Quarterly projection model for macroprudential policy analysis and financial stability in the Euro area

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Abstract: This paper enhances systemic risk assessment and Basel III implementation by extending the new Keynesian (NK) quarterly projection model (QPM) to encompass macroprudential policy in the Euro area. The integration of macroprudential and financial blocks enhances the understanding of the interaction between monetary policy, macroeconomic variables, and financial stability. The paper employs calibration and Bayesian estimation for model parametrization and assesses its strengths and weaknesses through impulse response functions and historical shock decompositions. The results demonstrate satisfactory model dynamics and highlight the role of macroprudential measures in promoting financial stability. The QPM proves effective in quantifying the impact of financial shocks on the banking system and macroeconomy, enabling evaluation of the effects of capital banking instruments. Policymakers and analysts can use this comprehensive tool to better understand complex economic dynamics, inform policy decisions, and promote financial stability.

Keywords: forecasting and policy analysis, quarterly projection model, monetary policy, macroprudential policy, financial stability, credit cycle, leverage ratio, Euro area.

JEL classification: C54, E47, E52, E58.

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Résumé : Cet article a pour objectif d'améliorer l'évaluation des risques systémiques et la mise en œuvre de Bâle III dans la zone euro en étendant le modèle de prévision trimestriel (QPM) nouveau keynésien (NK) aux politiques macroprudentielles. L'intégration des secteurs macroprudentiel et financier renforce la compréhension des interactions entre la politique monétaire, les variables macroéconomiques et la stabilité financière. Cet article utilise le calibrage et l'estimation bayésienne pour le paramétrage du modèle et évalue ses avantages et ses inconvénients à travers les fonctions de réponse impulsionnelle et la décomposition historique des chocs. Les résultats montrent une dynamique de modèle satisfaisante et mettent en évidence le rôle des mesures macroprudentielles dans la promotion de la stabilité financière. Les modèles QPM s'avèrent donc efficaces pour quantifier l'impact des chocs financiers sur le système bancaire et l'économie, permettant ainsi d'évaluer l'impact des instruments de capital bancaire. Les décideurs politiques et les analystes peuvent utiliser cet outil complet pour mieux comprendre les dynamiques économiques complexes, éclairer les décisions politiques et promouvoir la stabilité financière.

Mots-clés : prévision et analyse des politiques, modèle de projection trimestrielle, politique monétaire, politique macroprudentielle, stabilité financière, cycle de crédit, ratio de levier, zone euro.

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1. Introduction

The countries of the eurozone have divergent[2] conjunctural trajectories (economic and financial cycles),[3] which makes the eurozone a heterogeneous monetary zone. Indeed, this heterogeneity existed when the common currency was created but decreased during the subsequent decade (Le Cacheux, 2016). Thus, during this period, the economic and financial cycles of the member countries of the monetary union converged, relatively speaking (see, for instance, Berger, 2014). This languishing convergence was broken by the financial crisis of 2008, and especially by the measures designed to resolve the sovereign debt crisis (OECD, 2021; N'Goran, 2022).

These economic and financial-cycle divergences among eurozone members render the action of the monetary policy – the only instrument for macroeconomic adjustment – ineffective (Couppey-Soubeyran and Dehmej, 2017).[4] Indeed, monetary policy is designed for the average eurozone member and not for each individual member state. And this ignores the fact that, in the presence of growth and inflation differentials, area-wide inflation targeting would destabilize national economies whose characteristics diverge from the average. Thus, in a period of crisis, such as the 2008–9 global financial crisis, instead of allowing regulation of the financial cycle, monetary policy contributes to, and accentuates, intra-zone divergence (see Bank of Spain, 2009; Schnabl, 2013; Georgiadis, 2015). National fiscal policy actions in support of monetary policy, on the other hand, can be very useful in responding to a financial crisis in the downward phase of the cycle. However, it is during the ascending phase when imbalances are formed, imbalances that, given the weight of the banking and financial sector, are often financial before being economic (see Kindleberger, 1978; Allen and Gale, 1999; Bennani et al., 2017a; Corrado and Schuler, 2019); fiscal policy is therefore insufficient (Martin and Philippon, 2017). However, it is possible to minimize the formation of these financial imbalances by regulating the financial cycle, which is the countercyclical part of macroprudential policy (Schularick and Taylor, 2012). If this is the case, what is the basis for the success of macroprudential policy in the eurozone?

Badarau et al. (2020) answer this question by pointing out that the success of macroprudential policy (MaP) in the Euro area rests on two mistakes that should be avoided: ignoring national heterogeneity; and failing to consider the linkages between member states. Indeed, the macroprudential policy is primarily an instrument of financial stability through the prevention of systemic risk, which involves two actions. One – countercyclical – aims to counter the movement

[2] This divergence of member countries' cycles is caused by the diversity of their economic structures and institutions (see Berger, 2014 and OECD, 2021).
[3] For a complete literature review and an assessment, see, for example, N'Goran (2022).
[4] The single monetary policy is not designed to manage this heterogeneity and resolve divergences within the eurozone.

of the financial cycle, that is, to slow down financial booms and busts in the upward phase, and to limit financing restrictions and asset price falls (real estate, stock markets, etc.) in the downward phase. The other – cross-cutting – objective is to increase the resilience of banking groups, which, notably through their size, interconnections, and market power, contribute to systemic risk (Alessandri et al., 2009; Henry and Kok, 2013; Bennani et al., 2017b). While national divergences do not prevent cross-cutting action at the level of the eurozone, countercyclical action may seem more difficult to carry out within a monetary zone marked by divergences that are both economic and financial.[5] Its regulatory tools – countercyclical tools – are among other procyclical capital requirements and countercyclical capital buffers, and the first discussion about this comes from Borio (2003). The insight for a countercyclical capital tool is that banks should improve their capital in good times and reduce it in bad times (Jiménez et al., 2015). A higher level of requirements in expansions should help to moderate lending. Lower capital requirements in times of crisis should reduce the incentives for banks to further reduce lending and thus deepen the recession.

However, the question remains: *How do we combine the action of these instruments with that of monetary policy while considering heterogeneity between countries, in order to ensure financial stability within the Economic and Monetary Union (EMU) of the European Union (EU)?* This is the question that we will seek to answer in this paper. Specifically, we will seek to quantify the overall impact of financial shocks on the banking system and the macroeconomic environment of the Euro area. Also, we will estimate the macroeconomic effect of a capital bank instrument.

Indeed, this paper is motivated by the following facts. On the one hand, the recent COVID-19 pandemic illustrated the role of monetary policy in financial stability[6] and reopened the debate about the link between monetary policy and financial stability. On the other hand, it is clear that, despite all the interest in and discussion about macroprudential policies and, in particular, countercyclical policies and tools, there are: (i) no empirical studies on how these instruments can work over a business/lending cycle, and (ii) no empirical studies in the Euro area that assess the links between financial stability, macroprudential policy, and monetary policy. Most discussions are theoretical or assessments that are numerically simulated (Repullo et al., 2010; Fei et al., 2012; Badarau et al., 2020). The analytical framework and practical tools for policymakers, in the context

[5] In other words, in a heterogeneous currency area, it is not only economic cycles that diverge, but also, and perhaps even more so, financial cycles. See, for example, Antonin et al. (2014), Couppey-Soubeyran and Dehmej (2016) and N'Goran (2022).

[6] During the crisis, the European Central Bank, in coordination with the national central banks, with the goal of providing support in the crisis, decided to buy government bonds on the secondary market from the commercial banks, which in turn purchased them from their government upon issuance. This made it possible to keep government interest rates low and to create room on commercial bank balance sheets to issue new loans to firms and households (Claeys, 2020).

of the ongoing policy debate on the role of monetary and macroprudential policies in smoothing economic cycles and limiting financial vulnerabilities,[7] remain limited, especially in a monetary zone where economic and financial cycles are divergent between member countries.

The goal of this paper is to contribute to finding better ways of monitoring systemic risk and implementing Basel III requirements, by extending the new Keynesian (NK) quarterly projection model (QPM) to address macroprudential policy in the Euro area. The main focus will be on the role of macroprudential policy in moderating credit growth in the context of its interaction with monetary policy and financial stability. Our key innovation is the introduction of a financial stability variable (developed by N'Goran, 2022) in a new block (financial stability block) of the QPM model. This will allow us to assess not only the link between financial stability and monetary policy but also the link between financial stability and macroprudential policy.

The remainder of this paper is structured as follows. Section 2 reviews previous relevant literature. Section 3 presents the benchmark model of the QPM. Section 4 presents its extension to macroprudential policy analysis. Section 5 discuss model parametrization, calibration, and estimation processes. Section 6 identifies structural shocks, provides counterfactual policy analysis, and interprets economic results. Section 7 concludes.

2. Related literature

The first papers related to our analysis framework refers to Juillard et al. (2008) and Benes et al. (2017). Indeed, the contribution of Juillard et al. (2008) is part of a series of three papers[8] written in the context of a larger project to estimate a small quarterly global projection model[9] (GPM) initiated by the International Monetary Fund (IMF). The authors estimated a small quarterly projection model for the US, the Euro area, and the Japanese economies. By incorporating oil prices in the model and using Bayesian techniques estimation, they traced the impacts of shocks to oil prices and showed how the model can be used to construct efficient baseline forecasts that incorporate judgment imposed on the near-term outlook. They found that, quantitatively, the effects of the oil price movement are largest in the United States and smallest in Japan, because the estimated coefficients for the effects of oil price movements on equilibrium output and in inflation are higher in the US than in the other economies.

From a macroprudential perspective, Benes et al. (2017) highlighted financial variables to address macroprudential and financial stability issues. Recently, Adrian (2020) and Adrian et al. (2020a,

[7] See, for example, IMF (2015) and Adrian and Liang (2018).
[8] See Ermolaev et al. (2008) and Laxton et al. (2008) for the two previous ones.
[9] The GPM project is designed to improve the toolkit for studying both own-country and cross-country linkages.

2020b) developed NK models and featured intertemporal trade-offs between output volatility and financial vulnerability over time, among other complementary work by Alam et al. (2019), Brandao et al. (2020), and Chen et al. (2020) on macroprudential policy effectiveness and measures. IMF (2015) and Svensson (2018) pointed out that moving monetary and macroprudential policy in the same direction could have strong adverse effects on output. Building on the contribution of Guo et al. (2019),[10] Karam et al. (2021) added two additional blocks to the traditional QPM, focusing on the credit dynamic and macroprudential to analyze the interaction of monetary and macroprudential policies for the Philippines. The authors stressed that the model produces plausible dynamic and sensible forecasts and that its simplicity makes it useful for policy analysis. Their model embedded insights from more complex dynamic stochastic general equilibrium (DSGE) models into a simple QPM framework to facilitate structural data analysis, forecasting, and policy analysis.

Indeed, since the appearance of macroprudential instruments, the standard modeling approach has been the DSGE model.[11] Important contributions have been made by smaller static or multi-period analytical models, including Jeanne (2014), Korinek and Sandri (2016), and Kara (2016).[12] For instance, Jeanne (2014) presented a simple framework that enabled, first, a comparison of the welfare impacts of domestic prudential policies and prudential capital account policies in a small open economy. Second, the general equilibrium effects of the uncoordinated use of these policies were assessed, and the case for coordination of macroprudential and monetary policies at global level was investigated. The study highlighted three important conclusions: (i) domestic prudential policies are generally preferable to capital controls, but realistic constraints on the use of the former may justify using the latter; (ii) the fact that these policies have international spillovers does not per se imply that they should be subject to international rules or coordination; and (iii) international coordination may be justified if there is a global demand shortage.

Some of the literature has specialized in addressing the specific challenges that emerge in the context of EMU using core-periphery models. These studies include Gerali et al. (2010), Angelini et al. (2014), Quint and Rabanal (2014), Rubio and Carrasco-Gallego (2016), Martin and Zhang (2017), Bielecki et al. (2019), Darracq Pariès et al. (2019), Badarau et al. (2020), and Fernandez-

[10] Guo et al. (2019) analyzed the monetary policy stance and inflationary pressures during the 2018 exchange rate stress period, with a focus on the impact of exchange rate and trade dynamics.

[11] In DSGE models, modern macroeconomic theory is used to elucidate and predict co-movements of aggregate time series over the business cycle. See, for example, Smets and Wouters (2003), Christiano et al. (2005), Del Negro and Schorfheide (2012), and Christiano et al. (2018) for a detailed presentation.

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Gallardo and Paya (2020). For example, Gerali et al. (2010) studied the roles of credit supply factors in business cycle fluctuations by introducing an imperfectly competitive banking sector into a DSGE model with financial friction. They found that (i) the existence of a banking sector partially attenuates the effects of demand shocks, while it helps to propagate supply shocks; (ii) shocks originating in the banking sector explained the largest share of the fall in output in 2008 in the Euro area, while macroeconomic shocks played a limited role; and (iii) an unexpected destruction of bank capital has a substantial impact on the real economy and particularly on investment.

Very few studies have used this analytical framework – to our knowledge, only one study has done so to date: Karam et al. (2021). Second, in the Euro area, no empirical studies have assessed the links between financial stability, macroprudential policy, and monetary policy. For that reason, we use Karam et al.'s (2021) QPM methodology in this paper, albeit with some differences, to examine the role of macroprudential policy in achieving economic and financial stability in the Euro area. Our key innovation is the introduction of a new financial stability block to their model. This allows us to assess not only the link between financial stability and monetary policy but also the link between financial stability and macroprudential policy. Also, the model's structure allows us to consider the heterogeneity among Euro area countries and to analyze the cross-correlation[13] of macroprudential policy shocks among Euro area member states. The following section presents and discusses the model.

