and translate into computational issues.[11] Since our model is estimated on a country-by-country basis, we allow for country-specific relations between the domestic quantities and the global factor. Notice that we assume that the global financial factor is endogenous with respect to a given economy (but is restricted to react with a one-quarter lag to shocks in the remaining quantities). This assumption might be questionable since each economy we consider is small relative to the rest of the world. However, if the global factor is truly exogenous our flexible shrinkage prior captures this and pushes the corresponding coefficients towards zero.[12]

4.2. *An intensity-adjusted index for macroprudential policies*

Most of the literature studying the impact of MPPs has relied on rather simple indices that primarily account for the occurrence, but not for the intensity of measures. Some just rely on binary indicators that signal whether a certain instrument was in place at a given time or not (e.g., Reinhardt and Sowerbutts, 2015; Cerutti et al., 2017a). Most studies use an index where a tightening measure is coded with +1 and a loosening measure with −1, while ambiguous ones are not taken into account. By cumulatively summing them up over time, an index of macroprudential tightness can be compiled (e.g., Shim et al., 2013; Alam et al., 2019; Ahnert et al., 2021). The simplicity of these indices comes, however, with the drawback of neglecting variations in the intensity (i.e., the strength) of such measures. There are only a few papers that have already (partially) applied an intensity adjustment. Most notably, Vandenbussche et al. (2015) construct an intensity-adjusted index for 16 CESEE countries to investigate the effects of MPPs on housing prices. Dumičić (2018) studied the effectiveness of MPPs in mitigating excessive credit growth and accounted for different intensities of MPPs, using step functions that yield different values when the change of a particular instrument exceeds a certain threshold. Richter et al. (2019) and Alam et al. (2019) both focus on the effect of loan-to-value (LTV) limits on the broader macroeconomic environment and provide more detailed information regarding the intensity of the use of this instrument.

The index used in this study, introduced and described in detail in Eller et al. (2020b), represents another approach for building an index based on the intensity of MPPs. It includes "classic" macroprudential instruments and other requirements motivated by macroprudential objectives (e.g., system-wide minimum capital and reserve requirements) and covers the 11 CESEE EU member states from 1997 to 2018 on a quarterly basis. By applying a set of different weighting rules for the various incorporated measures, a quantitatively meaningful summary statistic of macroprudential activity within a given country is constructed. These rules depend on the nature, particularly on the complexity, of the individual instruments and ensure that, to the extent possible, differences in their intensities are reflected in the index. The combination of as many regulatory instruments as possible into a composite indicator bears the advantage of accounting for the various factors that are determining a country's overall macroprudential stance. However, this also implies that the exact composition of the MPPI varies across countries and over time (see Appendix B for more details), reflecting different regulatory approaches chosen by

[11] Inspecting screen plots reveals that this single factor explains over 80 % of the variation of the dataset and thus provides a rather general but highly informative measure of the global financial cycle.

[12] In the empirical application we do not report the reactions of the global factor to MPP shocks because, as expected, they are not statistically different from zero in most cases.

the respective authorities at different points in time. These discrepancies could lead to heterogeneities of dynamic responses to a macroprudential tightening across countries (see Section 6), highlighting the appropriateness of the chosen modeling framework that allows for country-specific estimation of these effects. It should also be noted that even though the MPPI differentiates between measures that were issued as recommendations rather than strict requirements, it does not reflect whether or not these measures are actually binding once they are announced or put in place. Constructing an objective measure controlling for this effect across countries and time is challenging given the sheer number of different aspects (e.g., balance sheet positions or liquidity measures) that would have to be considered. Thus, the estimated effects of a macroprudential tightening might be attenuated to a certain degree.

Another innovation of this index is the utilization of information regarding the timing of MPPs. While most existing studies use only the implementation date of a measure, the index at hand also utilizes information about its announcement date. In many cases, there is a nonnegligible gap between these two dates, especially in the case of capital-based measures. Financial institutions may react to regulatory changes as soon as they are announced (for a similar argumentation see e.g., IMF-FSB-BIS, 2016; Meuleman and Vander Vennet, 2020). Especially in the case of tightening incidents, it can be assumed that banks react to announcements in order to gradually prepare for meeting new regulations before they actually become binding (e.g., by building up a capital buffer). For loosening instances, this would not be the case, as banks have to fulfill the requirements until the day of actual implementation. To account for such anticipation effects, we use in our empirical investigation the intensity-adjusted MPPI of Eller et al. (2020b) based on announcement dates for tightening and implementation dates for loosening macroprudential measures.

Fig. 1 shows the MPPI for the countries and time period used in the subsequent estimations together with the capital inflow series. An increase (decrease) in the index signals a net tightening (loosening) in the overall macroprudential environment. It is noteworthy that the patterns across countries are quite heterogeneous. While Bulgaria, Croatia, Poland, Romania and to a certain extent Slovenia already had shown quite some tightening activity before the GFC, a significant pick-up thereof is observable for countries like the Czech Republic, Hungary or Slovakia only after it. In the Baltics, the overall net tightening in the macroprudential environment was not as pronounced, even though activity was apparent throughout the whole period.[13] This heterogeneity in the development of MPPs stresses the need to go beyond simple fixed-effects panel regressions and to analyze responses to a macroprudential tightening country-by-country. At the same time, we can see in Fig. 1 that CESEE countries have experienced a substantial boom-bust cycle in capital flows. Before the GFC hit, the CESEE countries attracted sizable gross capital inflows, in a few countries of up to 50 % of GDP (Bulgaria, Estonia, Hungary, Latvia). At a global scale, cumulative net capital inflows into the CESEE countries as a percentage of GDP were by far the highest worldwide in the period 2003–2008 and outstripped the flows that poured into East Asia before the Asian crisis hit in the late 1990s (Eller et al., 2016). After a sharp reversal in 2009, capital inflows have recovered somewhat in recent years, but are in most countries still far below the numbers recorded before the GFC. Moreover, gross other investment inflows made up for a major share of total

[13]For a closer description of the various country dynamics, also for the period before 2000, the role of different MPP instruments and the detailed construction of the MPPI, we refer to Eller et al. (2020b).

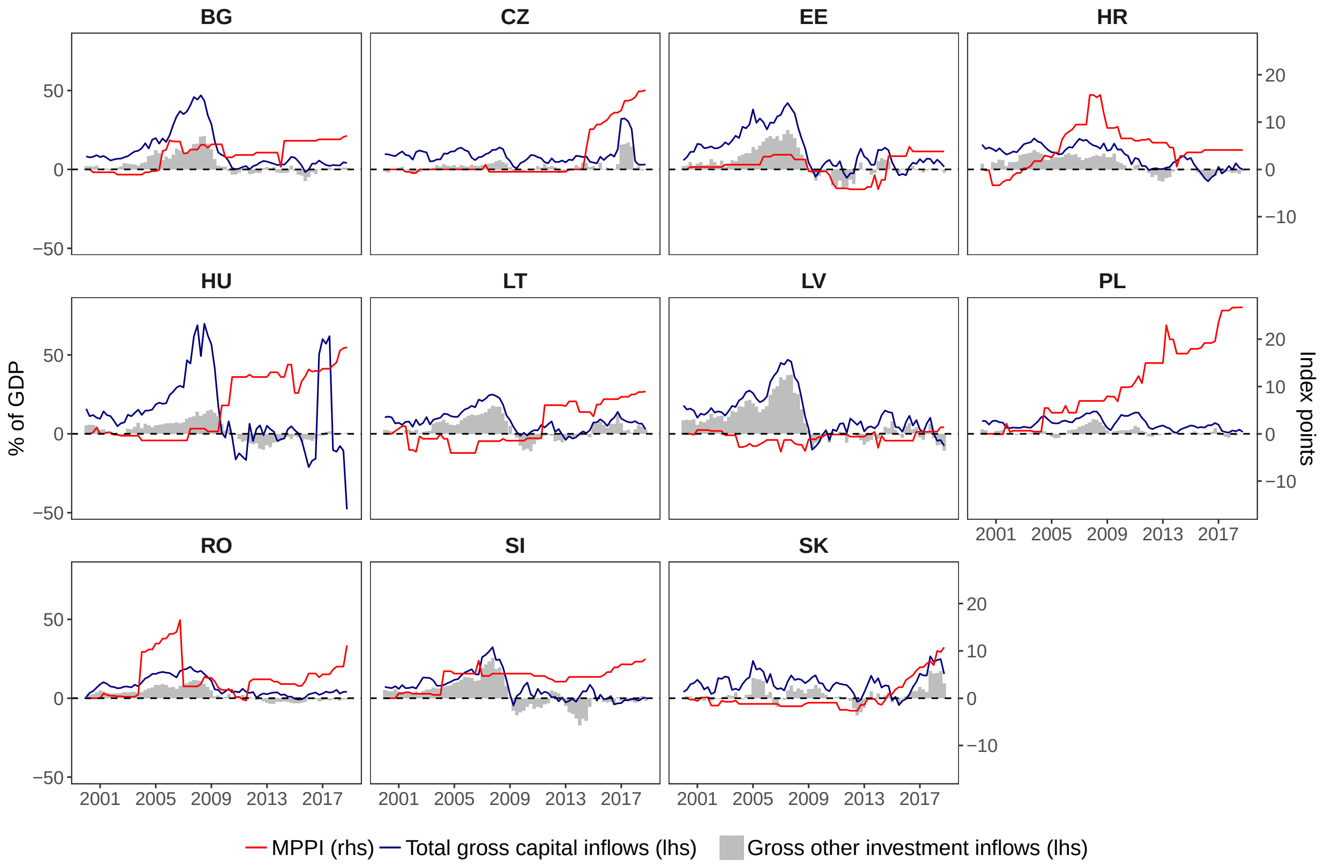


Fig. 1: Intensity-adjusted MPPI (red line) using announcement (implementation) dates for tightening (loosening) measures together with gross total capital inflows (blue line) and gross other investment inflows (grey bars), both in % of GDP, for the time period 2000Q1-2018Q4. Based on authors' own calculations and data from IMF-IFS. MPPI has been rescaled to start at 0.

inflows before the GFC, but in recent years portfolio inflows have gained importance.[14] The relation between the MPPI and capital flows is, at first glance, not always clear-cut. Before the GFC, several countries tightened their MPP stance, but capital inflows had still surged. At the same time, we do not know the counterfactual; the surge of capital flows could have been considerably stronger in the absence of the tightened MPP environment. After the GFC, in most, but not all, countries the capital flow reversal coincides with a procyclical tightening of the MPP stance.

[14]In the case of Hungary, the marked spikes of capital inflows (and outflows, not shown here) at the end of the sample were due to new SPEs that were established at the end of 2016 and left the country again at the end of 2018 (related to the worldwide restructuring of a large multinational pharmaceutic group).