3. QPM: the benchmark model

The foundation lies in a standard framework of a small, open economy with New Keynesian attributes, encompassing nominal and real rigidities. The model incorporates segments that depict the macroeconomic framework of an economy, designed for accessibility by model developers and clear understanding by policymakers. The model incorporates four pivotal behavioral equations: (i) the aggregate demand, which measures the output gap, (ii) the Phillips curve, (iii) the uncovered interest rate parity, and (iv) the monetary policy rule. Monetary policy exerts its influence through three channels: the interest rate, the exchange rate, and expectations. The real interest rate shapes the decisions of households and firms in terms of intertemporal choices, while forward-looking monetary policy sets the nominal interest rate. Additionally, nominal rigidities are formalized through variants of the NK Phillips curves. The exchange rate establishes a connection between domestic and foreign interest rates in accordance with a version of the uncovered interest rate parity principle.

[13] See, for example, Juillard et al. (2008).

3.1. The aggregate demand block (output gap)

The output gap is the first equation of the canonical QPM model. It resembles a Euler equation, which can be found in the literature on micro-founded DSGE models (see, for example, Fernández-Villaverde et al., 2016). We refer to it as an aggregate demand equation, or the IS curve. It relates the output gap for domestic economy to monetary conditions and to the output gap in the main trading partner:

$$\hat{y}_t = b_1\hat{y}_{t-1} - b_2 mci_t + b_3\hat{y}_t^* + \varepsilon_t^y \tag{1}$$

$$mci_t = b_4\hat{r}_t + (1 - b_4)(-\hat{z}_t) \tag{2}$$

where $\hat{y}_t$ represents the output gap;[14] $\hat{y}_{t-1}$ is the lagged output gap, which captures the persistence of the business cycle and enters the equation with the positive coefficient b_1 (which measures the persistence of the output gap); mci_t represents the real monetary condition index and enters with the coefficient minus b_2; and $\hat{y}_t^*$ corresponds to the foreign output gap, which enters with a positive coefficient b_3. The equation includes a structural demand shock ε_t^y.

The monetary condition index (equation (2)) is essentially a weighted average of two variables: the real interest rate gap ($\hat{r}_t$)[15] – where the real interest rate (r_t) is expressed as $r_t = i_t - E_t\{\pi_{t+1}\}$ with i_t the nominal interest rate and $E_t\{\pi_{t+1}\}$ the expected inflation rate at t for $t+1$; and the real exchange rate gap ($\hat{z}_t$) – where the real exchange rate (z_t) is expressed as $z_t = s_t + p_t^* - p_t$ with s_t the nominal exchange rate, p_t^* the foreign consumer price index, and p_t the domestic consumer price index.[16] These gaps are the deviations of variables from the equilibrium or long-term trends. This indicates that the equilibrium values of the real interest rate and the real exchange rate are consistent with the neutral monetary conditions. In other words, when the real interest rate and the real exchange rate are at equilibrium levels, both gaps are 0 (Batini and Turnbull, 2000). And the monetary conditions index is also 0. The index is a weighted average. Coefficient b_4 is a weight of the interest rate in this index. The index composition reflects our assumption of a small

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[14] By definition, the output gap ($\hat{y}_t = y_t - \bar{y}_t$) is a deviation of the log of real output (GDP in volume (y_t)) from its potential or long-term rate ($\bar{y}_t$). The long-term rate of output growth is $\Delta\bar{y}_t = \rho_{\bar{y}}\Delta\bar{y}_{t-1} + (1 - \rho_{\bar{y}})\Delta\bar{y}_{ss} + \varepsilon_t^{\bar{y}}$, where $\Delta\bar{y}_{ss}$ is the rate of output growth in the steady state (also called the non-inflationary output growth), and the coefficient $\rho_{\bar{y}}$ controls the speed of convergence to the steady state with smaller values, implying that the current values of the trend variables approach their respective steady states faster. It is important to note that the long-term rate of output is modeled as autoregressive processes of order one for the respective rates of change.

[15] The real interest rate gap is $\hat{r}_t = r_t - \bar{r}_t$, where $\bar{r}_t$ denotes the long-term (equilibrium) real interest rate and egal to $\bar{r}_t = \rho_{\bar{r}}\bar{r}_{t-1} + (1 - \rho_{\bar{r}})\bar{r}_{ss} + \varepsilon_t^{\bar{r}}$, where $\bar{r}_{t-1}$ represents the equilibrium of the real interest rate at the previous period and $\bar{r}_{ss}$ the steady-state level of domestic real interest rate.

[16] The real exchange rate gap ($\hat{z}_t = z_t - \bar{z}_t$) is defined as a deviation of the real exchange rate from its long-term rate ($\bar{z}_t$). Its long-term rate is $\Delta\bar{z}_t = \rho_{\bar{z}}\Delta\bar{z}_{t-1} + (1 - \rho_{\bar{z}})\Delta\bar{z}_{ss} + \varepsilon_t^{\bar{z}}$, where $\bar{z}_{t-1}$ refers to the exchange rate at the previous period and $\Delta\bar{z}_{ss}$, the real exchange rate appreciation/depreciation.

open economy. Not only the interest rate but also the exchange rate are important components defining the monetary stance, whether they are loose and stimulate demand or tight and constrain demand. Therefore, the index captures the impact of monetary policy on aggregate demand and, therefore, on the output via two of the (often) most important policy transmission channels: the interest rate and the exchange rate channels. The real interest rate impacts decisions to substitute between consumption today and savings today to consume in the future and to borrow funds to finance investment and consumption expenditure. The real exchange rate impacts substitution or shifts in demand between domestically and foreign-produced goods, as it captures changes in relative prices.

3.2. The aggregate supply equation (Phillips curve or inflation block)

The second equation in the canonical QPM is written for the headline inflation. It is similar to a Phillips curve equation (Mæhle et al., 2021; Phillips, 1958), which appears in the literature related to DSGE models:

$$\pi_t = a_1\pi_{t-1} + (1 - a_1)E\{\pi_{t+1}\} + a_2 rmc_t + \varepsilon_t^{\pi} \quad (3)$$

$$rmc_t = a_3\hat{y}_t + (1 - a_3)\hat{z}_t \quad (4)$$

Equation (3) describes the relationship between the headline inflation index at time t and the real marginal costs index, where π_t denotes inflation at time t, and π_{t-1} denotes the inflation rate at the previous period, which enter the equation with the coefficient a_1. a_1 measures the persistence of inflation; $E\{\pi_{t+1}\}$ represents the expected rate of inflation at the next period, and it enters with the coefficient $(1 - a_1)$; rmc_t is the real marginal cost index at time t; and ε_t^{π} refers to the structural shock (the cost push shock). So, equation (3) is a structural stochastic equation.

Concerning the real marginal cost (equation (4)), this index is a weighted average of two gap variables, the output gap ($\hat{y}_t$), which enters with the coefficient a_3, and the exchange rate gap ($\hat{z}_t$), which enters with the coefficient $(1 - a_3)$. As we see above, the gaps are deviations of variables from the equilibrium or long-term trends. This implies that when the output gap and the real exchange rate gap are closed, their values are at zero, and there are no extra inflationary or deflationary pressures associated with costs. The output gap in the real marginal cost index approximates the marginal cost of domestic producers, while the real exchange rate gap approximates the marginal cost of importers.

3.3. Uncovered interest rate parity (UIP) with backward-looking behavior block

The third equation in the canonical QPM is the modified uncovered interest rate parity condition. The equation establishes the link between the nominal change rate and the interest rate differential and the country risk premium; it is defined as follows:

$$s_t = (1 - e_1)E_t s_{t+1} + e_1 \left[s_{t-1} + \frac{2(\pi_t^T - \bar{\pi}_t^* + \Delta\bar{z}_t)}{4} \right] + \frac{i_t^* - i_t + prem_t}{4} + \varepsilon_t^s \quad (5)$$

where s_t corresponds to the nominal exchange rate at time t; s_{t-1} is the nominal exchange rate at the previous period; $E_t s_{t+1}$ denotes the expected rate of the nominal exchange rate at the next period; π_t^T refers to the domestic long-term inflation rate (inflation target), while $\bar{\pi}_t^*$ represents the foreign long-term inflation rate; and $\Delta\bar{z}_t$ represents the trend changes in the real equilibrium exchange rate. The parameter e_1 $(0 < e_1 \leq 1)$ allows us to control the tightness of the exchange rate management, which is a policy choice, and setting it should be part of the internal policy discussion. $e_1 = 1$ means a hard peg exchange rate arrangement; i_t^* corresponds to the foreign interest rate, while i_t is the domestic interest rate (the policy rate); $prem_t$ is exogenous and represents the country risk premium; and ε_t^s corresponds to the structural shock.

Let $\mathbf{A} = (1 - e_1)E_t s_{t+1}$; $\mathbf{B} = e_1 \left[s_{t-1} + \frac{2(\pi_t^T - \bar{\pi}_t^* + \Delta\bar{z}_t)}{4} \right]$ and $\mathbf{C} = \frac{i_t^* - i_t + prem_t}{4}$.

A is the forward-looking expectations with weight $(1 - e_1)$; **B** is the backward-looking component of the expected exchange rate at time $t + 1$ with weight e_1; and **C** refers to the interest rate differential and the country risk premium.

The backward-looking component is the level of the exchange rate at time $t + 1$ that would take place if the exchange rate to time $t - 1$ were depreciated by two periods up to time $t + 1$. For this reason, we multiply the equilibrium rate of depreciation, given by the purchasing power parity (PPP) condition, by 2. We include this component in the UIP condition because we use quarterly data. Indeed, the exchange rate can be very volatile and jumpy, especially at high frequencies, indicating that new information is readily incorporated into its determination. However, at quarterly frequency, the exchange rate tends to display some inertia, consistent with some backward-looking behavior. To accommodate this feature of the data, we must include a backward-looking component in the UIP condition.

3.4. Monetary policy function (or the interest rate policy rule block)

The interest rate or policy rule used in the canonical model assumes that the central bank uses the interest rate as the main policy variable; it can be described as follows:

$$i_t = g_1 i_{t-1} + (1 - g_1)\{i_t^n + g_2(E_t[\pi_{t+N}^4] - \pi_{t+N}^T) + g_3 \hat{y}_t\} + \varepsilon_t^i \qquad (6)$$

where i_t is the interest rate at time t and the instrument that the central bank changes in response to important developments in the economy; i_{t-1} is the interest rate at the previous period, assimilated as the smoothing component; and i_t^n corresponds to the neutral interest rate.

$E_t[\pi_{t+N}^4] - \pi_{t+N}^T$ is the deviation of expected inflation from is target, while $\hat{y}_t$ refers to the output gap; and ε_t is the monetary shock. The parameters g_1, g_2, and g_3 refer to the lag of interest rate, the deviation of expected inflation from the target, and the output gap, respectively.

The policy rule describes how the interest rate will be adjusted if output is different from the potential output. So, the interest rate reacts to the output gap. If the output gap is different from 0, then the interest rate will change. Also, the interest rate will be adjusted if the expected inflation is off-target; in other words, if there is any difference between the expected year-on-year inflation at period $t + N$ and the target for inflation at that time. The policy rule accounts for non-systematic changes in policy too, and it is captured by a policy shock ε_t. The smoothing component (the lag of interest rate) accounts for *"wait and see"* considerations when setting the policy rate. It means capturing the notion that central banks generally avoid changes in policy rate that are too abrupt. The lag also means that changes in policy made today will continue to affect the economy in the next period, albeit to a lesser extent, because of the parameter $g_{1,}$ which is less than 1. Therefore, the policy will move gradually and not abruptly in response to current or expected developments, which brings more realism to the central bank's behavior in the model.

Lastly, the policy rule responds to changes in the natural or neutral nominal interest rate, which is defined as the sum of the equilibrium real interest rate and the expected year-on-year inflation N quarter ahead. The policy rule can be described as follows:

$$i_t^n = \bar{r}_t + E_t[\pi_{t+N}^4] \qquad (7)$$

The neutral interest rate, i_t^n, represents the level of the interest rate that is consistent with the economy operating at its potential level of output. This means that when the output gap is equal to 0, and with inflation equal to its target, the interest rate will eventually converge to its neutral or natural level. Thus, the natural level of the interest rate denotes a neutral stance of the monetary policy, whereby the policy rate does not introduce any inflationary or deflationary stimuli. Therefore, a response of the policy rate to a change in the neutral rate should not be seen as tightening or easing policy.

4. QPM extension: credit behavior, banking sector, macroprudential policy instrument, and financial stability objective

The first QPM extension related to the macroprudential policy analysis is Karam et al. (2021). Starting from the simple version of the QPM, the authors added two new blocks (credit block and macroprudential policy block) and focused on analyzing the interplay between monetary and macroprudential policies, aiming to enhance the comprehension of unintended consequences and temporal trade-offs. This paper differs from Karam et al. (2021) one in two ways. First, we rewrite the macroprudential block using linear equations, which simplifies the model's resolution.[17] Indeed, QPMs are a system of equations that require linearity and independence among equations to be solved. Second, we add a financial stability block, based on the aggregate financial stability indicator (AFSI) calculated by N'Goran (2022), to analyze how policymakers can set both monetary and macroprudential policies to achieve economic and financial stability. We now present the credit cycle block, macroprudential policy block, and financial stability block.