5. IDENTIFICATION

Theoretical contributions, such as Gerali et al. (2010), Akram (2014) and Angelini et al. (2014), proposing dynamic stochastic general equilibrium (DSGE) models, offer a theoretical justification to identify the transmission channels of an MPP shock in a VAR model. In a first step, a linear specification of the FAVAR model for the whole period is estimated in order to contrast these results (which can be found in Sub-section 6.1) with the ones obtained for the specification that allows for a possible regime switch as described in Section 3. The latter results (see Sub-section 6.2) and their interpretation is the main focus of this study, as they allow for nonlinear policy shifts and should thus capture a more accurate picture of the changing effectiveness of macroprudential policies. To inform and update the transition probabilities of the endogenous regime-switching step, we use information about short-term interest rates to identify a high- and a low-interest rate regime. However, Appendix C.3 also provides results for a deterministic regime switch set equal to the onset of the GFC.

Moreover, we propose a Cholesky-type identification scheme in Tab. 1, assuming that macroprudential policy responds in the period of the shock only to (exogenous) global financial cycle movements, but not to other (faster) variables in the system. These impact restrictions can be advocated by the legislation process of macroprudential policy, by the long lead time of these measures and by the use of quarterly data. For example, Meeks (2017) argues that the policy variable does not react immediately to macroeconomic changes and that there is only an indirect transmission through lending channels. Similar identification schemes have been proposed to study the dynamic effects of MPPs using a panel VAR framework (e.g., Kim and Mehrotra, 2017; 2018; Kim et al., 2019). Alternatively, identification based on sign restrictions would be feasible. However, using sign restrictions implies that we obtain a *set* of structurally identified impulse responses. This, in light of weak identifying assumptions on the impulse responses, potentially inflates the estimation uncertainty surrounding our impulse responses, especially in the second part of our sample.

Table 1: Identification scheme defining zero impact restrictions. Bold letters indicate a vector of multiple variables. **Slow macro** covers real GDP growth, CPI inflation and credit growth. **Stir** captures the short-term interest rate to account for the impact of monetary policies. As **Fast macro-fin**, we consider equity price growth and the volatility of the REER. **Capital flow** covers the respective capital in- and outflow series and their volatility proxies.

	Global factor	MPPI	**Slow macro**	Stir	**Fast macro-fin**	**Capital flow**
Global factor	x	0	**0**	0	**0**	**0**
MPPI	x	x	**0**	0	**0**	**0**
Slow macro	$\boldsymbol{x}$	$\boldsymbol{x}$	$\boldsymbol{x}$	**0**	**0**	**0**
Stir	x	x	$\boldsymbol{x}$	x	**0**	**0**
Fast macro-fin	$\boldsymbol{x}$	$\boldsymbol{x}$	$\boldsymbol{x}$	$\boldsymbol{x}$	$\boldsymbol{x}$	**0**
Capital flow	$\boldsymbol{x}$	$\boldsymbol{x}$	$\boldsymbol{x}$	$\boldsymbol{x}$	$\boldsymbol{x}$	$\boldsymbol{x}$

6. DYNAMIC STRUCTURAL RESPONSES TO MACROPRUDENTIAL TIGHTENING

Given the setup of the model and the variable definitions discussed in previous sections, we have a large number of possible combinations of results. Our findings may vary when examining different specifications of the FAVAR model (linear, nonlinear, different types of regime switching) or different types of capital flows. To get a robust picture across these various combinations, we summarize the main results for the responses of credit growth and capital inflows to the identified macroprudential tightening shock. We start by illustrating the impact of MPP tightening using a linear specification of the FAVAR, i.e., a specification without a regime switch (Sub-section 6.1). The nonlinear results based on the endogenously specified regime shift are provided for both the high- and low-interest rate regime in Sub-section 6.2 and Appendix C.2. Additionally, Appendix C.3 provides results for the model with a deterministic regime allocation set equal to the onset of the GFC. Finally, Sub-section 6.3 summarizes the results obtained across the different model specifications in view of our main research questions. Notwithstanding the nonlinear setup that allows for assessing whether responses to MPP shocks are different in particular subperiods, it should be noted that our impulse-response analysis is symmetric. Therefore, any finding for macroprudential policy tightening holds – with reverse sign – also for macroprudential policy easing.

6.1. *Results from a linear FAVAR specification*

In this sub-section, we start by considering a model setup that assumes the transmission mechanisms outlined in Section 2 to be constant over time. To this end, we estimate a linear FAVAR model (i.e., $S_{it} = 0, \forall i, t$) and study the impulse-response functions (IRFs) over the entire sample period. The peak IRFs to a 1 SD tightening shock in the baseline MPP indicator are summarized in Fig. 2. Empty cells indicate insignificant IRFs in the sense that the 68 % credible interval covers zero. The number in the box marks the quarter after the shock at which the posterior mean of the IRF reaches its minimum (negative numbers in red) or maximum (positive numbers in blue).[15]

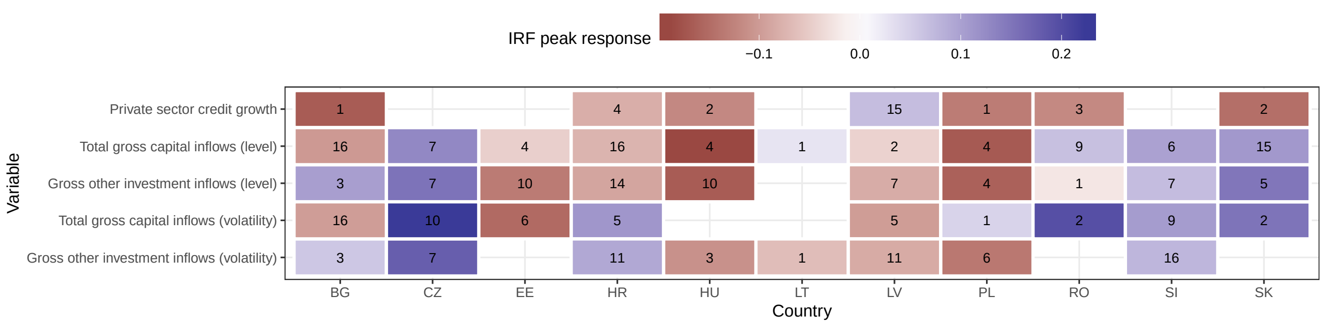
Considering this, Fig. 2 shows that private sector credit growth reacts negatively to tighter macroprudential regulations in six out of the eleven countries. These peak reactions appear to materialize within the first year after the shock hits the system, pointing towards a relatively fast transmission of MPPs to credit growth. These results resemble findings reported in Meeks (2017), who provides VAR-based evidence for a decline in private and corporate lending after an MPP shock in the UK. Similarly, a series of papers (Kim and Mehrotra, 2017; 2018; 2019; Kim et al., 2019) utilize a panel VAR structure to obtain aggregate impulse responses for several Asian economies and show that tightening MPP shocks are indeed effective with regard to its primary goal of reducing private sector credit extension.

Turning to the peak reactions of capital flows reveals that tighter MPPs result in decreasing levels of gross capital inflows in six out of the eleven countries under consideration. As opposed to the reactions of credit growth, these effects appear to be often longer-lived and tend to fade out much later. For instance, we observe that total gross capital inflows exhibit the strongest reactions four years after the shock in the case of Bulgaria and Croatia, while an earlier peak reaction, namely just after one year, can be observed in

[15] Note that the decision criterion for selecting the peak is always the maximum absolute value (i.e., in the few cases of changes from negative to positive responses – or vice versa –, we take the larger one).

Estonia, Hungary and Poland. The responses of gross other investment inflows are mostly similar, except for Bulgaria whose peak response turns positive. However, these peak reactions have to be viewed with some caution. First, some responses peak later due to the fact that the corresponding time series is much more persistent. In such a situation, the econometric model will detect this high degree of persistence and yield impulse responses which fade out much more slowly. This is the case for the level and volatility reactions of total gross capital inflows in Bulgaria, Croatia and Slovakia. Second, the timing of the peak does not say anything about the economic size of the reaction. For instance, considering the level reaction of gross capital inflows in Slovakia (see panel (b) of Fig. 3) shows that while the IRF peaks in the 15th quarter, the related peak effect is only slightly larger than the effect we have observed after around a year or the effect measured after about two years. With that being said, the peak effects provide a rough summary but should be considered in light of the full set of IRFs provided in Fig. 3.

The volatility reactions, as shown in the last two rows of Fig. 2, are more diverse. For some countries, we find that MPPs succeed in lowering the volatility of capital inflows, whereas for other economies we observe that unexpected innovations to the MPP indicator increase capital flow volatility. However, it should be noted that in most countries where the capital flow levels showed already negative peak responses, their volatilities do so too (with the exception of Croatia or Poland).



Note: Red shaded cells denote negative and blue shaded cells denote positive responses. Cell numbers indicate the quarter at which the response reaches its peak. Empty cells refer to insignificance with respect to the 68 % credible interval.

Fig. 2: Entire-period (posterior median) **peak responses of private sector credit growth, total gross capital and gross other investment inflows** (levels & volatilities) to a 1 SD tightening shock in the MPPI.

For a closer inspection of the size, shape and evolution of the underlying IRFs, Fig. 3 provides their posterior median (blue line) surrounded by the corresponding 68 % credible interval (blue shaded area). Consistent with the discussion of the peak effects, we find that the impact of MPPs yields economically important effects. The reactions of private sector credit growth (shown in panel (a)) points towards strong cross-country heterogeneity in terms of shape and magnitudes. Some responses appear to be rather persistent (see, e.g., the reactions in Bulgaria and Poland) whereas other reactions are rather short-lived (see, e.g., Romania and Slovakia). In most cases, we observe that the impact of MPPs on credit growth is of transitory nature, fading out after several quarters.

Turning to the reaction of capital inflows in panels (b) and (c), we find that in a few cases there are economically very meaningful and persistent negative responses in Hungary and Poland. Sizable negative responses, though for only shorter periods, can be detected in the case of total capital inflows in Bulgaria and Croatia and in the case of other investment inflows in Estonia, Croatia and Latvia. The volatility IRFs shown in panels (d) and (e) reveal quite some diversity across countries, with some economies responding to an MPP tightening with a comparatively strong decline in capital flow volatility (e.g., Bulgaria, Estonia, and Latvia in the case of total flows and Hungary, Latvia and Poland in the case of OI flows), while a few others even experience a sharp increase (e.g., the Czech Republic rather persistently and Romania temporarily).

Comparing the level with the corresponding volatility reaction suggests a considerably positive correlation between the two. In case capital inflows increase, volatility also tends to increase, whereas declining levels of capital inflows are often accompanied by negative volatility reactions. This pattern holds for most countries which display both a significant level and volatility response.

As noted in Sub-section 4.2, and laid out in more detail in Appendix B, the overall MPPI used for this analysis captures a range of different measures that target different aspects of the banking and lending system. Given the focus of the present paper on the effects of overall MPP intensity in different interest rate environments, we only provide in Appendix C.1 some evidence regarding the impact of different types of MPPs on our variables of interest, computed for the entire period.

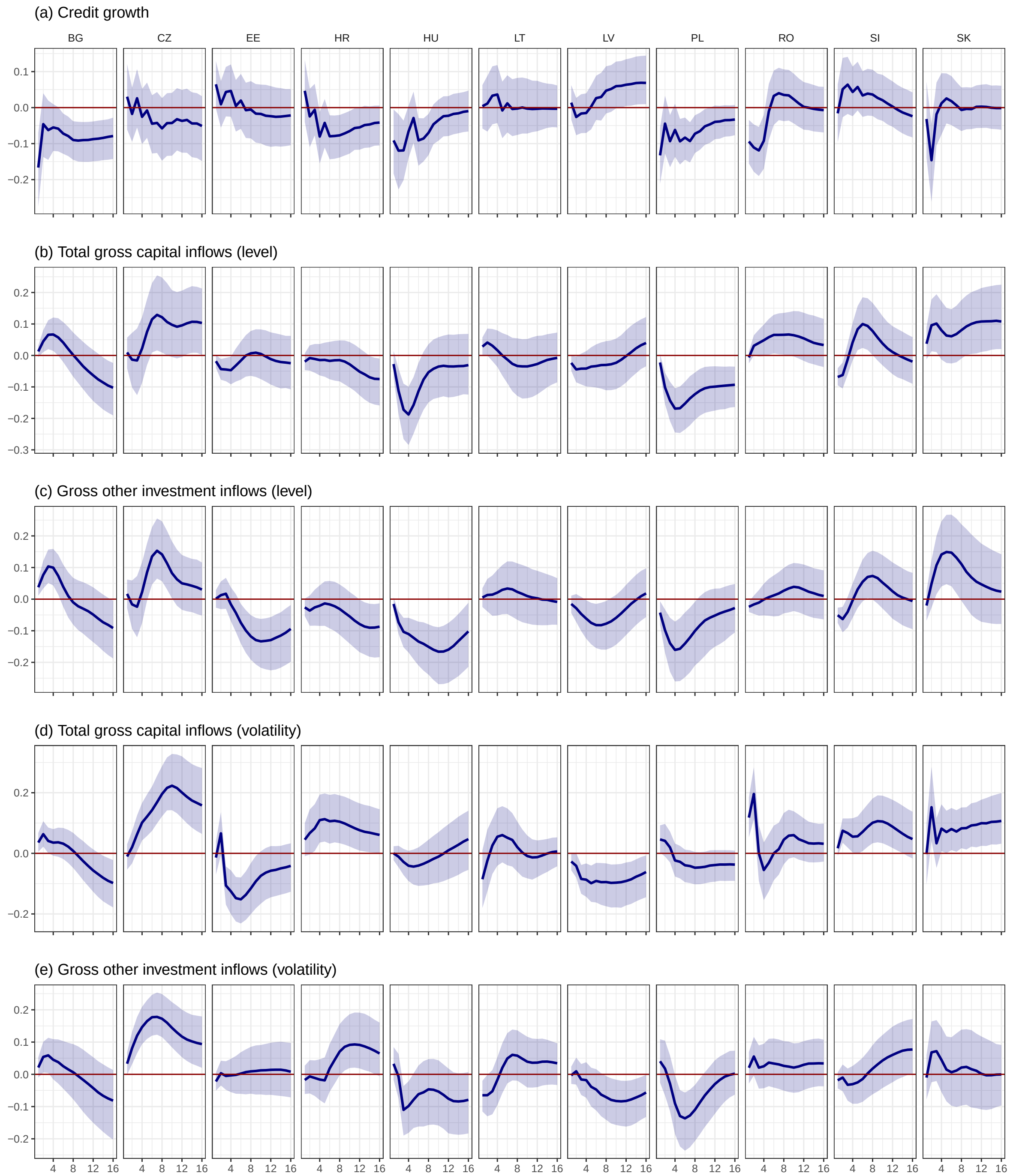
6.2. *Impulse-responses using a nonlinear modeling approach*

In the previous sub-section, we emphasized that MPP tightening leads to pronounced reactions of the quantities under consideration over the whole sample period. Next, we assess whether these reactions are different in specific subperiods, as the role of different transmission mechanisms may change over time. Before discussing the related IRFs, we focus on some features of our nonlinear modeling approach, such as the transition probabilities and the corresponding regime allocation, shown in Fig. 4.

Fig. 4 shows by country the posterior mean of the transition probabilities (solid lines), the short-term interest rate (dashed) and the filtered probabilities (gray shaded areas) for being in a certain interest rate regime. From this figure, we can observe that most countries under investigation were quite uniformly considered to be part of the high-interest rate regime in the period before and shortly after the onset of the GFC (until about end-2009). This consistent pattern carries over to the post-GFC period. In accordance with the fact that most countries decreased their policy rates markedly to alleviate the impact of the GFC, a pronounced increase in the probability of moving into the low-interest rate regime can be observed. In parallel, we observe that the filtered probabilities of a given country being in the low-interest rate regime also tick up substantially. A notable exception is Poland, which shows more frequent fluctuations between the two regimes around the onset of the GFC and afterwards.

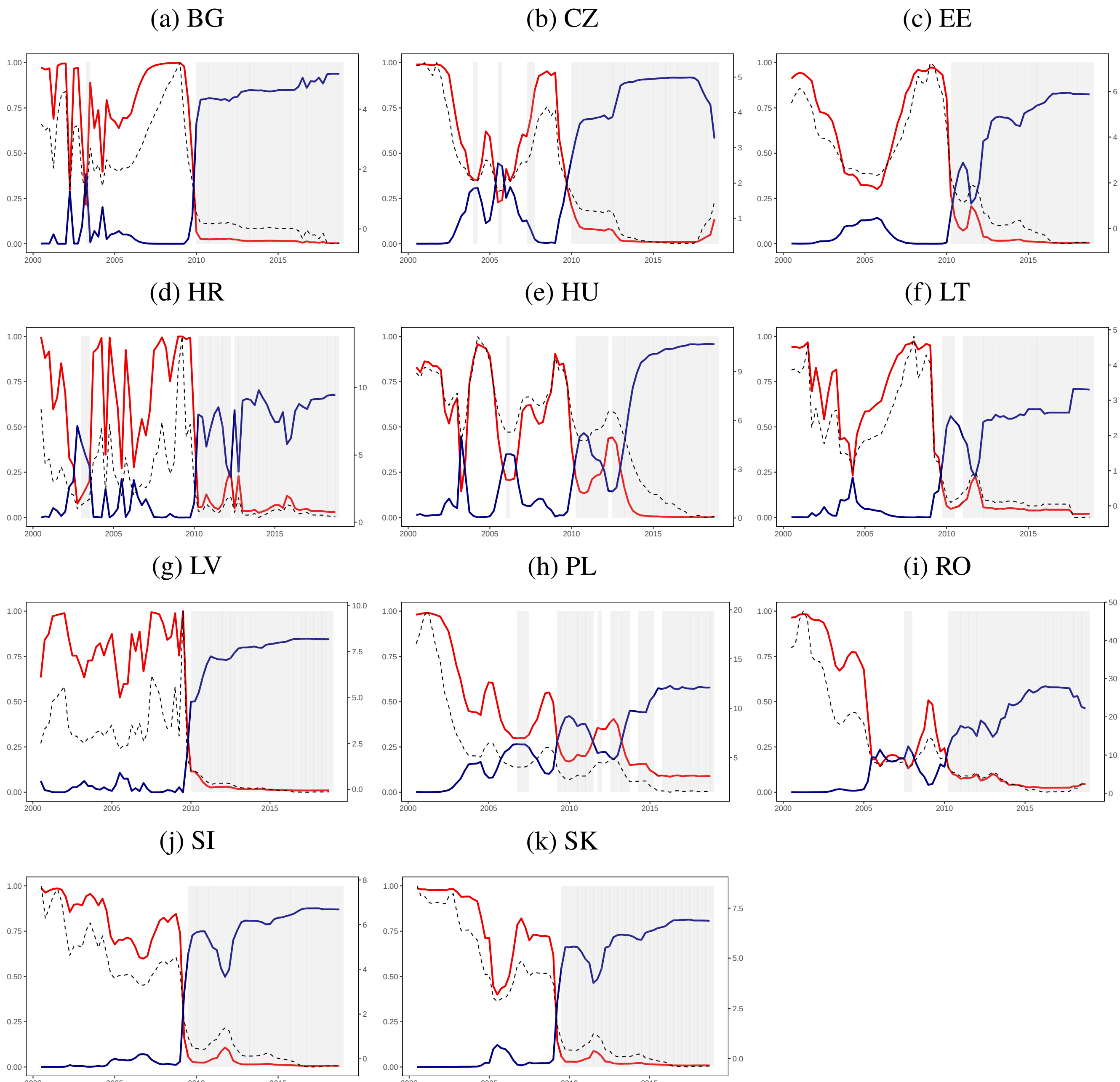
From this discussion, we observe that our model is quite successful in detecting regimes that are characterized by relatively low interest rates. Notice, however, that these regime allocations are stochastic, implying that our flexible specification is able to adapt the regime allocation accordingly, if other nonlinear features in our data set are observed. Moreover, one additional takeaway from this discussion is that transition probabilities tend to feature time-variation, suggesting that lagged policy rates tend to predict movements in the regime allocation.

Next, we again consider the dynamic reactions of our variables of interest to an MPP tightening shock. Figs. 5 and 6 report the peak responses of credit growth, capital inflow levels and volatilities for the high-



Note: The blue line denotes the posterior median and blue shaded areas refer to the 68 % credible set.

Fig. 3: Entire-period **impulse responses of private sector credit growth, total gross capital and gross other investment inflows** (levels & volatilities) to a 1 SD tightening shock in the MPPI.



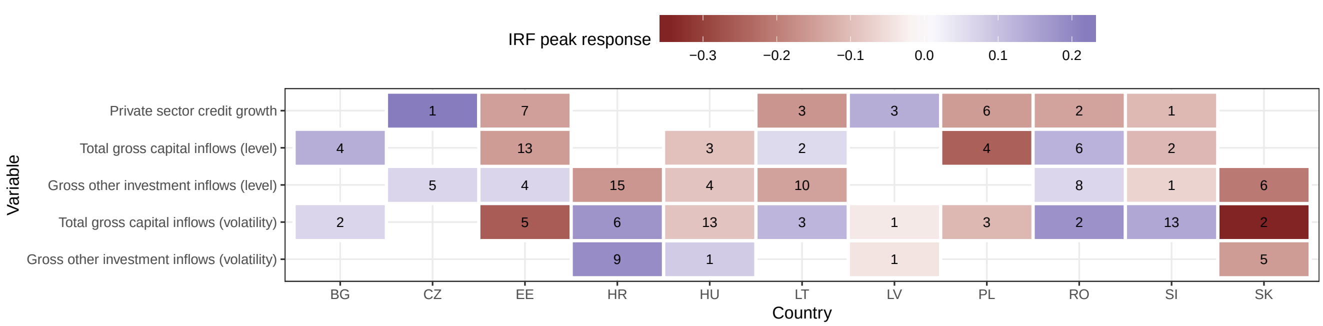
Note: The red line indicates $\Pr(S_{it} = 0|S_{it-1} = 1)$, the blue line refers to $\Pr(S_{it} = 1|S_{it-1} = 0)$. The gray shaded areas indicate the posterior mean probability of a low-interest rate regime. The dashed black line depicts the country-specific interest rate. The left-hand axis shows the transition probabilities and the right-hand scale the values of interest rates.