4.1. Credit cycle block

The credit cycle block supposes that business cycle factors and financial shocks are the principal driving forces of the credit cycle. In other words, the business cycle position and the lending rate (the credit price) are the key factors. The model also includes a retroaction channel from the credit cycle to the economic cycle. Similar to a typical financial framework (see, for example, Bernanke et al., 1999), the model supposes that the credit gap block is linear. And the credit default risks of contractors are caught by the credit risk premium, which is given by the business cycle.

The main identities and behavioral equations start by transforming the outstanding credit into flow of credit by making the first difference of the stock of outstanding credit (CR). The flow of credit (NCR) is considered the new credit issued, and it is defined as follows:

$$NCR_t = CR_t - CR_{t-1} \tag{8}$$

[17] In the model presented by Karam et al. (2021), the macroprudential block equations are not linear and independent.

Dividing the elements of equation (8) by the nominal GDP gives us both the flow of nominal credit to GDP (ncr) and the ratio of outstanding nominal credit to GDP (cr). Then, the ratio of credit flow to GDP is decomposed into gap and trend components, as translated by equation (9):

$$ncr_t = \widehat{ncr}_t + \overline{ncr}_t \tag{9}$$

where $\widehat{ncr}_t$ is the gap part, reflecting the cyclical credit dynamics, and $\overline{ncr}$ corresponds to the trend growth, catching the structural part of credit.

The credit gap (cyclical demand for credit to finance production) is determined by the business cycle and the cost of lending. Current and future cash flow, concerning credit to finance production, support the contracted loans. The output gap approximates the revenue dynamics and the demand for credit (increasing with the expansion of the economy, production, and revenue). The credit cost is reflected by the gap component of the real lending rate – a higher (respectively lower) real interest rate gap reduces (respectively increases) the demand for credit. Therefore, the credit gap is as follows:

$$\widehat{ncr}_t = \rho^{\widehat{ncr}} \widehat{ncr}_{t-1} + \alpha_1 \hat{y}_t - \alpha_2 \hat{r}_t^L + \varepsilon_t^{\widehat{ncr}} \tag{10}$$

where $\hat{y}_t$ represents the output gap, $\hat{r}_t^L$ is the real lending rate, and $\varepsilon_t^{\widehat{ncr}}$ is the credit demand shock, which drives credit expansion beyond business cycle considerations.

The trend of credit flow to GDP is defined by the long-term country fundamentals. And the rate of change in the trend variable is assumed following a simple AR[18] process for simplification:

$$\Delta\overline{ncr}_t = \rho^{\Delta\overline{ncr}} \Delta\overline{ncr}_{t-1} + (1 - \rho^{\overline{ncr}})\Delta\overline{ncr}^{ss} + \varepsilon_t^{\Delta\overline{ncr}} \tag{11}$$

where $\Delta\overline{ncr}$ is the rate of change in the credit flow to GDP trend, $\Delta\overline{ncr}^{ss}$ represents the steady-state rate of growth, and $\varepsilon_t^{\Delta\overline{ncr}}$ is the shock to the equilibrium rate of growth. $\Delta\overline{ncr}^{ss}$ is defined as zero – reflecting that credit increases at the same GDP growth rate in steady state – since the share of outstanding credit to GDP cannot grow indefinitely.

The credit trend in level terms is:

$$\overline{ncr}_t = \overline{ncr}_{t-1} + \frac{\Delta\overline{ncr}_t}{4} + \varepsilon_t^{\overline{ncr}} \tag{12}$$

$\varepsilon_t^{\overline{ncr}}$ represents a shock shifting the level of the trend directly, and $\varepsilon_t^{\Delta\overline{ncr}}$ in equation (11) is a shock to the trend growth with persistent effects on growth.[19]

[18] Similarly, like all long-term trends in the QPM (see Mæhle et al., 2021).

[19] Both types of shock are introduced to smooth the estimate of the credit gap.

The model links the lending rate and the policy interest rate via the unobserved 1-year benchmark rate,[20] which is consistent with current and expected policy rates. This 1-year benchmark rate is based on the term structure on the forward policy rates over the current and subsequent 3 quarters.[21] It is defined as follows:

$$rs_t^{1y} = \rho^{rs1y} rs_{t-1}^{1y} + \frac{\left(1-\rho^{rs1y}\right)[rs_t + rs_{t+1} + \cdots + rs_{t+3}]}{4} + prem^{TERM} + \varepsilon_t^{rs1y} \quad (13)$$

where rs_t^{1y} is the 1-year benchmark rate, $(rs_t + \cdots + rs_{t+3})$ represents the term-structure of the forward policy rates from the current and following 3 quarters. $prem^{TERM}$ refers to the term premium,[22] and ε_t^{rs1y} is the shock to the benchmark rate, which makes it deviate from the 1-year rate implied by the structure of the forward policy rates. ρ^{rs1y} represents the persistence parameter controls (the passthrough of the policy rate to the 1-year benchmark rate).

The observed lending rate is equal to the 1-year benchmark rate adjusted for credit risk and regulatory requirements. Its expression is as follows:

$$rs_t^L = rs_t^{1Y} + prem_t^C + sp_t \quad (14)$$

rs_t^L is the lending rate, and sp_t is the spread that reflects regulatory requirements imposed on banks;[23] $prem_t^C$ represents the credit premium. It is required to account for the probability of borrower default. Credit premium dynamics expand the business cycle.[24] Also, the model includes the VIX, which measures the fluctuations in risk appetite in the global business cycle (see, for example, Rey, 2015)[25] and submits the credit premium. Thus, the credit premium is:

$$prem_t^C = \rho^{premC} prem_{t-1}^C - \alpha_3 E_t \hat{y}_{t+1} + \alpha_4 vix_t + \varepsilon_t^{premC} \quad (15)$$

---

[20] The choice of the 1-year maturity for the benchmark rate is arbitrary, given that data on the exact average maturity of loans is not available. This assumption can be subject to further scrutiny and reconsidered if found to be inconsistent with an observed 1-year rate or with the average maturity of loans.

[21] This is a no-arbitrage condition, between investing at the 1-year benchmark rate over the 1-year future period, and rolling the investment over at quarterly frequency (i.e., four times in the same 1-year period) with the yields from the sequence of the policy rates.

[22] The term premium, assumed to be constant, is the margin that banks require for maturity transformation to compensate for the additional uncertainty and illiquidity associated with longer maturities. The term premium can potentially be changed to be a time-varying process. This would, however, complicate the model in linking the time-varying term premium with the business cycle. The challenge lies in distinguishing the unobserved term premium from the unobserved credit premium.

[23] The spread is the margin that banks can impose to meet regulatory capital requirements. In the model, capital accumulation can only be done by retaining profits, with a positive margin.

[24] Since the model assumes that the default rate varies inversely with the future business cycle (approximated by the expected output gap) – low during high economic activity and high in economic downturn. The link to expected output gap shrinks the credit premium during booms (further stimulating credit growth) and increases it during busts.

[25] See also, for example, Miranda-Agrippino and Rey (2020) for a larger discussion.

where ε_t^{premC} represents the shock to the credit premium. This equation supposes that the credit premium is zero in its steady state.[26]

The real lending rate at time t (r_t^L), is calculated based on the Fisher equation, as follows:

$$r_t^L = rs_t^L - E_t\pi_{t+1} \tag{16}$$

Then, it is decomposed into gap ($\hat{r}_t^L$) and trend ($\bar{r}_t^L$) parts:

$$r_t^L = \hat{r}_t^L + \bar{r}_t^L \tag{17}$$

The equilibrium real lending rate, which is the natural real rate ($\bar{r}$), adjusted by the term premium, is as follows:

$$\bar{r}_t^L = \bar{r} + prem^{TERM} \tag{18}$$

To assess the effects of the credit cycle on the business cycle and the impact of the credit cycle shock on output, two main modifications must be made in the aggregate demand equation.

First, the real lending rate must be incorporated in the monetary condition index. Thus, equation (2) above becomes:

$$mci_t = b_4(b_5\hat{r}_t + (1 - b_5)\hat{r}_t^L) + (1 - b_4)(-\hat{z}_t) \tag{19}$$

Second, the credit demand shock is included in the output gap equation (equation (1)):

$$\hat{y}_t = b_1\hat{y}_{t-1} - b_2 mci_t + b_3\hat{y}_t^* + b_6\varepsilon_{t-1}^{\widehat{ncr}} + \varepsilon_t^{\hat{y}} \tag{20}$$

where $\varepsilon_{t-1}^{\widehat{ncr}}$ is the lag of credit gap shock from equation (10).[27] The lag of shock allows us to explain the dynamics of the observed data and to facilitate unobserved shocks and gap identification.

4.2. Macroprudential policy block

This block depends on the credit block and consists of a bank and a representative macroprudential authority. This macroprudential block is inspired by Bennani et al. (2017a; 2017b) and highlights

[26] The premia's handling here is restricted by the availability of data. In general, the term premium in equation (13) would change over time, and the credit premium in equation (15) must not be zero in a steady state. Nevertheless, in order to include these properties in the model, the 1-year benchmark interest rate must be observed. Unfortunately, data are not available, so they are treated as unobserved. Thus, the capacity to identify term and credit premia is limited. Therefore, the constant term premium in equation (13) may also incorporate the constant non-zero level of the steady-state credit premium, and some of the time variation in our estimate of the credit premium could be due to variation in the term premium (see Karam et al., 2021).

[27] Here, the focus is on the shock to the credit gap, rather than the credit gap itself, to capture the impact of credit developments on output.

the link between regulatory capital (based on risk), the leverage ratio, and the countercyclical buffer. The interaction between the risk-based solvency ratio and the leverage ratio leads banks to adopt complex incentives. The banking sector accumulates capital by extending credit to the economy. The model focuses on credit for production on the asset side of the balance sheet, and capital is presented on the liability side.[28] The total asset-to-GDP ratio equation is:

$$ta_t = ncr_t + ta^{wedge} + \varepsilon_t^{ta} \tag{21}$$

where ta_t represents the total asset-to-GDP at t, ta_t^{wedge} refers to the constant term used to calibrate the credit-to-GDP ratio to match total asset-to-GDP, and ε_t^{ta} is the shock to the asset side of bank balance sheets.

The amount of required capital (Tier 1) under the leverage ratio depends on an exposure measure (em_t), which covers total assets (unweighted) and certain off-balance sheet items. It is assumed that the leverage ratio is set at a minimum of 3%, in accordance with the decision of Governors and Heads of Supervision, GHOS (a group from the Bank for International Settlements), of January 2016. The amount of required capital (bc_t) under the leverage ratio is therefore represented by the following equation:

$$bc_t = 3\% \times em_t + \varepsilon_t^{bc} \tag{22}$$

where bc_t is required capital at time t, em_t represents exposure measure, and ε_t^{bc} is the shock to capital.

The requirements in terms of the Tier 1 solvency ratio (sr_t) depend on risk-weighted assets (rwa_t) and are given by:

$$sr_t = 8.5\% \times rwa_t + \varepsilon_t^{sr} \tag{23}$$

where sr_t denotes the solvency ratio at time t, rwa_t represents risk-weighted assets, and ε_t^{sr} is the shock-to-solvency ratio.

The required capital and the leverage ratio require the same amount of capital when $8.5\% \times rwa_t = 3\% \times em_t$, from which it follows that:

[28] Other assets (e.g., holding government bonds, reserves) and liabilities (e.g., deposits) are not modeled explicitly to keep the model tractable.

$$rwa_t = 35\% \times em_t + \varepsilon_t^{rwa} \quad (24)$$

where ε_t^{rwa} is the shock to risk-weighted assets at time t.

To simplify the model, we suppose that the exposure measure in equations (22) and (24) is equivalent to the total asset-to-GDP ratio ($em_t \approx ta_t$).

The banks are confronted with macroprudential regulatory requirements set through the ratio of capital to total assets. The ratio is considered to be a leverage ratio.[29] The leverage ratio target[30] is set countercyclically, with the aim of moderating the credit cycle, following this simple rule:

$$bc_t^{TAR} = \rho^{bc^{TAR}} bc_{t-1}^{TAR} + \left(1 - \rho^{bc^{TAR}}\right)(bc_{SS}^{TAR} + \phi \widehat{ncr}_t) + \varepsilon_t^{bc^{TAR}} \quad (25)$$

where bc_t^{TAR} is the leverage ratio target, bc_{SS}^{TAR} denotes the steady-state level of the leverage ratio, $\rho^{bc^{TAR}}$ represents the degree of persistence in setting the instrument, $\widehat{ncr}_t$ corresponds to the credit gap for newly issued loans, and $\varepsilon_t^{bc^{TAR}}$ is the shock to the target level. The extent of policy countercyclicality is indicated by the parameter ϕ.

The return on assets (roa) is determined by the following equation:

$$roa_t = \frac{rs_t^L - rs_t}{4} + cost^{adj} + \varepsilon_t^{roa} \quad (26)$$

where $cost^{adj}$ represents a constant to shift the return on assets to match data. The lending rate can be a proxy for the return on assets, and the policy rate can be viewed as a cost on the liability side that covers bank deposits or central bank loans to banks.

With these equations, we include the countercyclical capital buffer (CCyB), which constitutes a cyclical capital requirement. The CCyB is a supervisory tool used by financial authorities to strengthen banks' resilience during periods of economic expansion and to mitigate the risks associated with financial cycles. The main objective of the CCyB is to incentivize banks to raise

[29] The ratio does not use risk-weighted assets. The leverage ratio is a natural choice following the Basel III and Basel IV regulations and the CCyB recommendations. The definition of the leverage ratio, compatible with the Basel III and Basel IV rules, namely, "capital to risk-weighted assets," is used but without risk weights, because the data on risk weights for universal and commercial bank assets are not available. This is not to be confused with an inverse definition in financial economics, with capital in the denominator (for example, assets/capital or debt/capital) (see Basel III and IV).

[30] The target ratio is not new: it is driven by the Basel regulatory reforms concerning capital adequacy requirements – Basel IV introduced a leverage ratio requirement (defined as the lower limit) that is expected to come into practice with the implementation of Basel IV.

additional capital in times of excessive economic growth. Calibration of the CCyB allows us to analyze the structural dynamic interaction between the banking sector and the real economy. Specifically, the Basel-III-type capital buffer rule (see Bennani et al., 2017b) equation is as follows:

$$v_t = \rho^v v_{t-1} + (1-\rho^v) bc_{SS}^{TAR} + \phi^v (ncr_t - \Delta\overline{ncr}^{ss}) + \epsilon_t^v \tag{27}$$

where ρ^v measures the persistence of CCyB, bc_{SS}^{TAR} denotes the steady-state level of required capital (the leverage ratio), ϕ^v represents the systematic reaction coefficient to developments in the credit-to-GDP (ncr_t) deviations from the steady-state level ($\Delta\overline{ncr}^{ss}$), and ϵ_t^v denotes discretionary unanticipated deviation from the rule.

4.3. Financial stability block

This block is motivated by the financial system's stylized facts. Indeed, financial shocks may have a significant effect on macroeconomic developments, as shown in much of the empirical literature (Svensson, 2012; Claessens et al., 2012; Furlanetto et al., 2019). Since the model is a gap model, financial stability (fs) is decomposed into gap ($\widehat{fs}_t$) and trend ($\overline{fs}_t$):

$$fs_t = \widehat{fs}_t + \overline{fs}_t \tag{28}$$

Thus, the financial stability gap equation that captures the evolution of financial stability is defined following Tan and Wang (2015), Ma et al. (2017), and Sui et al. (2022). The equation is described as follows:

$$\widehat{fs}_t = \varphi_1 \widehat{fs}_{t-1} + \varphi_2 \hat{y}_t + \varphi_3 i_t - \phi \widehat{ncr}_t + \varepsilon_t^{\widehat{fs}} \tag{29}$$

where φ_1 captures the persistence of financial stability, φ_2 measures the effect of the output on financial stability, φ_3 captures the monetary policy (nominal interest rate) impact on financial stability, ϕ corresponds to the parameter in equation (23) above and denotes the countercyclical regulation of macroprudential policy on financial stability, and ε_t^{fs} is the financial stability shock.

As shown by Sui et al. (2022), financial stability has feedback on aggregate demand and the interest rate (monetary policy). To assess this feedback, both aggregate demand and monetary policy rule equations must be modified by including the financial stability variable.

Thus, the aggregate demand equation (equation (20)) becomes:

$$\hat{y}_t = b_1 \hat{y}_{t-1} - b_2 mci_t + b_3 \hat{y}_t^* + b_6 \varepsilon_{t-1}^{\widehat{ncr}} + b_7 \widehat{fs}_t + \varepsilon_t^{\hat{y}} \tag{30}$$

where the parameter b_7 measures the effect of financial stability on the output gap.

And the novel monetary policy rule equation (equation (6)) is:

$$i_t = g_1 i_{t-1} + (1 - g_1)\{i_t^n + g_2(E_t[\pi_{t+N}^4] - \pi_{t+N}^T) + g_3 \hat{y}_t + g_4 \widehat{fs}_t\} + \varepsilon_t \quad (31)$$

The trend equation is defined as:

$$\overline{fs}_t = \rho^{\overline{fs}} \overline{fs}_{t-1} + (1 - \rho^{fs}) \overline{fs}_{ss} + \varepsilon_t^{\overline{fs}} \quad (32)$$

where $\overline{fs}_{ss}$ denotes the steady state as the characterization of equilibrium of financial stability, and $\varepsilon_t^{\overline{fs}}$ is the financial trend shock.

5. Data, model calibration, and estimation processes

The coefficient of the structural equation of the model defines the model's properties. There are different ways to set these parameters: they can be set by calibration, estimated using Bayesian methods, or using both calibration and estimating. Before presenting the parametrization method used in this paper, we present the data used for our study.

5.1. Data sources and preliminary analysis

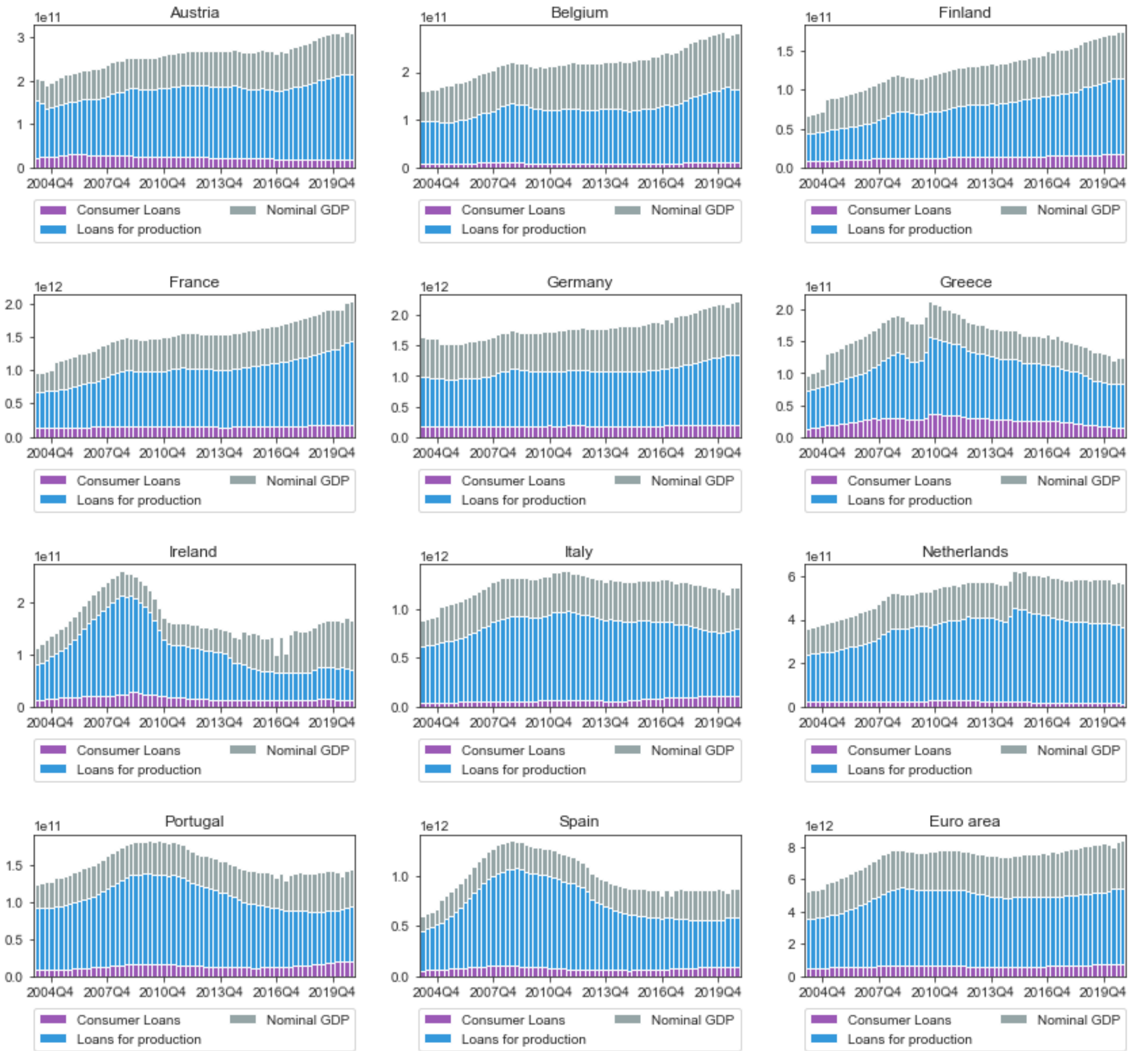
We considered a sample of 11 countries in the Euro area: Austria (AUS), Belgium (BEL), Finland (FIN), France (FRA), Germany (GER), Greece (GRE), Ireland (IRE), Italy (ITA), the Netherlands (NET), Spain (SPA), and Portugal (POR), in addition to data on the Euro area (EUR) as a whole. First, we solicited the database of the Federal Reserve Bank of Saint Louis for monthly and quarterly data on the real gross domestic product (GDP), consumer price index (CPI), and nominal exchange rate of the euro to the US dollar (EUR/USD).

To these variables are added the foreign – considered US – variables (GDP, CPI, Fed fund rate, and the volatility index VIX). The monthly variables are then converted to quarterly ones for the purposes of the study. The second database is that of the Bank for International Settlements (BIS), where the policy rate of the Euro area takes its source. The third database is the IMF (International Monetary Fund) database, where we download the return on assets (ROA), bank capital, total asset data, and nominal GDP. The last database that we consult is the Euro area and national central bank statistics database[31] for data on the Euro area national commercial bank assets and the stock of outstanding credit for production.

[31] https://www.euro-area-statistics.org/?lg=en.

A focus on the share of outstanding bank credit to GDP in euro national countries shows that, while the credit to finance production varies in terms of evolution from one country to another over the period, it has a majority share compared with a smaller share of consumer credit (Figure 1).

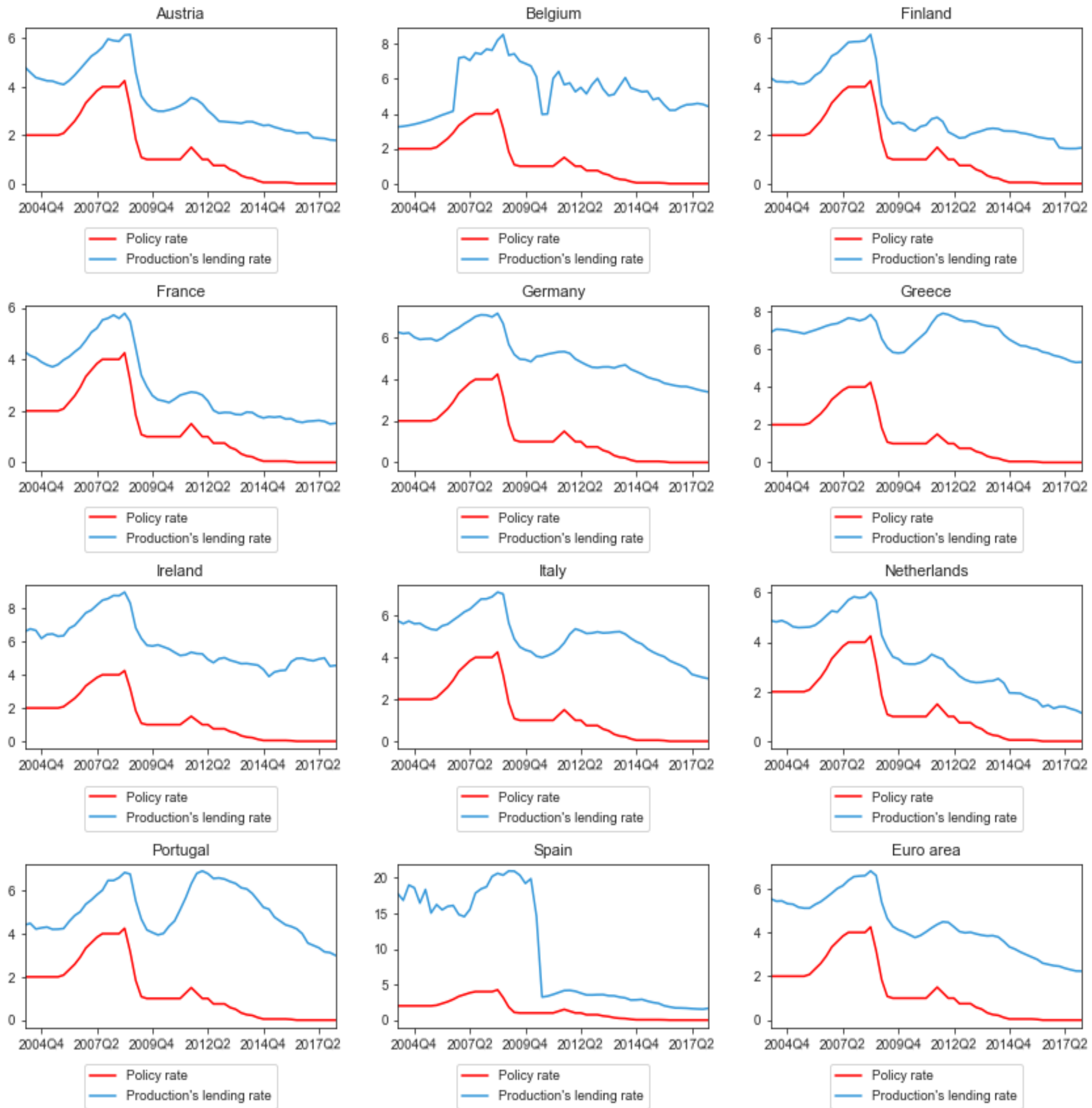
Figure 1: Outstanding loans and nominal GDP



Source: Author' computation.

On the other side, the dynamic of lending rate for loans to finance production is the same as the policy rate in Euro area countries. We can see a positive spread between the lending and policy rates over the period (Figure 2), which suggests that the lending rate has relatively short maturity.