Fig. 4: Posterior mean of transition probabilities and filtered probabilities of being in the high-interest rate regime $S_{it} = 0$ or in a low-interest rate regime $S_{it} = 1$.

and the low-interest rate regime, respectively. The corresponding Figs. C.5 and C.6 in Appendix C.2, similar to Fig. 3, again give an overview of the shape and evolution of the IRFs.

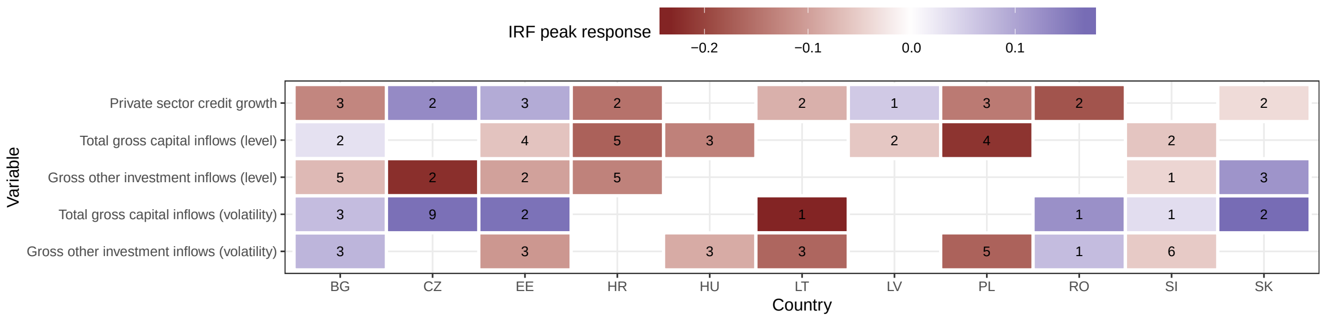
In the high-interest rate regime, predominantly negative peak responses of credit growth are observable. The same holds true for level responses of both types of capital inflows. Hence, MPPs in an environment with high interest rates appear to be effective with regard to reining in potentially excessive credit and capital inflows. However, a mixed pattern can again be observed for the corresponding volatilities of the capital flow series. For total capital inflows, a reduction in levels seems to be accompanied by a reduction in the corresponding volatility in most countries, while for other investment inflows the contrary is the case (whereby rather few countries exhibit significant volatility responses).

The results for the low-interest rate regime, as depicted in Fig. 6, may be of relevance for the current COVID-19 crisis situation, as most countries are still, or again, subject to a low-interest rate environment. Additionally, as discussed above, the time period covered in this regime mostly corresponds to the period in which the recovery from the GFC took place. This was also the period where most countries became more active in the macroprudential realm, globally but also in CESEE, a trend that continues from then on. Hence, these results can be viewed as having greater importance for policy-makers in current times. Under this regime, credit growth in Bulgaria, Croatia, Lithuania, Poland, Romania and Slovakia reacts negatively and these reactions occur in the first two or three quarters after the tightening shock in the macroprudential environment. Even more pronounced than in the high-interest rate regime, total capital inflows preponderantly show decreasing level reactions to an MPP tightening shock. Compared to the high-interest rate regime and entire-period results, this transmission is swifter. For capital flow volatilities, again a mixed picture emerges. While we can often observe declining volatilities of other investment inflows in response to an MPP tightening shock, volatilities of total capital inflows do in fact increase significantly in a majority of countries.



Note: Red shaded cells denote negative and blue shaded cells denote positive responses. Cell numbers indicate the quarter at which the response reaches its peak. Empty cells refer to insignificance with respect to the 68 % credible interval.

Fig. 5: High-interest rate regime (posterior median) **peak responses of private sector credit growth, total gross capital and gross other investment inflows** (levels & volatilities) to a 1 SD tightening shock in the MPPI.



Note: Red shaded cells denote negative and blue shaded cells denote positive responses. Cell numbers indicate the quarter at which the response reaches its peak. Empty cells refer to insignificance with respect to the 68 % credible interval.

Fig. 6: Low-interest rate regime (posterior median) **peak responses of private sector credit growth, total gross capital and gross other investment inflows** (levels & volatilities) to a 1 SD tightening shock in the MPPI.

6.3. *Summary of results*

Given the wide range of possible model specifications and to provide a more compact overview of the different results, Tab. 2 summarizes the number of CESEE countries with statistically significant peak responses considering all specifications and variables of interest, grouped by negative (column "< 0") and positive responses (column "> 0"). Our main focus is on the results obtained for the whole period as a baseline as well as the ones for the low-interest rate regime as they more accurately reflect the current policy environment. They are captured within the first two lines in the various subpanels of Tab. 2.[16]

In line with expectations and large parts of the literature, not all but a majority of countries responds to a macroprudential tightening with a decline in private sector credit growth, in fact comparatively quickly – within one year after the shock. The negative response is somewhat stronger pronounced (and occurs quicker) in the low-interest rate regime, as compared to other subperiods. This would be a good signal in the current low-interest rate environment of the COVID-19 crisis, as an MPP easing – with reverse sign – would give a positive impetus to lending activities and thus contribute to crisis mitigation.

Similarly, a majority of countries show a negative response of capital flow volumes to a MPP tightening for the entire period but also the one corresponding to a low-interest rate regime. This indicates that MPPs can contribute to bringing capital inflows back to more sustainable levels in the case of an overshooting and would thus contribute to stabilization, especially in times where monetary policy is at its limits. Notably, negative volume responses are rather equally pronounced for total and other investment inflows and more often significant in this environment but also the period after the global financial crisis more generally. Thus, macroprudential tightening in the post-GFC episode with low interest rates could have reinforced cross-border deleveraging effects. On the other hand, MPP instruments in the pre-GFC period were probably not yet strong, developed, or targeted enough to decisively contribute to a reduction in capital inflows.

[16]For completeness, we also include peak responses for a model which allows for a deterministic regime switch only. The full set of impulse responses are provided in the empirical appendix.

Table 2: Number of countries with significant peak responses to a tightening shock in macroprudential policies

Variable	FAVAR setup	Regime switch	Reference period	< 0	> 0	Total
Private sector credit growth	Linear	None	Entire period	6	1	7
	Nonlinear	Endogenous	Low-interest rate periods	6	3	9
	Nonlinear	Endogenous	High-interest rate periods	5	2	7
	Nonlinear	Deterministic	Post-GFC period	3	5	8
	Nonlinear	Deterministic	Pre-GFC period	5	1	6
Total gross capital inflows (level)	Linear	None	Entire-period	6	5	11
	Nonlinear	Endogenous	Low-interest rate periods	6	1	7
	Nonlinear	Endogenous	High-interest rate periods	4	3	7
	Nonlinear	Deterministic	Post-GFC period	5	2	7
	Nonlinear	Deterministic	Pre-GFC period	1	4	5
Gross other investment inflows (level)	Linear	None	Entire-period	6	4	10
	Nonlinear	Endogenous	Low-interest rate periods	5	1	6
	Nonlinear	Endogenous	High-interest rate periods	5	3	8
	Nonlinear	Deterministic	Post-GFC period	6	2	8
	Nonlinear	Deterministic	Pre-GFC period	3	2	5
Total gross capital inflows (volatility)	Linear	None	Entire-period	3	6	9
	Nonlinear	Endogenous	Low-interest rate periods	1	6	7
	Nonlinear	Endogenous	High-interest rate periods	5	5	10
	Nonlinear	Deterministic	Post-GFC period	4	5	9
	Nonlinear	Deterministic	Pre-GFC period	4	3	7
Gross other investment inflows (volatility)	Linear	None	Entire-period	4	4	8
	Nonlinear	Endogenous	Low-interest rate periods	5	2	7
	Nonlinear	Endogenous	High-interest rate periods	2	2	4
	Nonlinear	Deterministic	Post-GFC period	5	3	8
	Nonlinear	Deterministic	Pre-GFC period	1	2	3

Note: This table shows the number of significant negative vs. positive peak responses of selected variables to the identified tightening (1 SD) shock in the MPPI, based on nonlinear or linear FAVAR estimates, respectively, over the period 2000–2018 across the 11 CESEE EU Member States. Significance inference is based on 68 % credible sets.

The responses of capital flow volatilities to an MPP tightening shock display a more mixed pattern. Positive volatility responses are often found in combination with significantly positive level responses.[17] By contrast, if the level reaction of capital flows is negative, volatility reactions are often negative as well. This suggests that if MPPs are successful in reducing capital inflows, we find appreciable evidence that this also translates into lower levels of capital flow volatility.

Contrasting the results of the nonlinear model with the linear (i.e., entire-period) model reveals interesting patterns for different interest rate regimes that would be concealed when employing a linear model over the whole period only. Our nonlinear specification is able to unveil differences across such regimes and shows, as already mentioned, that MPPs are more effective when conventional monetary policy is at its limits. This is a crucial point to consider for authorities, pointing to important policy interactions and implying that the interest rate environment should carefully be taken into account when conducting macroprudential policy, especially with respect to the intensity of such adjustments.

7. CONCLUSIONS

Studying the impact of MPPs on capital flows in the CESEE countries is appealing for at least two reasons. *First*, CESEE countries have experienced a substantial boom-bust cycle in capital flows, with a correspondingly pronounced credit cycles. Because of the large reversal of flows (in particular related to bank flows) during the 2008/2009 crisis, the CESEE region suffered stronger output declines than any other region in the world (Berglöf et al., 2010). *Second*, in contrast to the experience of advanced economies with MPPs, which attracted more attention only in the aftermath of the global financial crisis, some CESEE countries, e.g., Bulgaria, Croatia and Romania, had been quite active in adopting MPPs already before the crisis – on the back of extraordinary credit growth, predominantly denominated in foreign currency, at the time.

Examining the impact of MPPs on domestic macroeconomic variables, such as the credit cycle, has gained a lot of attention in recent years. Still, there are only a few studies on the related global dimension (as summarized in Portes et al., 2020), such as the role of international spillovers, cross-border leakages or, more specifically, capital flow responses. The question whether MPPs are effective in taming capital flows is particularly interesting for the CESEE countries, as MPPs are expected to have had a sizable impact on cross-border flows – in particular on bank flows – given the prominent role of foreign-owned banks in the region.

To measure MPPs, we rely on an intensity-adjusted index developed by (Eller et al., 2020b), which allows for capturing both if and to what extent the respective MPP tool was implemented. Moreover, to study the dynamic responses of capital flows to MPP shocks, a novel regime-switching factor-augmented vector autoregressive model has been applied. It allows for capturing potential structural breaks in the policy regime and controls – besides domestic macroeconomic quantities – for the impact of global factors such as the global financial cycle over the period from 2000 to 2018.