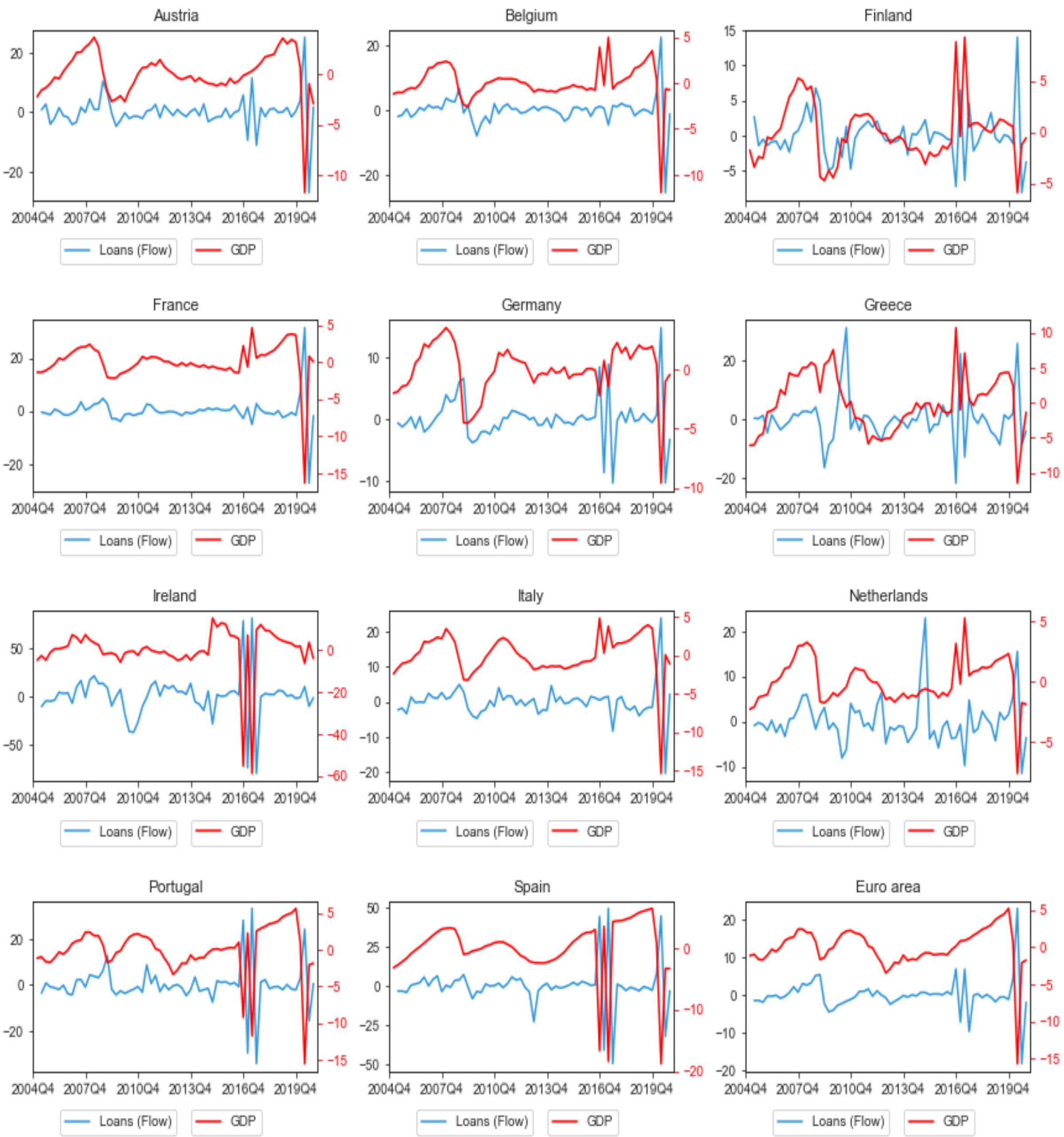
Figure 2: Interest rates (in percent)



Source: Author' computation.

While many studies on the countercyclical capital buffer (CCyB) have used outstanding credit in stock to measure credit, in this study we use the flow of outstanding credit measured as the first difference of the stock. The reason for this is that the stock indicator can be misleading, since it divides a stock of outstanding credit by a flow variable of nominal GDP (Karam et al., 2021). Furthermore, there is a positive correlation between the flow of outstanding credit with the output gap (business cycle). The credit gap follows the output gap with a lag in euro aera countries over the period studied, with the exception of Greece in 2015–20, the Netherlands in 2011–15, Italy in 2014–17, and the Euro area in 2015–19 as a whole (see Figure 3).

Figure 3: Gap in the flow of credit for production[a] and output gap[b]



Source: Author' computation.
Notes: [a] percent of GDP, [b] in percent. Gaps are computed using HP filter.

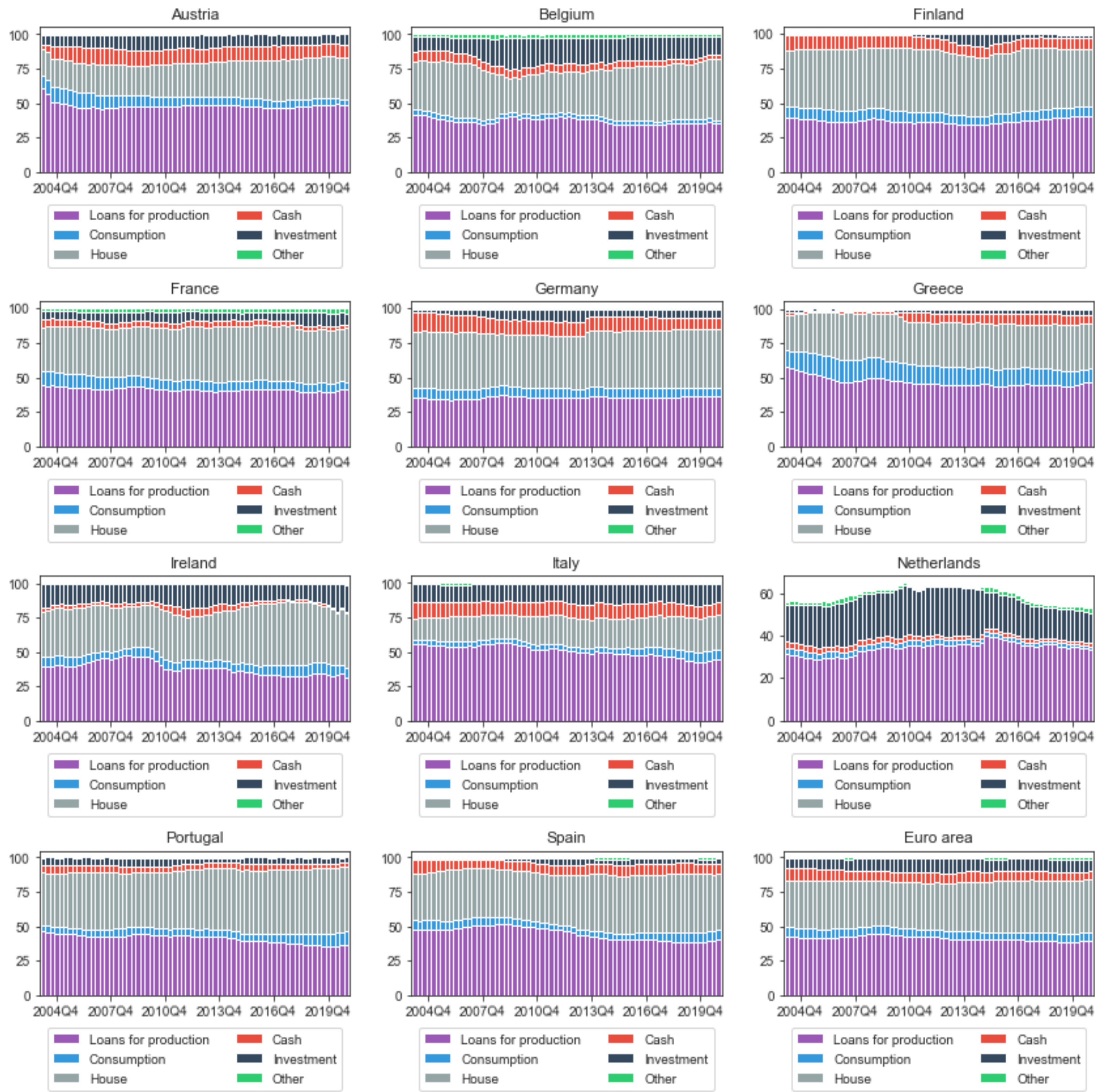
Our analyses include regulatory requirements in the sense of concerning the leverage ratio. The capital requirements relate to banks' exposure to credit risk, and they strive to maintain good-quality credit oriented toward productive use to support the economy. Thus, we use the leverage ratio to represent the regulatory requirement to moderate credit creation. In our sample of eurozone countries, except Finland, Spain, and the Euro area as a whole, where the leverage ratio seems to be stable, around 5%, 6%, and 4.8%, respectively, it has increased steadily since 2007 for the other countries (see Figure 4).

Figure 4: Leverage ratio (defined as bank capital-to-total assets ratio)

Source: Author' computation.

The regulatory requirements (leverage ratio) are defined here as bank capital-to-total assets. The decomposition of bank assets shows that its main component is credit to finance production, followed by house credit, for all countries in our sample except the Netherlands, where the data on house credit are missing (Figure 5). The credit to finance production for the Netherlands is followed by investment credit. However, it is important to note that this part of the Netherlands bank asset has seen a slight decline since 2016. For Belgium, France, Ireland, Italy, and the Euro area as a whole, the share of investment credit comes third, while for Austria, Finland, Germany, and Spain, it is the share of credit for cash that comes third. And, for Greece and Portugal, the share of consumer loans follows that of house credit. However, while this share of bank assets has gradually declined at the margin in Greece, in recent years it has risen slightly in Portugal.

Figure 5: Bank assets



Source: Author' computation.

5.2. Model calibration and estimation processes

The parametrization of the QPM model is a crucial exercise since it determines the model properties. Generally, studies using the QPM model typically prioritize calibration over estimation when determining their parameters. This approach has several advantages. First, the calibration process facilitates a deeper comprehension of the model's properties. Second, since no model can completely capture all of the essential characteristics of the data, attempting to estimate such aspects may lead to fitting the data in ways that the model was not intended to accommodate. For instance, it might try to "explain" a significant price surge caused by a weather-related shock (Mæhle et al., 2021). Furthermore, the availability of a sufficiently long data series for robust parameter estimation is limited, particularly in emerging market economies. Even when longer data series are accessible, economic and structural changes over time diminish the relevance of older data. This is particularly true for monetary policy regimes, which frequently undergo alterations, making older data less applicable or meaningful for estimation purposes.

However, in this study, instead of calibrating the model parameters, we combine the Bayesian estimation and calibration to set the parameter values, for two main reasons. First, this methodology aims to ensure that the model exhibits sensible properties that align with prior knowledge of the Euro area economy and historical data. This enhances the interpretation of forecasts and policy implications derived from the model. Second, given our country sample, this methodology allows us to have different model properties from one country to another. This approach, combining calibration and Bayesian estimation, lies between fully micro-founded estimated DSGE models and pure time series models (Jakab et al., 2015).

Parameters are divided into two groups. The first group consists of calibrated parameters, which determine the steady state of the model and those in non-structural equations. The calibration of steady-state parameters is based on either target variable levels or historical data averages. We establish the parameters in non-structural equations, primarily those related to trends, in a manner that facilitates a gradual and smooth adjustment of model variables toward their steady states. Rather than estimating these parameters, we choose to calibrate them, since they govern the dynamics of unobserved variables. Similarly, in order to ensure reasonable dynamics of gaps and trends observed when applying the calibrated model to filter historical data, the standard deviations of shocks are typically calibrated unless specified as estimated. This careful calibration process aims to achieve a realistic representation of the dynamics, allowing for a proper analysis of the gaps and trends within the data. The values of this group of parameters are documented in Table B.1 in Appendix B.

The second set of parameters is estimated using both the model and the available data. This group includes parameters found in the structural equations within the new blocks or in the extended business cycle section of the model. Estimating these parameters poses a significant challenge because of the complexity of the system. We use the Andrle (2018) system prior method to estimate the group's parameters, including the elasticities in aggregate demand equation (b_1, b_2, b_3, b_4, b_5, b_6, and b_7), exchange rate equation (e_1), Phillips Curve equation (a_1, a_2, and a_3), credit cycle and lending rate equation ($\rho^{\widehat{ncr}}$, α_1, α_2, α_3, α_4, ρ^{rs1y}, and ρ^{premC}), financial stability equation (φ_1,

φ_2, $\varphi_{3,}$ and $\rho^{\overline{fs}}$), and countercyclical capital buffer equation ($\rho^v$and ϕ^v). The estimated parameter values of this group are shown in Table 1 (below). To ensure sensible dynamic properties of the model, the remainder of the parameters in the second group are meticulously calibrated.

For example, parameters in monetary policy equation (g_1, g_2, $g_{3,}$ and g_4) are set identically for all countries, after being obtained through Bayesian estimation using Euro area data. Finally, the setting rules for leverage targets are calibrated. Calibration of the steady-state level of leverage is done ad hoc, but since Euro area banks typically have a buffer above regulatory requirements to avoid penalties and stigma, we set targets based on historical observations of leverage ratio. Therefore, the parameter bc_{SS}^{TAR} in the target leverage ratio equation is calibrated to be lower than the average leverage of historical data, while the target persistence ($\rho^{bc^{TAR}}$) and credit gap responsiveness are chosen for consistency with the observed data.

Table 1: Estimated country-level model parameters

Parameters	Parametrization method	Distr.	Prior	AUS	BEL	FIN	FRA	GER	GRE	IRE	ITA	NET	POR	SPA	EUR
				Posterior mode											
Real GDP															
b_1	B.E.	Beta	7.000	0.387	0.370	0.374	0.323	0.401	0.376	0.106	0.377	0.977	0.296	0.225	0.409
b_2	B.E.	Normal	0.500	0.216	0.219	0.224	0.242	0.198	0.471	0.395	0.210	0.520	0.256	0.423	0.189
b_3	B.E.	Normal	0.500	0.506	0.510	0.499	0.512	0.508	0.501	0.501	0.508	0.497	0.513	0.514	0.506
b_4	B.E.	Normal	0.400	0.343	0.344	0.340	0.335	0.352	0.161	0.250	0.347	0.368	0.328	0.216	0.356
b_5	B.E.	Normal	0.500	0.544	0.544	0.545	0.545	0.542	0.545	0.528	0.543	0.533	0.544	0.530	0.541
b_6	B.E.	Normal	0.250	0.163	0.162	0.180	0.129	0.175	0.148	-0.123	0.171	0.145	0.079	0.040	0.182
b_7	B.E.	Normal	0.600	0.319	0.326	0.323	0.318	0.320	0.326	0.551	0.329	0.011	0.359	0.388	0.317
Inflation															
a_1	B.E.	Beta	0.600	0.829	0.825	0.827	0.825	0.832	0.679	0.315	0.836	0.858	0.819	0.311	0.841
a_2	B.E.	Normal	0.200	0.572	0.558	0.576	0.563	0.546	0.672	0.487	0.556	0.434	0.562	0.620	0.549
a_3	B.E.	Beta	0.700	0.516	0.511	0.521	0.498	0.517	0.678	0.439	0.513	0.562	0.480	0.479	0.524
Exchange rate															
e_1	B.E.	Beta	0.450	0.410	0.412	0.412	0.414	0.409	0.467	0.556	0.408	0.399	0.416	0.541	0.405

Table 1 (continue): Estimated country-level model parameters

	Parametrization method			AUS	BEL	FIN	FRA	GER	GRE	IRE	ITA	NET	POR	SPA	EUR
Parameters		Distr.	Prior	Posterior mode											
Credit Cycle[a]															
$\rho^{\widehat{ncr}}$	B.E.	Normal	0.500	0.369	0.438	0.511	0.401	0.464	0.451	-0.423	0.488	0.443	-0.030	-0.365	0.498
α_1	B.E.	Normal	0.500	0.417	0.404	0.436	0.373	0.427	0.425	-0.279	0.427	0.432	0.234	0.112	0.439
α_2	B.E.	Normal	0.400	0.351	0.340	0.360	0.455	0.341	0.569	0.552	0.375	0.335	0.466	0.741	0.325
α_3	B.E.	Normal	0.200	0.155	0.156	0.159	0.159	0.157	0.184	0.162	0.159	0.128	0.158	0.161	0.158
α_4	B.E.	Normal	0.021	0.019	0.018	0.017	0.019	0.017	0.020	0.019	0.019	0.017	0.019	0.024	0.019
ρ^{prem^C}	B.E.	Normal	0.800	0.757	0.743	0.759	0.765	0.746	0.742	0.742	0.744	0.784	0.745	0.773	0.746
$\rho^{rs^{1y}}$	B.E.	Normal	0.600	0.572	0.576	0.577	0.573	0.573	0.604	0.593	0.583	0.580	0.579	0.616	0.584
Financial stab.[b]															
φ_1	B.E.	Beta	0.300	0.247	0.238	0.244	0.274	0.243	0.248	0.267	0.240	0.308	0.254	0.271	0.242
φ_2	B.E.	Beta	0.400	0.195	0.191	0.194	0.203	0.194	0.209	0.139	0.192	0.335	0.175	0.173	0.197
φ_3	B.E.	Beta	0.200	0.003	0.003	0.003	0.003	0.003	0.004	0.003	0.003	0.217	0.003	0.003	0.003
ϕ	B.E.	Normal	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
$\rho^{\overline{fs}}$	B.E.	Normal	0.35	0.337	0.333	0.345	0.345	0.339	0.328	0.293	0.340	0.349	0.318	0.317	0.341

Notes: Distr. is Distribution. B.E. is Bayesian estimation. [a] Credit cycle and Lending rate. [b] Financial stability block.
See text for country codes. See Appendix A for description of the parameters.

6. Model evaluation: IRF analysis and economic interpretation

Before using our QPM for forecasting and policy analysis, it is important to verify that its behavior is consistent with our understanding and empirical evidence of economic relationships in our country. First, we must check the properties of the calibration model to ensure its validity and reliability. The process of reviewing model properties includes assessing the response of the modeled economy to common shocks. This includes looking at how GDP and inflation might respond following fiscal stimulus, or the magnitude of changes in QPM macroeconomic variables following a rise in banks' leverage ratio. Answering these questions based on a single model equation is challenging because they relate to the overall behavior of the model and account for complex interactions between variables. Impulse response functions (IRF) are invaluable graphical tools for summarizing the responses of the model.

We select seven shocks divided into two categories to analyze the model.[32] The first one is common business cycle shocks, which refer to demand, exchange rate, and monetary policy shocks. The second category is shocks originating from the financial system (credit demand, solvability ratio shock, countercyclical capital buffer, and financial stability shocks). The addition of new credit, macroprudential and financial stability blocks in the native QPM did not significantly alter the impulse response to business cycle shocks. For this reason, we will pay more attention to the second group in what follows. It is worth noting that our model begins from a steady state. In the first simulation, an unexpected shock with 1% in magnitude occurs, which is transient and lasts only 1 quarter. However, because of the rigidity and friction of the model, it takes time for the economy to fully adjust to the shock.

6.1. Credit demand shock

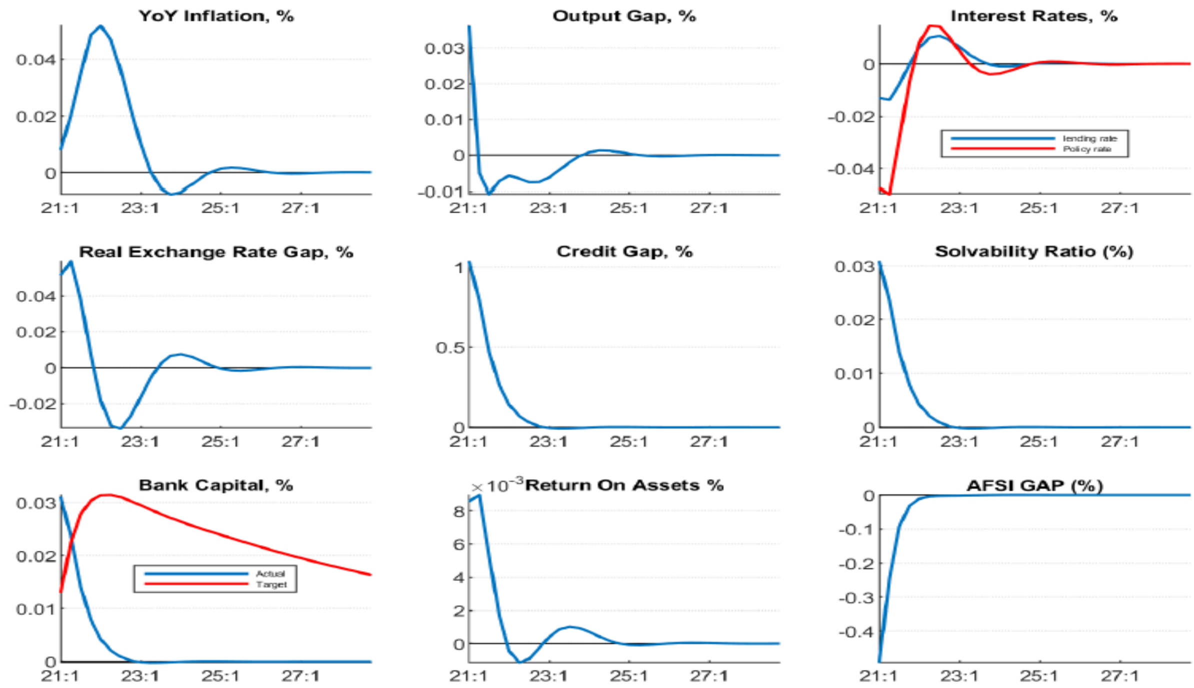
Assessed as a shock to the credit gap, a positive shock to credit demand captures growth in the credit demand above the trend given business cycle credit conditions and costs. Figure 6 (below) shows that the credit demand shock has a positive effect on both inflation (inflation stays positive for many quarters after the shock) and the output gap (the output gap is positive after the shock), while simultaneously it has a negative impact on interest rates (the policy and lending rate are negative after the shock before going up). This implies an interesting dynamic in the model, and

[32] To save space and for clarity, in this paper we only report the results for the QPM concerning the Euro area. We add supplementary online appendix and results for a comprehensive and complete overview of all model outcomes for all countries in the Euro area (here).

such a scenario may indicate the following. (i) The positive impact on inflation suggests that increased demand for credit will put upward pressure on prices. This may be due to the increased availability of credit driving higher spending and economic activity. The expansionary effect of credit demand on aggregate demand can be greater than the economy's capacity to produce goods and services, leading to inflationary pressures. (ii) The positive effect on the output gap suggests that credit demand shocks are stimulating growth and pushing output levels above their potential. This suggests that the increase in credit supply is effectively boosting investment, consumption, and overall economic activity. The positive output gap indicates that the economy is above its sustainable long-term trend during the first quarter after the shock. Or (iii) the negative impact on interest rates suggests that the central bank or monetary authority are responding to a credit demand shock by lowering interest rates. Lower interest rates help to stimulate borrowing and investment, which supports economic growth. Its purpose may be to encourage businesses and households to take advantage of credit and further stimulate economic activity. Lower interest rates can also act as a countermeasure to potentially mitigate inflationary pressure resulting from the positive shock to credit demand.

The figure also shows that excessive credit growth may threaten financial stability (the AFSI gap becomes negative after the shock before returning to its steady state). Faced with this situation, the macroprudential authority enhances the stability and resilience of banks by raising the required leverage ratio. This measure aims to moderate the growth of credit and ensure that banks maintain a healthy financial position. For their part, banks engage in capital accumulation efforts to meet the elevated leverage ratio requirement (bank capital increases after the shock). By increasing their capital levels, banks aim to maintain a strong financial position and ensure compliance with regulatory standards. These measures may include retaining earnings, reducing dividend payouts, raising additional capital through equity issuances, or reallocating resources to less risky assets. The accumulation of capital enhances the resilience and stability of banks, providing them with a buffer against potential losses and reinforcing the overall soundness of the banking system. We can also see that the increase in demand for credit leads to higher bank profitability, resulting in improved returns on their assets after the shock. Some quarters after the shock, given a specific level of bank capital, the leverage ratio falls below the desired target. This implies that there is insufficient capital available to support the desired level of leverage mandated by regulatory requirements. In this situation, banks may need to take appropriate measures to increase their capital base or adjust their leverage ratio to align with the target.

Figure 6: Credit demand shock for Euro area as a whole



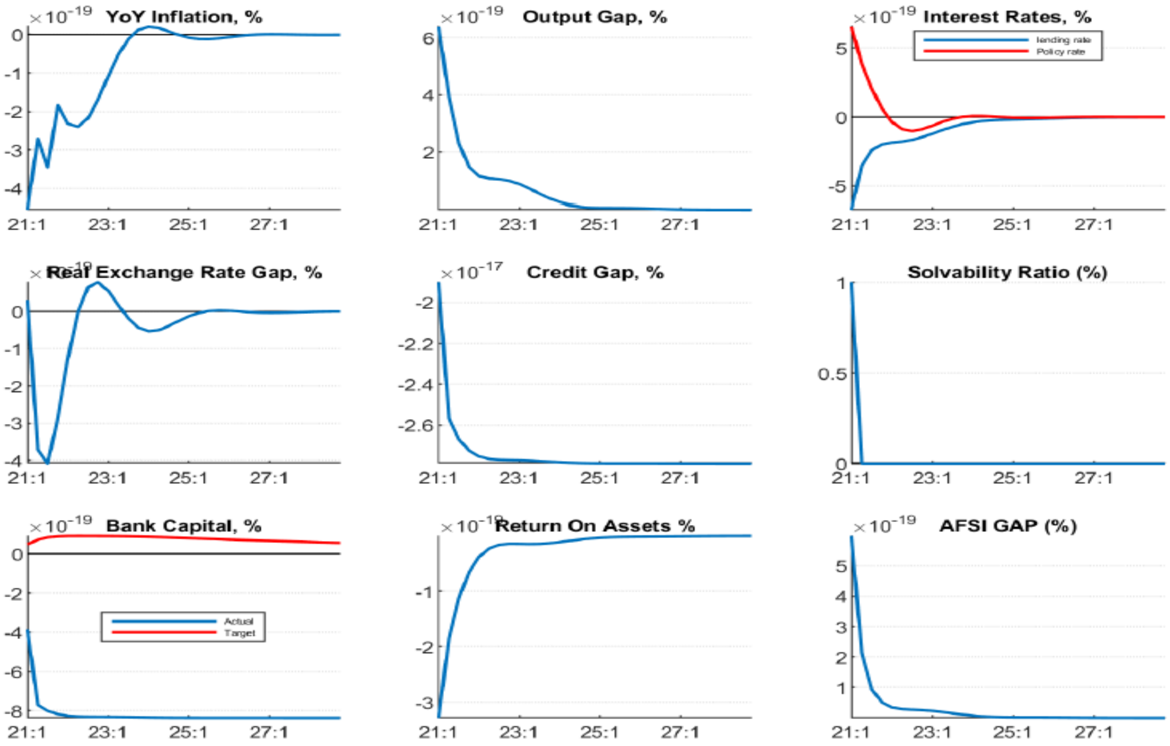
Source: Author' computation.
Notes: (i) On the interest rates figure, the red line represents the response of the policy rate, while the blue line indicates the lending rate to the shock. (ii) On the bank capital figure, the red line represents the response of the bank capital target, while the blue line indicates the actual (bank capital) to the shock.