[17]Positive volatility responses to MPP tightening could also be due to the introduction of new sets of MPP instruments over time (e.g., borrower-based instruments or capital buffers in recent years). These new tools might have created stronger adjustment pressure for market participants and could thus also have led to more frequent investment or disinvestment decisions with a positive impact on capital flow volatility.

The empirical analysis reveals that tighter MPPs are effective in containing excessive private sector credit growth and the volumes of gross capital inflows in a majority of the CESEE countries under scrutiny. Negative responses of credit growth and capital flow volumes are somewhat stronger pronounced (and occur quicker) in a low-interest rate environment or, in the case of capital flows, in the period after the GFC. Finally, the responses of capital flow volatilities to an MPP tightening shock display a rather mixed pattern with both positive and negative responses being important. However, we can observe a positive correlation between level and volatility responses of capital inflows, suggesting that if MPPs were successful in reducing the levels of capital inflows, they would also lower the volatility of capital inflows. Thus, if a country faces a period of capital flow surges, tighter MPPs would contribute to bringing back capital inflows to more sustainable levels.

It should be noted that our country-specific results indicate some cross-country heterogeneity, which could be attributed to differences in domestic financial cycles, country-specific banking sector characteristics (e.g., level of financial sector depth), the structure of bilateral capital flows vis-à-vis more vulnerable partner countries, or other structural differences such as the respective exchange rate regime or the extent and structure of a country's external debt – to be investigated in future research.

One limitation of the econometric model employed in this study is that it is linearly conditional on a regime. This implies that shocks enter the system symmetrically and negative shocks would simply mirror positive shocks (subject to a sign switch). There are recent papers (see, e.g., Bertolotti and Marcellino, 2019) which allow for asymmetric reactions to macroeconomic shocks. However, they all have in common that they rely on observed shock series to identify the shock of interest. Since our identification strategy relies on using zero restrictions we can unfortunately not easily adopt similar techniques. Another approach would be to rely on non-parametric methods but doing so would be beyond the scope of the paper (for recent papers proposing non-parametric VAR models, see Huber and Rossini, 2020; Huber et al., 2020; Adrian et al., 2021). Given that this question is of high relevance for practitioners, we leave this open for further research.

REFERENCES

Adrian T, Boyarchenko N and Giannone D (2021) Multimodality in macrofinancial dynamics. *International Economic Review* ahead-of-print

Ahnert T, Forbes K, Friedrich C and Reinhardt D (2021) Macroprudential FX regulations: shifting the snowbanks of FX vulnerability? *Journal of Financial Economics* 140(1), 145–174

Aizenman J, Chinn MD and Ito H (2020) Financial spillovers and macroprudential policies. *Open Economies Review* , 1–35

Akram QF (2014) Macro effects of capital requirements and macroprudential policy. *Economic Modelling* 42, 77–93

Alam Z, Alter A, Eiseman J, Gelos RG, Kang H, Narita M, Nier E and Wang N (2019) Digging deeper – evidence on the effects of macroprudential policies from a new database. IMF Working Paper 19/66, International Monetary Fund

Allenby GM, Arora N and Ginter JL (1998) On the heterogeneity of demand. *Journal of Marketing Research* 35(3), 384–389

Amisano G and Fagan G (2013) Money growth and inflation: A regime switching approach. *Journal of International Money and Finance* 33, 118–145

Angelini P, Neri S and Panetta F (2014) The interaction between capital requirements and monetary policy. *Journal of Money, Credit and Banking* 46(6), 1073–1112

Avdjiev S, Bruno V, Koch C and Shin HS (2019) The dollar exchange rate as a global risk factor: evidence from investment. *IMF Economic Review* 67(1), 151–173

Aysan AF, Fendoğlu S and Kilinc M (2015) Macroprudential policies as buffer against volatile cross-border capital flows. *The Singapore Economic Review* 60(01), 1550001

Bakker B and Klingen C (2012) *How emerging Europe came through the 2008/09 crisis: An account by the staff of the IMF's European department*. International Monetary Fund, Washington, D.C.

Beirne J and Friedrich C (2017) Macroprudential policies, capital flows, and the structure of the banking sector. *Journal of International Money and Finance* 75, 47–68

Bergant K, Grigoli F, Hansen NJ and Sandri D (2020) Dampening global financial shocks: can macroprudential regulation help (more than capital controls)? IMF Working Paper 20/106, International Monetary Fund

Berglöf E, Korniyenko Y, Plekhanov A and Zettelmeyer J (2010) Understanding the crisis in Emerging Europe. *Public Policy Review* 6(6), 985–1008

Bernanke B, Boivin J and Eliasz P (2005) Measuring the effects of monetary policy: a factor-augmented vector autoregressive (FAVAR) approach. *The Quarterly Journal of Economics* 120(1), 387–422

Bertolotti F and Marcellino M (2019) Tax shocks with high and low uncertainty. *Journal of Applied Econometrics* 34(6), 972–993

Billio M, Casarin R, Ravazzolo F and Van Dijk HK (2016) Interconnections between eurozone and US booms and busts using a Bayesian panel Markov-switching VAR model. *Journal of Applied Econometrics* 31(7), 1352–1370

Blanchard O, Ostry JD, Ghosh AR and Chamon M (2016) Capital flows: expansionary or contractionary? *American Economic Review* 106(5), 565–69

Brandao-Marques L, Gelos G, Narita M and Nier E (2020) Leaning against the wind: a cost-benefit analysis for an integrated policy framework. IMF Working Paper 20/123, International Monetary Fund

Buch CM and Goldberg LS (2017) Cross-Border Prudential Policy Spillovers: How Much? How Important? Evidence from the International Banking Research Network. *International Journal of Central Banking* 13(S1), 505–558

Bussière M, Schmidt J and Valla N (2018) International financial flows in the new normal: key patterns (and why we should care). In Ferrara L, Hernando I and Marconi D, eds., *International Macroeconomics in the Wake of the Global Financial Crisis*. Springer, 249–269

Calvo GA, Leiderman L and Reinhart CM (1996) Inflows of capital to developing countries in the 1990s. *Journal of Economic Perspectives* 10(2), 123–139

Cerutti E, Claessens S and Laeven L (2017a) The use and effectiveness of macroprudential policies: new evidence. *Journal of Financial Stability* 28, 203–224

Cerutti E, Correa R, Fiorentino E and Segalla E (2017b) Changes in prudential policy instruments – a new cross-country database. *International Journal of Central Banking* 13(1), 477–503
Cerutti E and Zhou H (2018) Cross-border banking and the circumvention of macroprudential and capital control measures. IMF Working Paper 18/217, International Monetary Fund
Cesa-Bianchi A, Ferrero A and Rebucci A (2018) International credit supply shocks. *Journal of International Economics* 112, 219–237
Cizel J, Frost J, Houben A and Wierts P (2019) Effective Macroprudential Policy: Cross-Sector Substitution from Price and Quantity Measures. *Journal of Money, Credit and Banking* 51(5)
Coman A and Lloyd S (2019) In the face of spillovers: prudential policies in emerging economies. ECB Working Paper 2339, European Central Bank
Dumičić M (2018) Effectiveness of macroprudential policies in Central and Eastern European countries. *Public Sector Economics* 42(1), 1–19
Eller M, Haiss P and Steiner K (2006) Foreign direct investment in the financial sector and economic growth in Central and Eastern Europe: The crucial role of the efficiency channel. *Emerging Markets Review* 7(4), 300–319
Eller M, Huber F and Schuberth H (2016) Understanding the drivers of capital flows into the CESEE countries. *Focus on European Economic Integration* Q2/16, 79–104
Eller M, Huber F and Schuberth H (2020a) How important are global factors for understanding the dynamics of international capital flows? *Journal of International Money and Finance* 109, 102221
Eller M, Martin R, Schuberth H and Vashold L (2020b) Macroprudential policies in CESEE – an intensity-adjusted approach. *Focus on European Economic Integration* Q2/20, 65–81
Fendoğlu S (2017) Credit cycles and capital flows: effectiveness of the macroprudential policy framework in emerging market economies. *Journal of Banking & Finance* 79, 110–128
Filardo AJ (1994) Business-cycle phases and their transitional dynamics. *Journal of Business & Economic Statistics* 12(3), 299–308
Forbes KJ (2020) The International Aspects of Macroprudential Policy. NBER Working Paper 27698, The National Bureau of Economic Research
Forbes KJ, Fratzscher M and Straub R (2015) Capital-flow management measures: what are they good for? *Journal of International Economics* 96, S76–S97
Forbes KJ and Warnock FE (2012) Capital flow waves: surges, stops, flight, and retrenchment. *Journal of International Economics* 88(2), 235 – 251
Fratzscher M (2012) Capital flows, push versus pull factors and the global financial crisis. *Journal of International Economics* 88(2), 341–356
Frost J, Ito H and van Stralen R (2020) The effectiveness of macroprudential policies and capital controls against volatile capital inflows. BIS Working Papers 867, Bank for International Settlements
Frühwirth-Schnatter S, Tüchler R and Otter T (2004) Bayesian analysis of the heterogeneity model. *Journal of Business & Economic Statistics* 22(1), 2–15
Galati G and Moessner R (2013) Macroprudential policy – a literature review. *Journal of Economic Surveys* 27(5), 846–878
Galati G and Moessner R (2018) What do we know about the effects of macroprudential policy? *Economica* 85(340), 735–770
Gerali A, Neri S, Sessa L and Signoretti FM (2010) Credit and banking in a DSGE model of the Euro area. *Journal of Money, Credit and Banking* 42, 107–141
Hahm Jh, Shin HS and Shin K (2013) Noncore bank liabilities and financial vulnerability. *Journal of Money, Credit and Banking* 45(S1), 3–36
Hauzenberger N and Huber F (2020) Model instability in predictive exchange rate regressions. *Journal of Forecasting* 39(2), 168–186
Hauzenberger N, Huber F, Pfarrhofer M and Zörner TO (2021) Stochastic model specification in Markov switching vector error correction models. *Studies in Nonlinear Dynamics & Econometrics* 25(2)
Hegerty SW (2009) Capital inflows, exchange market pressure, and credit growth in four transition economies with fixed exchange rates. *Economic Systems* 33(2), 155–167
Huber F and Fischer MM (2018) A Markov Switching Factor-Augmented VAR Model for Analyzing US Business

Cycles and Monetary Policy. *Oxford Bulletin of Economics and Statistics* 80(3), 575–604

Huber F, Koop G, Onorante L, Pfarrhofer M and Schreiner J (2020) Nowcasting in a pandemic using non-parametric mixed frequency VARs. *Journal of Econometrics* ahead-of-print

Huber F and Rossini L (2020) Inference in Bayesian Additive Vector Autoregressive Tree Models. *arXiv preprint arXiv:2006.16333*

Igan D and Tan Z (2017) Capital inflows, credit growth, and financial systems. *Emerging Markets Finance and Trade* 53(12), 2649–2671

IMF (2016) Capital flows – review of experience with the institutional view. IMF Policy Paper, International Monetary Fund

IMF (2017) Increasing resilience to large and volatile capital flows: the role of macroprudential policies. IMF Policy Paper, International Monetary Fund