The results showing the demand for credit shock on the different variables of the Euro area as a whole are the same when we take each country individually, except Ireland, Portugal and Spain, where credit demand shock negatively affects the output gap (see Figure D.1 in Appendix D). However, it is important to note that, again, the extent and depth of the shock, and the speed with which these different variables return to the steady state, differ from country to country. The negative impact of demand for credit shock on output for these countries indicates a contractionary effect on economic activity. This means that the shock reduces the demand for credit, leading to a decrease in borrowing and spending by businesses and households. As a result, investment and consumption decline, leading to a decrease in overall output. Policymakers in this situation may need to consider appropriate measures to stimulate demand and support economic growth, such as implementing expansionary fiscal or monetary policies to boost spending and investment.

6.2. Solvability ratio shock

Figure 7 presents the reaction of the variables of the Euro area as a whole to banks' positive solvability ratio shocks. The figure shows that the year-on-year inflation reacts negatively to the shock (inflation becomes negative many quarters after the shock), the shock effect on the output gap is positive, its impact on the policy rate is negative, its effect on the lending rate is positive, its effect on the bank capital ratio is negative, and its impact on the bank's return on assets is negative.

Figure 7: Solvability ratio shock for Euro area as a whole



Source: Author' computation.
Notes: (i) On the interest rates figure, the red line represents the response of the policy rate, while the blue line indicates the lending rate to the shock. (ii) On the bank capital figure, the red line represents the response of the bank capital target, while the blue line indicates the actual (bank capital) to the shock.

This suggests that rising solvability ratios are dampening inflationary pressures in the economy, which may be due to factors such as reduced lending capacity and tighter credit conditions. In addition, the positive impact of the solvability ratio on the output gap indicates that an increase in the solvability ratio leads to a rise in the output gap. This suggests that a higher solvability ratio improves the stability and resilience of banks, thereby increasing lending and investment, boosting economic activity, and narrowing the output gap. Moreover, we can see in the figure that the policy rate reacts negatively to the solvability ratio shock. This means that the central bank responds to the positive impact on output and the negative impact on inflation by lowering the policy rate. This action has the purpose of further supporting economic expansion and counteracting any disinflationary pressures resulting from the shock.

Furthermore, the positive reaction of lending after the shock suggests that banks increase their lending rates in response to a higher solvability ratio. This may be due to factors such as perceived reduced credit risk and the need to maintain profitability and adequate returns on loans.

Additionally, the effect of the solvability ratio shock on the bank's capital ratio is negative. This might be due to factors such as increased risk-taking or a decrease in capital due to other financial factors. A lower bank capital ratio can impact the stability and solvency of banks. Finally, the negative impact of the solvability ratio shock on the bank's return on assets suggests that the shock leads to a decline in banks' profitability. This could be due to factors such as the increased costs associated with maintaining a higher solvability ratio or reduced lending capacity.

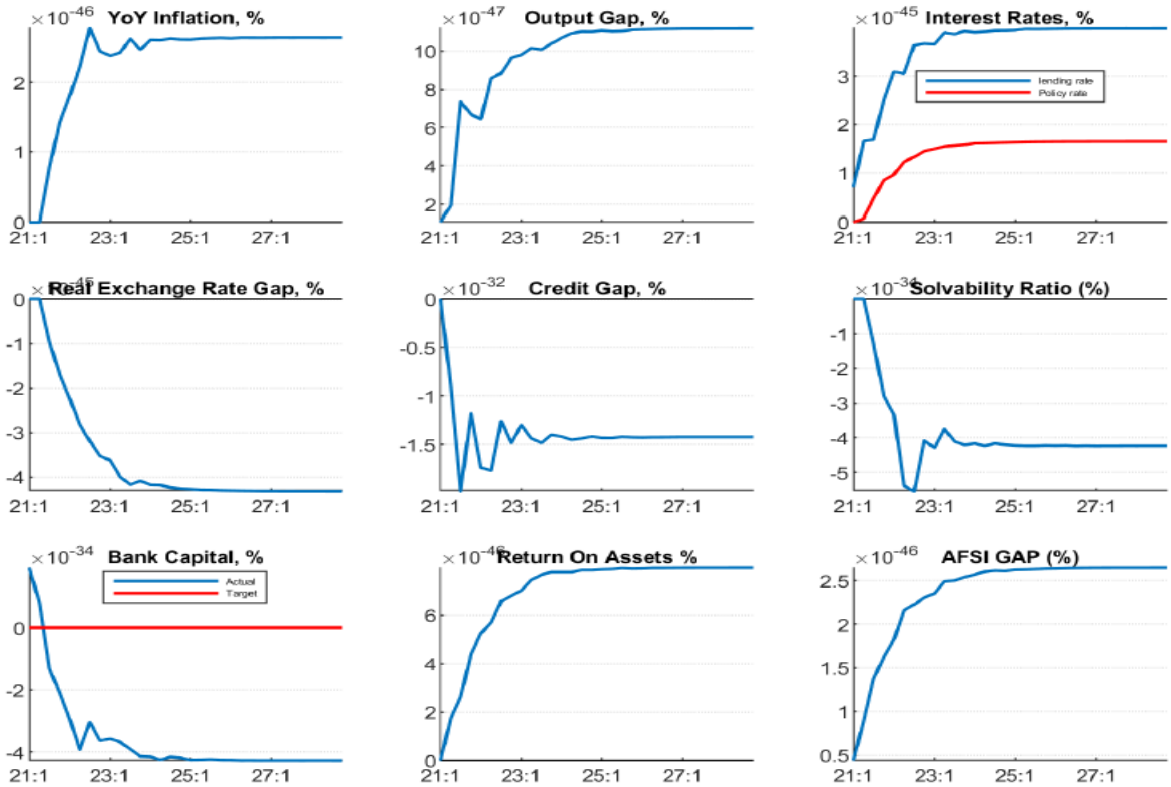
These results are different when we take each country individually (see Figure D.2 in Appendix D). For example, while the inflation rate reacts negatively to the solvability shock for Austria, Germany, Greece and Spain, it reacts positively for countries such as Belgium, France, Finland, and so on. This means that an increase in the solvability ratio leads to upward pressure on inflation (because of several factors, such as increased lending capacity, easing credit conditions, or improved economic outlook). Likewise, the output gap, interest rates, and reaction of other variables vary from country to country, depending on their specificity.

6.3. Countercyclical capital buffer (CCyB) shock

A countercyclical buffer shock is a change in the CCyB requirement imposed on banks by the regulatory authorities. The CCyB is a regulatory tool designed to enhance the resilience of the banking sector during periods of excessive credit growth and economic expansion, and to release it during periods of financial stress. When a CCyB shock occurs, the objective is usually to adjust the capital buffer requirement upward or downward to reflect the current economic conditions.

Figure 8 (below) presents the reaction of the variables of the Euro area as a whole to a positive shock in the CCyB. The figure shows that the year-on-year inflation reacts positively to the CCyB shock, which means that activating the CCyB leads to upward pressure on inflation, for several reasons. (i) Activation of the CCyB implies an increase in bank capital requirements (we can see in the figure that bank capital reacts positively after the shock) during economic upturns. This action has a restrictive effect on banks' ability to extend credit and reduce the overall availability of loans in the economy. With reduced credit supply (the credit gap decreases after the shock and stays negative for several quarters after the shock), aggregate demand may be dampened, leading to lower inflationary pressures. (ii) The increase in capital requirement associated with CCyB leads to higher borrowing costs for banks. The higher capital requirements associated with the CCyB can lead to increased borrowing costs for banks. Since banks pass on these higher costs to borrowers, interest rates for loans may rise (both policy and lending rates rise after the shock and stay positive for many quarters). Thus, higher interest rates can reduce investment and consumption, leading to decreased aggregate demand and potentially lower inflation. (iii) The positive impact on financial stability suggests that activation of the CCyB helps to strengthen the resilience of banks and the overall financial system. This might contribute to greater stability and confidence in the financial sector, which could have positive spillover effects on the broader economy, including inflation. Finally, (iv) activation of the CCyB, by enhancing the capital position of banks, can improve their profitability and return on assets. This may be due to reduced risk and increased confidence from investors and depositors.

Figure 8: Countercyclical capital buffer shock for Euro area as a whole



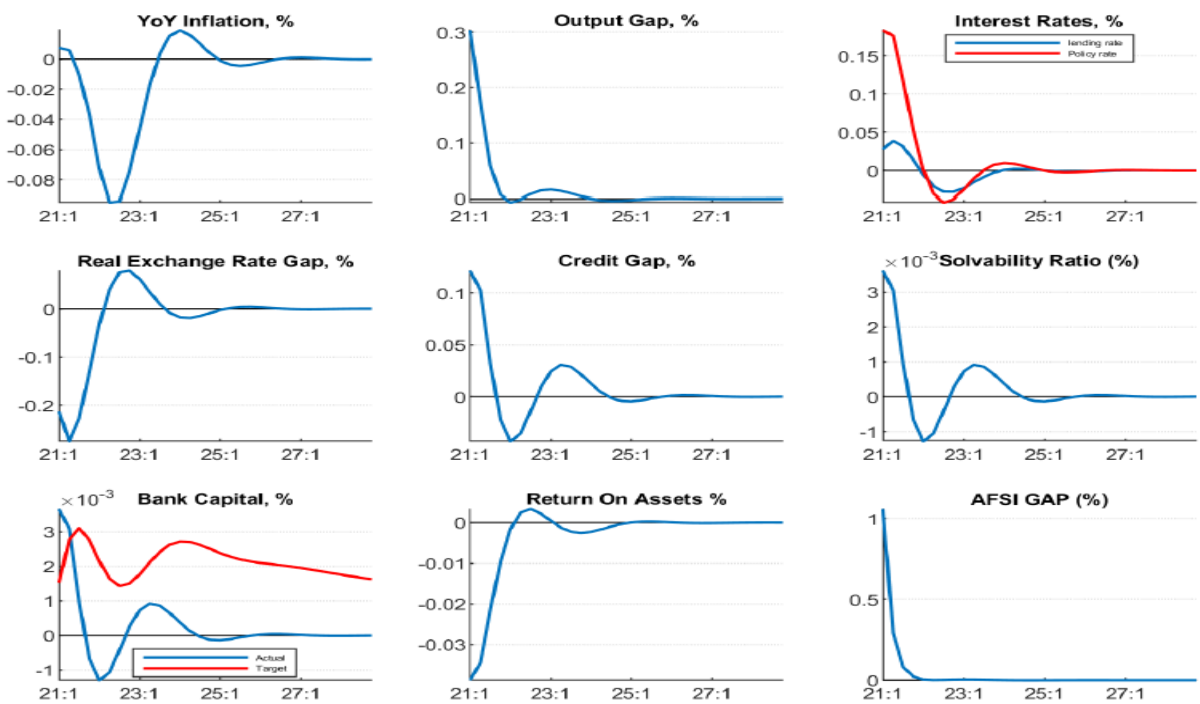
Source: Author' computation.
Notes: (i) On the interest rates figure, the red line represents the response of the policy rate, while the blue line indicates the lending rate to the shock. (ii) On the bank capital figure, the red line represents the response of the bank capital target, while the blue line indicates the actual (bank capital) to the shock.

However, it is crucial to note that the specific impact of a CCyB shock on different variables, including inflation, output gap, policy rate, lending rate, credit growth, bank capital, and bank return on assets, depends on the specific design and implementation of the CCyB, as well as the prevailing economic conditions. For example, we will see a different result if we take Euro area countries individually (see Figure D.3 in Appendix D).

6.4. Financial stability shock

Financial stability shock can be defined as an unexpected event or development that disrupts the stability of the financial system. The impact of a financial stability shock on various macroeconomic variables can vary depending on the nature and magnitude of the shock. Figure 9 (below) shows that the impact of financial stability shock on year-on-year inflation is positive in the first quarters, and then negative, its effect on the output gap is positive, its impact on both the policy rate and lending rate is positive, its effect on the credit gap is positive, its impact on bank capital is positive, its impact on banks' return on assets is negative, and its effect on financial stability is positive.

Figure 9: Financial stability shock for Euro area as a whole



Source: Author' computation.
Notes: (i) On the interest rates figure, the red line represents the response of the policy rate, while the blue line indicates the lending rate to the shock. (ii) On the bank capital figure, the red line represents the response of the bank capital target, while the blue line indicates the actual (bank capital) to the shock.

The positive impact of the financial stability shock on inflation in the first quarter, followed by a decrease, suggests an initial increase in inflationary pressures due to disruptions in the financial system. Over time, however, the negative effect indicates a moderation or decline in inflation when stability returns. This may be a result of policy measures aimed at addressing the root causes of the shock or restoring confidence in the financial sector. Furthermore, the positive effect on the output gap indicates an expansionary impact on the economy. This positive reaction of the economy could be attributed to measures taken to stabilize the financial system, such as liquidity injections or government interventions, which can stimulate economic activity. In addition, both policy and lending rates have a positive reaction after the shock, meaning that the central bank is responding to the financial instability by tightening monetary conditions. This measure is aimed at controlling inflationary pressures or dealing with risks in the financial sector. Higher interest rates also serve as a deterrent against excessive borrowing and to promote financial stability.