IMF (2020) Toward an integrated policy framework. IMF Policy Paper, International Monetary Fund

IMF-FSB-BIS (2016) Elements of effective macroprudential policies: lessons from international experience. IMF Policy Paper, International Monetary Fund

Kaufmann S (2015) K-state switching models with time-varying transition distributions - Does loan growth signal stronger effects of variables on inflation? *Journal of Econometrics* 187(1), 82–94

Kim CJ and Nelson CR (1998) Business cycle turning points, a new coincident index, and tests of duration dependence based on a dynamic factor model with regime switching. *Review of Economics and Statistics* 80(2), 188–201

Kim J, Kim S and Mehrotra A (2019) Macroprudential policy in Asia. *Journal of Asian Economics* 65, 101149

Kim S and Mehrotra A (2017) Managing price and financial stability objectives in inflation targeting economies in Asia and the Pacific. *Journal of Financial Stability* 29, 106–116

Kim S and Mehrotra A (2018) Effects of monetary and macroprudential policies – evidence from four inflation targeting economies. *Journal of Money, Credit and Banking* 50(5), 967–992

Kim S and Mehrotra A (2019) Examining macroprudential policy and its macroeconomic effects – Some new evidence. BIS Working Papers 825, Bank for International Settlements

Lepers E and Mehigan C (2019) The broad policy toolkit for financial stability: Foundations, fences, and fire doors. OECD Working Papers on International Investment 2, Organisation for Economic Co-operation and Development

Lepers E and Mercado R (2020) Sectoral Capital Flows: Covariates, Co-movements, and Controls. SEACEN Working Paper 04/20, The South East Asian Central Banks Research and Training Centre

Malsiner-Walli G, Frühwirth-Schnatter S and Grün B (2016) Model-based clustering based on sparse finite Gaussian mixtures. *Statistics and Computing* 26(1), 303–324

McCann F and O'Toole C (2019) Cross-Border Macroprudential Policy Spillovers and Bank Risk-Taking. *International Journal of Central Banking* 15(4), 267–311

McQuade P and Schmitz M (2017) The great moderation in international capital flows: a global phenomenon? *Journal of International Money and Finance* 73, 188–212

Meeks R (2017) Capital regulation and the macroeconomy: empirical evidence and macroprudential policy. *European Economic Review* 95, 125–141

Meuleman E and Vander Vennet R (2020) Macroprudential policy and bank systemic risk. *Journal of Financial Stability* 47, 100724

Ostry JD, Ghosh AR, Chamon M and Qureshi MS (2012) Tools for managing financial-stability risks from capital inflows. *Journal of International Economics* 88(2), 407–421

Portes R, Beck T, Buiter W, Dominguez K, Gros D, Gross C, Kalemli-Ozcan S, Peltonen T and Sánchez Serrano A (2020) The global dimensions of macroprudential policy. Reports of the Advisory Scientific Committee of the ESRB 10, European Systemic Risk Board

Reinhardt D and Sowerbutts R (2015) Regulatory arbitrage in action: evidence from banking flows and macroprudential policy. Bank of England Working Paper 546, Bank of England

Reininger T and Walko Z (2020) A sleeping beauty or a dead duck? The state of capital market development in CESEE EU Member States. *Focus on European Economic Integration* Q3/20, 7–35

Rey H (2015) Dilemma not trilemma: the global financial cycle and monetary policy independence. Working Paper 21162, National Bureau of Economic Research

Richter B, Schularick M and Shim I (2019) The costs of macroprudential policy. *Journal of International Economics* 118, 263–282
Rojas D, Vegh CA and Vuletin G (2020) The macroeconomic effects of macroprudential policy: Evidence from a narrative approach. NBER Working Paper 27687, The National Bureau of Economic Research
Shim I, Bogdanova B, Shek J and Subelyte A (2013) Database for policy actions on housing markets. *BIS Quarterly Review* September, 83–95
Sims CA and Zha T (1998) Bayesian methods for dynamic multivariate models. *International Economic Review* , 949–968
Svensson LE (2018) Monetary policy and macroprudential policy: different and separate? *Canadian Journal of Economics/Revue canadienne d'économique* 51(3), 802–827
Vandenbussche J, Vogel U and Detragiache E (2015) Macroprudential policies and housing prices: a new database and empirical evidence for Central, Eastern, and Southeastern Europe. *Journal of Money, Credit and Banking* 47(S1), 343–377
Verbeke G and Lesaffre E (1996) A linear mixed-effects model with heterogeneity in the random-effects population. *Journal of the American Statistical Association* 91(433), 217–221

A. DATA DESCRIPTIVES

Table A.1: Variable description

Variable	Description	Main source(s)
Global factor	Factor extract of equity price, credit and deposit growth for a set of 45 developed & developing countries; no further transformation	own calculations; IMF-IFS
MPPI	Intensity-adjusted macroprudential policy index; first differences	Eller et al. (2020b)
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 change	IMF-IFS
Credit growth	Domestic banks' claims on the resident nonbank private sector, 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); no further transformation	IMF-IFS; ECB; Eurostat
Equity price growth	Equity price index, 2005=100, seasonally adjusted, in logarithms, quarter-on-quarter change	IMF-IFS; OECD
REER volatility	Real effective exchange rate, CPI-based index, seasonally adjusted, in logarithms, estimated log-variances of AR(5)-SV process	own calculations; IMF-IFS
Gross capital inflows	Cumulative four-quarter moving sums of either total capital inflows (i.e., incurrence less repayment of residents' totaled direct, portfolio and other investment (OI) liabilities vis-á-vis nonresidents) or OI inflows only (BPM6 definition), as percentage of nominal GDP	IMF-IFS
Gross capital outflows	Cumulative four-quarter moving sums of either total capital outflows (i.e., residents' acquisition less disposal of totaled direct, portfolio and other investment (OI) assets abroad) or OI outflows only (BPM6 definition), as percentage of nominal GDP	IMF-IFS
Capital flow volatilities of in- and outflows	Estimated log-variances of AR(5)-SV process on respective capital flow series	own calculations; IMF-IFS

Notes: This table presents the variables included in the country-specific FAVAR models, a short description and their corresponding transformations for estimation as well as sources from where they were gathered. Seasonal adjustment was conducted using the Census X12 method. A few capital flow series were not satisfactorily available at quarterly frequency at the beginning of the sample; we used the corresponding annual figures and the quarterly dynamics of the remaining sample for data interpolation. If for equity prices data from the IMF-IFS was missing, dynamics from OECD series on equity prices or from GDP growth were used for interpolation. Moreover, in a few cases where the short-term interest rate was missing, we used the dynamics of the deposit rate for data interpolation similarly to Eller et al. (2020a). In cases where a few observations were missing at the beginning or the end of the sample, we used the average of the subsequent or previous four quarters to fill these gaps. All variables were standardized prior to estimation by subtracting the mean and dividing them by their standard deviations.

B. DETAILED COMPOSITION OF THE MPPI

While Fig. 1 in the main part of this paper gives an overview of total macroprudential activity in CESEE, Fig. B.1 allows for a more granular consideration. It depicts the individual subindices as defined in Eller et al. (2020b) and their respective contributions to the overall intensity-adjusted MPP index. With regards to the employment of macroprudential policies some general patterns can be observed but there are also heterogeneities across countries.

First, there are some countries that already showed considerable activity before the crisis. Bulgaria, Croatia, Poland, Romania and Slovenia exhibited quite some tightening in the run-up to the GFC. Other countries such as the Baltics or Slovakia also showed substantial usage of macroprudential tools prior to the GFC, however not as clearly towards a tightening of the situation. For Hungary and the Czech Republic rather few changes to the macroprudential environment occurred prior to the GFC.

Second, a clearly increased usage of MPPs can be observed for the post-GFC period. The majority of changes in the macroprudential environment took place in the aftermath of the GFC for most of the countries under consideration. This is in line with the literature that stresses the increased attention paid to such policies in this period (Galati and Moessner, 2013). Hungary, the Czech Republic, Lithuania and Poland represent such cases, where a strong tightening in the aftermath of the crisis was observable even though the employed instruments do differ between these countries. In terms of the type of used measures it is apparent that for most countries the implementation of borrower-based measures like LTV or debt service-to-income (DSTI) limits is rather a post-GFC phenomenon. Romania constitutes the only case that shows considerable changes in the pre-GFC period. Buffer rates also represent a group of measures that were implemented in the rather recent past.

Third, Fig. B.1 reveals that the instruments used vary not only over time but also across countries. For example, while other countries adjusted their risk weights more extensively, the Czech republic, Hungary and Romania did less so, at least for the period under scrutiny. Furthermore, some MPPs have only been applied by a subset of countries. For instance, this is the case for limits on currency mismatch of assets and liabilities (FX mismatch limits in Fig. B.1), which have only been employed by Croatia, Hungary, Lithuania, Latvia and Poland. These different compositions of the MPPI could be a factor for some of the heterogeneity in the observed results. In Appendix C.1 we provide some evidence on the effects that materialize when feeding some of the subindices of the MPPI in the linear model for the entire period instead of the composite index.[18]

[18] Identifying the effect of more granular individual MPP instruments may provide additional important insights but would go beyond the scope of the present paper that focuses on the effects of the overall MPP stance in different interest rate environments.

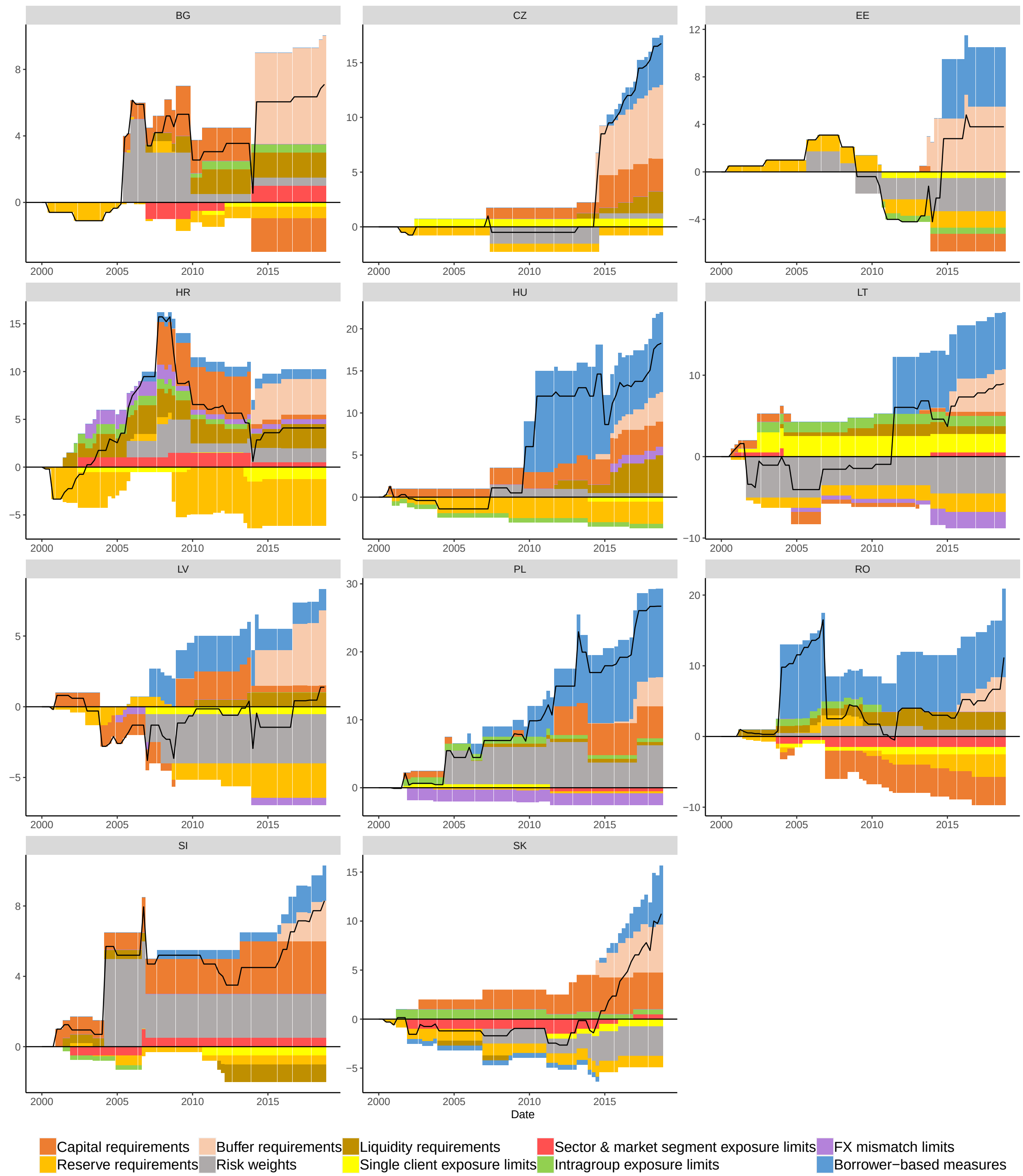


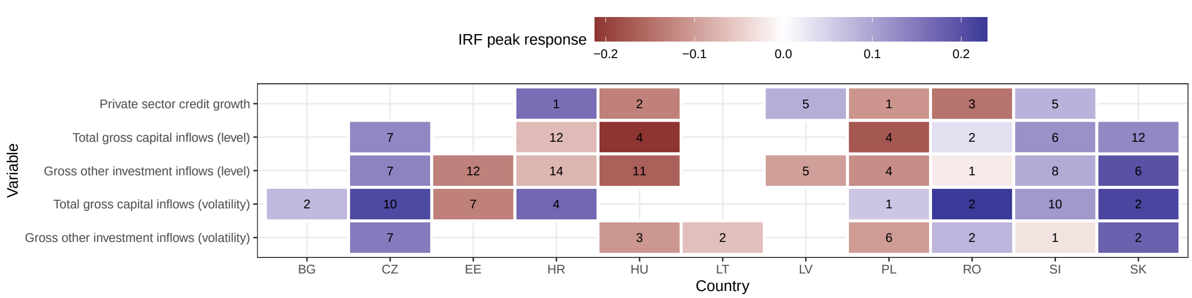
Fig. B.1: Different subindices of the intensity-adjusted MPP index using announcement (implementation) date for tightening (loosening) measures and their respective contribution to the overall index for the time period 2000Q1-2018Q4. Authors' own calculations based on Eller et al. (2020b). Time series have been rescaled to start at 0.

C. ADDITIONAL RESULTS

C.1. *Impulse responses for different types of macroprudential measures*

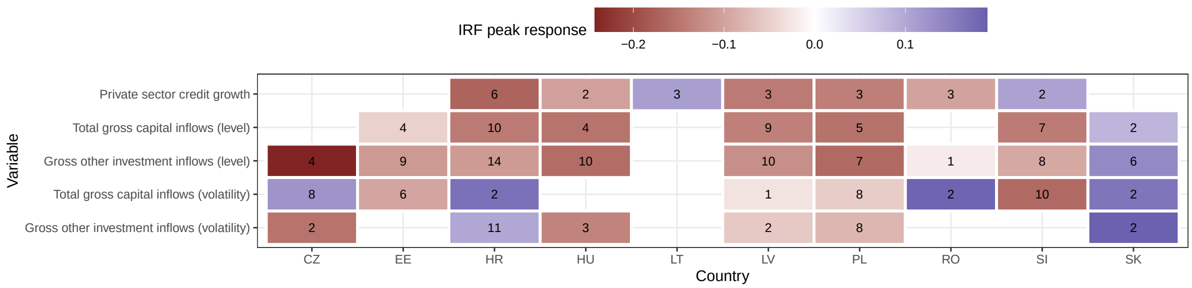
Fig. C.1 to Fig. C.4 show the peak responses for the entire period using a narrow version of the MPPI (i.e., the MPPI excluding minimum capital and reserve requirements), the subindex capturing borrower-based instruments (such as LTV or DSTI limits), the subindex capturing capital-based instruments (such as risk weights or buffer requirements) and the subindex capturing liquidity-based instruments (such as liquidity requirements or FX mismatch limits), respectively. It is worth noting that some of the country-specific subindices do not exhibit much variation, possibly impairing the reliability of estimated impulse responses.

As can be seen from Fig. C.2, the majority of responses to a tightening of MPPs that are capturing borrower-based measures point to a decline in credit growth. This pattern is less pronounced for the subindices capturing capital-based and liquidity-based measures (Fig. C.3 and Fig. C.4, respectively). The stronger negative response of credit growth to a tightening of borrower-based measures compared to other MPPs is in line with previous literature (e.g., Cerutti et al., 2017b; Fendoğlu, 2017; Alam et al., 2019). With regards to the level and volatility of capital flows, existing literature to draw on becomes much more sparse. However, the results reveal an interesting pattern. A tightening in borrower-based measures is mostly associated with a decrease in the levels of capital inflows, while a tightening of capital- or liquidity-based measures often leads to less pronounced responses of capital inflows with increases dominating. This is in line with expectations insofar as the latter instruments are aiming at the capitalization and liquidity of banks with respect to existing balance sheet positions that may not be instantaneously adjustable, potentially increasing refinancing needs of subsidiary banks when they are tightened. On the other hand, borrower-based measures such as LTV and DSTI limits are typically targeting newly created loans but do not apply to the existing stock of loans. This implies that following the introduction of harsher lending restrictions and the resulting decrease in credit growth (as has been observed in most countries), foreign capital inflows could also be expected to decrease more strongly.



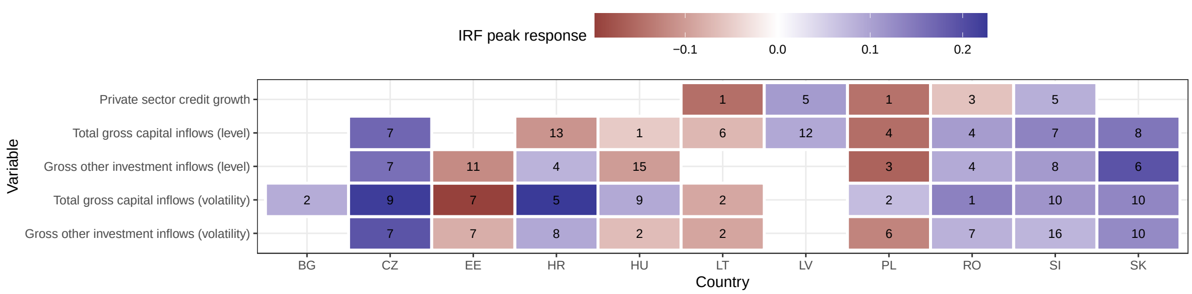
Note: Red shaded cells denote negative and blue shaded cells denote positive responses. Cell numbers indicate the quarter at which the response reaches its peak. Empty cells refer to insignificance with respect to the 68 % credible interval.

Fig. C.1: Entire-period (posterior median) **peak responses of private sector credit growth, total gross capital and gross other investment inflows** (levels & volatilities) to a 1 SD tightening shock in the **narrow MPPI** (i.e., excluding minimum capital and reserve requirements).



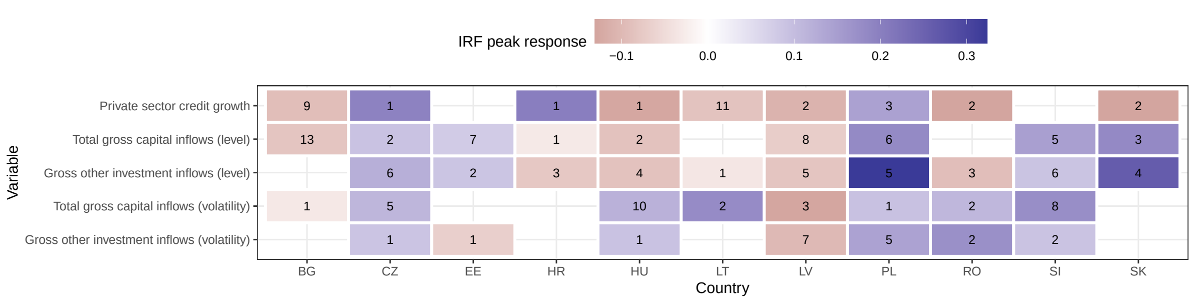
Note: Red shaded cells denote negative and blue shaded cells denote positive responses. Cell numbers indicate the quarter at which the response reaches its peak. Empty cells refer to insignificance with respect to the 68 % credible interval.

Fig. C.2: Entire-period (posterior median) **peak responses of private sector credit growth, total gross capital and gross other investment inflows** (levels & volatilities) to a 1 SD tightening shock in the **borrower-based subindex of the MPPI**. BG is missing due to the lack of variation in the subindex capturing borrower-based measures.



Note: Red shaded cells denote negative and blue shaded cells denote positive responses. Cell numbers indicate the quarter at which the response reaches its peak. Empty cells refer to insignificance with respect to the 68 % credible interval.

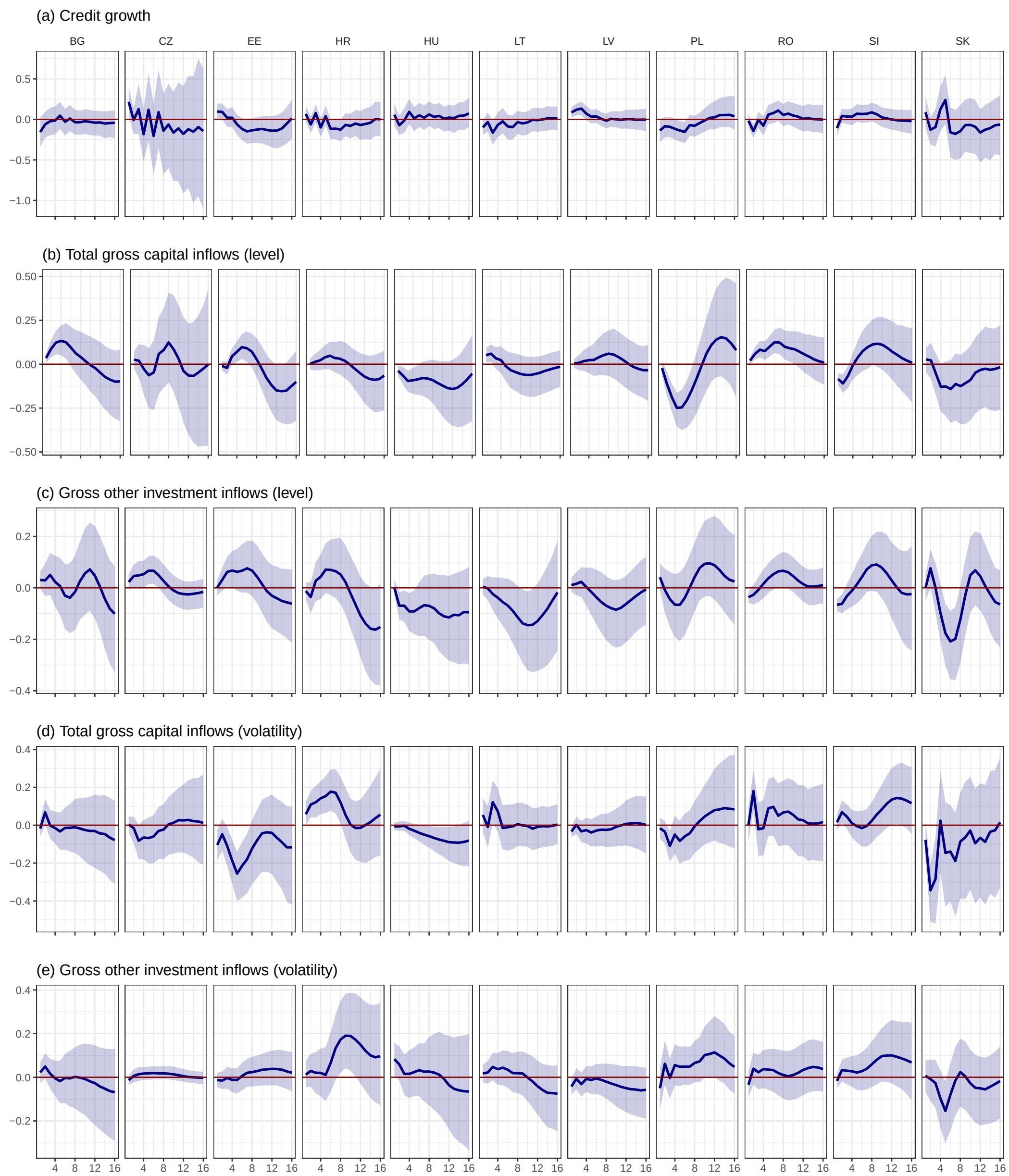
Fig. C.3: Entire-period (posterior median) **peak responses of private sector credit growth, total gross capital and gross other investment inflows** (levels & volatilities) to a 1 SD tightening shock in the **capital-based subindex of the MPPI**.



Note: Red shaded cells denote negative and blue shaded cells denote positive responses. Cell numbers indicate the quarter at which the response reaches its peak. Empty cells refer to insignificance with respect to the 68 % credible interval.

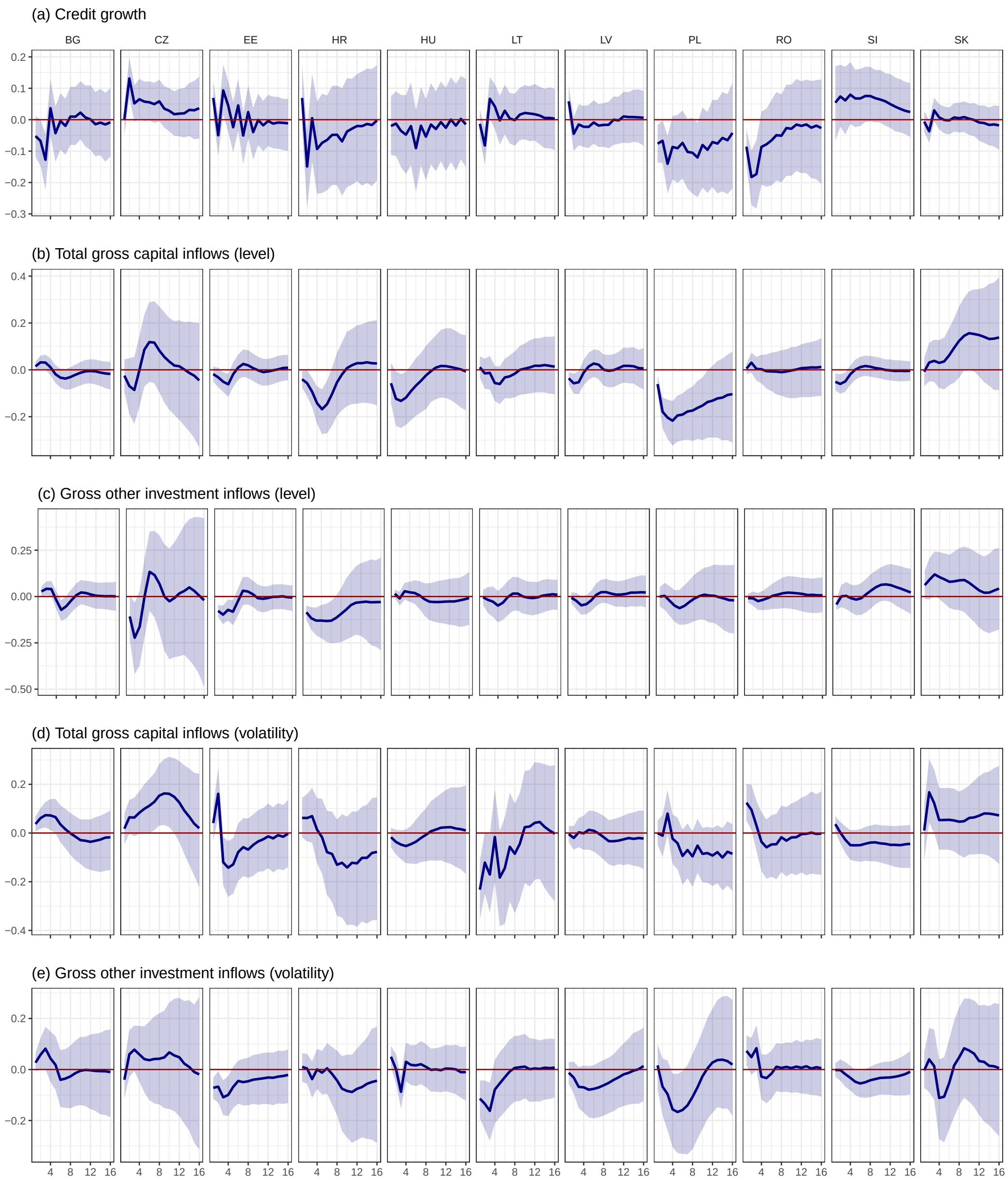
Fig. C.4: Entire-period (posterior median) **peak responses of private sector credit growth, total gross capital and gross other investment inflows** (levels & volatilities) to a 1 SD tightening shock in the **liquidity-based subindex of the MPPI**.

C.2. *Impulse responses for Markov-switching specification*



Note: The blue line denotes the posterior median and blue shaded areas refer to the 68 % credible set.

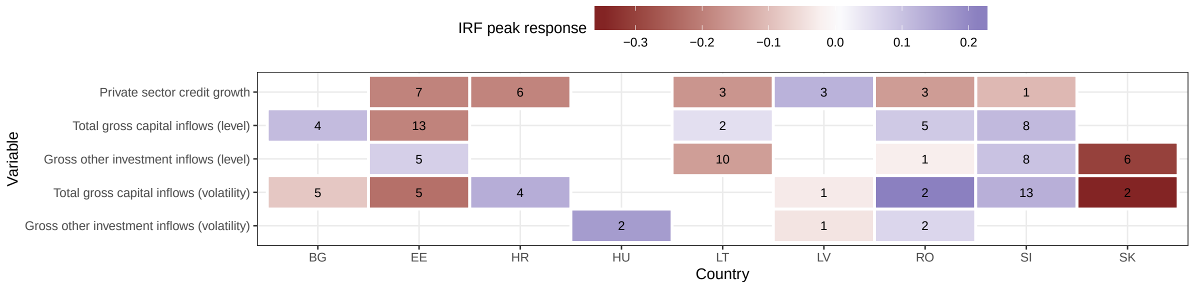
Fig. C.5: High-interest rate regime **impulse responses of private sector credit growth, total gross capital and gross other investment inflows** (levels & volatilities) to a 1 SD tightening shock in the MPPI.



Note: The blue line denotes the posterior median and blue shaded areas refer to the 68 % credible interval.

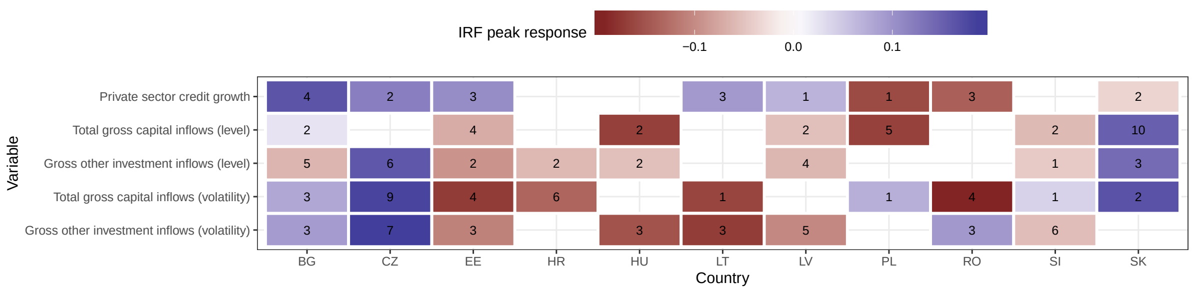
Fig. C.6: Low-interest rate regime **impulse responses of private sector credit growth, total gross capital and gross other investment inflows** (levels & volatilities) to a 1 SD tightening shock in the MPPI.

C.3. *Peak impulse responses for deterministic regime allocation*



Note: Red shaded cells denote negative and blue shaded cells denote positive responses. Cell numbers indicate the quarter at which the response reaches its peak. Empty cells refer to insignificance with respect to the 68 % credible interval. For CZ and PL, we do not observe any significant responses of these variables.

Fig. C.7: Pre-GFC (posterior median) **peak responses of private sector credit growth, total gross capital and gross other investment inflows** (levels & volatilities) to a 1 SD tightening shock in the MPPI.



Note: Red shaded cells denote negative and blue shaded cells denote positive responses. Cell numbers indicate the quarter at which the response reaches its peak. Empty cells refer to insignificance with respect to the 68 % credible interval.

Fig. C.8: Post-GFC (posterior median) **peak responses of private sector credit growth, total gross capital and gross other investment inflows** (levels & volatilities) to a 1 SD tightening shock in the MPPI.