Moreover, the positive effect of the credit gap (credit growth) points to an increase in lending activity. This could be a result of measures taken to restore confidence in the financial system, such as providing liquidity support to banks or implementing policies to encourage lending. These measures, in addition to macroprudential measures such as regulatory measures or capital injections, lead to an improvement in the financial health and resilience of banks (banks' capital reacts positively to the shock). However, the shock decreases banks' profit, since it has a negative impact on their return on assets. This could be due to factors such as higher regulatory compliance costs, higher funding costs, or reduced lending due to financial instability. However, the positive impact on bank capital suggests that the shock contributes to strengthening the overall financial position of banks.

The analysis of Figure D.4 in Appendix D shows that the financial stability of a positive shock has the same impact on each Euro area country of our sample. However, it is important to note that, again, the extent and depth of the shock, and the speed with which these different variables return to the steady state, differ from country to country.

7. Summary and conclusion

This paper makes a valuable contribution to the ongoing effort to improve systemic risk monitoring and implement Basel III requirements. This is achieved by extending the existing new Keynesian (NK) quarterly projection model (QPM) to incorporate macroprudential policy and financial stability considerations that are specific to the Euro area. By incorporating these two blocks into the QPM framework, we have sought to improve the understanding and analysis of the interplay between monetary policy, macroeconomic variables, and financial stability in the Euro area context.

Our model parametrization is based on both calibration and Bayesian estimation, especially the Andrle (2018) system prior method. Our analysis focuses on examining the model's properties and conducting an extensive evaluation exercise to identify its strengths and weaknesses. From this evaluation, we found that the impulse response functions of the model gave satisfactory results. They improve the understanding of model dynamics and effectively demonstrate the impact of macroprudential policies on promoting financial stability.

The main objective of this paper has been to present and demonstrate the practical value of the QPM as a tool for quantifying the impact of financial shocks on the Euro area banking system and macroeconomic environment. Furthermore, we assess the macroeconomic impact of capital banking instruments. Utilization of the QPM framework leads to a comprehensive analysis of the overall impact of financial shocks and assesses how the introduction of capital banking instruments affects macroeconomic conditions. The results of the analyzed shocks reveal important insights into the dynamics of the Euro area economies and the interplay between various variables.

Credit demand shocks play a significant role in shaping the behavior of credit growth, bank solvability ratios, and lending rates. The analysis indicates that increased credit demand can lead to higher lending rates, potentially affecting borrowing costs for individuals and businesses. Additionally, the impact on bank solvability ratios emphasizes the importance of maintaining adequate capital buffers to ensure the stability and resilience of the banking system. Our analysis corroborates the findings of previous studies. For instance, Barnett and Ryland (2014) and Islam (2022) highlighted the relationship between credit demand, lending rates, and bank solvability. By comparing our results with these studies, we validate the model's ability to capture these dynamics and contribute to the broader understanding of credit market dynamics. This comparison with existing literature helps to validate the model's ability to capture these dynamics and contributes to a broader understanding of credit market dynamics and their impact on the banking sector.

Furthermore, the analysis of shocks related to financial stability reveals the interconnectedness between financial conditions and macroeconomic outcomes. The results indicate that shocks to financial stability indicators can have both positive and negative effects on inflation, output gap, interest rates, and bank performance. These findings underscore the importance of monitoring and addressing the risks to financial stability to safeguard the overall health of the economy. Our findings are consistent with research conducted by Bauducco et al. (2011) and Tunay and Tunay (2021). These studies also examined the impact of financial stability shocks on macroeconomic indicators and the banking system.

Macroprudential authorities and analysts are strongly encouraged to utilize the quarterly projection model for their analyses, as it offers valuable insights into the impact of financial shocks and the effectiveness of specific policies in promoting financial stability and economic growth. By employing the QPM framework, policymakers and analysts can enhance their understanding of the intricate dynamics of the economy and make more informed decisions. The QPM enables a comprehensive assessment of the effects of financial shocks on various macroeconomic variables, providing a deeper understanding of the channels through which shocks propagate. It allows for the evaluation of different policy measures and their potential impact on financial stability, offering insights into the effectiveness of these policies in mitigating risks and promoting sustainable growth. Furthermore, the QPM facilitates scenario analysis, enabling policymakers to assess the potential outcomes of different shocks and policy interventions. This helps in designing appropriate measures to address emerging challenges and risks in the financial system. To sum up, the QPM serves as a powerful tool for policymakers and analysts to better understand the impact of financial shocks, to evaluate the effectiveness of policy measures, and to make more informed decisions. Its comprehensive framework and scenario analysis capabilities offer valuable insights into the dynamics of the economy, contributing to the promotion of financial stability and sustainable economic growth.

Overall, the model offers a flexible and adaptable framework for analyzing macroprudential, financial risks and policy implications. Its structure allows for easy modifications and extensions to capture sector-specific risks that may concern policymakers. Adding a fiscal policy block, for example, helps policymakers to understand how fiscal policy can affect financial stability. This comprehensive analysis allows them to make more informed decisions that consider the broader implications for both the economy and the stability of the financial system.

References

Adrian, T. 2020. “"Low for Long" and Risk-Taking”, *IMF-MCM departmental paper note 20/15*, International Monetary Fund.

Adrian, T., Duarte, F., Liang, N. and Zabczyk, P. 2020a. “NKV: A New Keynesian Model with Vulnerability”, *AEA Papers and Proceedings*, vol. 110, pp. 470-476.

Adrian, T., Erceg, C., Linde, J., Zabczyk, P. and Zhou, J. 2020b. “Quantitative Model of the Integrated Policy Framework”, *IMF working paper 20/122*, International Monetary Fund.

Adrian, T. and Liang, N. 2018. “Monetary Policy, Financial Conditions, and Financial Stability”, *International Journal of Central Banking*, vol. 14(1), pp. 73-131.

Alam, Z., Alter, M. A., Eiseman, J., Gelos, M. R., Kang, M. H., Narita, M. 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.

Alessandri, P., Gai, P., Kapadia, S., Mora, N. and Puhr, C. 2009. “Towards a Framework for Quantifying Systemic Stability”, *International Journal of Central Banking*, vol. 5(3), pp. 47-81.

Allen, F. and Gale, D. 1999. “Bubbles, crises and policy”, *Oxford Review of Economic Policy*, vol. 15(3), pp. 9-18.

Andrle, M. 2018. “System Priors on Top Of IRIS: Estimation, Calibration and Testing”, *International Monetary Fund, Research Dept.*

Angelini, P., Neri, S. and Panetta, F. 2014. “The Interaction between Capital Requirements and Monetary Policy”, *Journal of Money, Credit and Banking*, vol. 46(6), pp. 1073-1112.

Antonin, C., Blot, C. and Rifflart, C. 2014. “Politiques monétaires : normalisation ou divergence ?”, *Revue de l’OFCE*, vol. 135, pp. 219-242.

Badarau, C., Carias, M. and Figuet, J-M. 2020. “Cross-border spillovers of macroprudential policy in the Euro area”, *Quarterly Review of Economics and Finance*, vol. 77, pp. 1-13.

Bank of Spain. 2009. “Spain and the euro. The first ten years”, *an international conference sponsored by the Banco de España*.

Barnett, A. and Ryland, T. 2014. “Has Weak Lending and Activity in the UK Been Driven by Credit Supply Shocks?”, *The Manchester School*, vol. 82(S1), pp. 60-89.

Batini, N. and Turnbull, K. 2000. “Monetary Conditions Indices for the UK: A Survey”, *External MPC Unit discussion paper 1*, Bank of England.

Bauducco, S., Bulíř, A. and Čihák, M. 2011. "Monetary Policy Rules with Financial Instability", *Czech Journal of Economics and Finance*, vol. 61(6), pp. 545-565.

Benes, J., Clinton, K., George, A., Gupta, A., John, J., Kamenik, O., Laxton, D., Mitra, P., Nadhanael, G. V., Portilo, R. A., Wang, H. and Zhang, F. 2017. "Quarterly Projection Model for India: Key Elements and Properties", *IMF working paper 17/33*, International Monetary Fund.

Bennani, T., Clerc, L., Coudert, V., Dujardin, M. and Idier, J. 2017a. *Politique macroprudentielle : Prévenir le risque systémique et assurer la stabilité financière*, Pearson.

Bennani, T., Couaillier, C., Devulder, A., Gabrieli, S., Idier, J., Lopez, P., Piquard, T. and Scalone, V. 2017b. "An analytical framework to calibrate macroprudential policy", *Banque de France working paper 648*, Banque de France.

Berger, R. 2014. "La Divergence des Economies Européennes : comment en faire une opportunité ?", *Think act.*

Bernanke, B., Gertler, M. and Gilchrist, S. 1999. "The Financial Accelerator in a Quantitative Business Cycle Framework", *in: John B. Taylor and Michael Woodford, eds., Handbook of Macroeconomics*, vol. 1(C), pp. 1341-1393.

Bielecki, M., Brzoza-Brzezina, M., Kolasa, M. and Makarski, K. 2019. "Could the Boom-Bust in the Eurozone Periphery Have Been Prevented?", *Journal of Common Market Studies*, vol. 57(2), pp. 336-352.

Borio, C. 2003. "Towards a Macroprudential Framework for Financial Supervision and Regulation", *CESifo Economic Studies*, vol. 49, pp. 181-215.

Chen, J., Finocchiaro, D., Lindé, J. and Nunes, C. R. 2020. "The Costs of Macroprudential Deleveraging in a Liquidity Trap", *IMF working paper 20/89*, International Monetary Fund.

Christiano, L. J., Eichenbaum, M. S. and Evans, C. L. 2005. "Nominal rigidities and the dynamic effects of a shock to monetary policy", *Journal of Political Economy*, vol. 113(1), pp. 1-45.

Christiano, L. J., Eichenbaum M. S. and Trabandt, M. 2018. "On DSGE Models", *Journal of Economic Perspectives,* vol. 32(3), pp. 113-140.

Claessens, S., Kose, M. and Terrones, M. 2012. "How do business and financial cycles interact?", *Journal of International Economics*, vol. 87(1), pp. 178-190.

Claeys, G. 2020. "The European Central Bank in the COVID-19 crisis: Whatever it takes, within its mandate", *Bruegel Policy Contribution 2020/09*, Bruegel.

Couppey-Soubeyran, J. and Dehmej, S. 2016. "Pour une combinaison politique monétaire / politique macroprudentielle au service de la stabilité économique et financière de la zone euro", *Revue d'Économie Politique*, vol. 126, pp. 3-31.

Couppey-Soubeyran, J. and Dehmej, S. 2017. "Le rôle de la politique macroprudentielle dans la prévention et la correction des divergences au sein de la zone euro", *Parlement Européen, direction générale des politiques internes* – Unité d'assistance à la gouvernance économique.

Corrado, L. and Schuler, T. 2019. "Financial cycles, credit bubbles and stabilization policies", *ECB working paper 2336*, European Central Bank.

Darracq Pariès, M., Kok, C. and Rancoita, E. 2019. "Macroprudential policy in a monetary union with cross-border banking", *ECB working paper 2260*, European Central Bank.

Del Negro, M. and Schorfheide, F. 2012. "DSGE Model-Based Forecasting", *Federal Reserve Bank of New York Staff Reports.*

Ermolaev, I., Juillard, M., Carabenciov, I., Freedman, C., Laxton, D., Kamenik, O. and Korshunov, D. 2008. "A Small Quarterly Projection Model of the US Economy", *IMF working paper 08/278*, International Monetary Fund.

Fei, F., Fuertes, A-M. and Kalotychou, E. 2012. "Credit Rating Migration Risk and Business Cycles", *Journal of Business Finance and Accounting*, vol. 39(1-2), pp. 229-263.

Fernandez-Gallardo, A. and Paya, I. 2020. "Macroprudential Policy in the Euro area", *Economics working paper 2020/020*, Lancaster University.

Furlanetto, F., Ravazzolo, F. and Sarferaz, S. 2019. "Identification of financial factors in economic fluctuation", *Economic Journal*, vol. 129(617), pp. 311-337.

Georgiadis, G. 2015. "Examining asymmetries in the transmission of monetary policy in the Euro area: Evidence from a mixed cross-section global VAR model", *European Economic Review*, vol. 75, pp. 195-215.

Gerali, A., Neri, S., Sessa, L. and Signoretti, F. M. 2010. "Credit and banking in a DSGE model of the Euro area", *Banca d'Italia working paper 740*, Bank of Italy.

Guo, S., Karam, P. and Vlcek, J. 2019. "Decomposing the Inflation Dynamics in the Philippines", *IMF working paper 19/153,* International Monetary Fund.

Henry, J. and Kok, C. 2013. "A Macro Stress Testing Framework for Assessing Systemic Risks in The Banking Sector", *ECB Occasional Paper Series 152*, European Central Bank.

IMF. 2015. "Monetary Policy and Financial Stability", *IMF policy paper*, International Monetary Fund.

Islam, D. 2022. "Determinants of Domestic Bank Credit to Private sectors in Bangladesh: An Empirical Investigation", *Journal of Economic Impact*, vol. 4(2), pp. 65-74.

Jakab, Z., Lukyantsau, P. and Wang, S. 2015. "A Global Projection Model for Euro area Large Economies", *IMF working paper 15/50*, International Monetary Fund.

Jeanne, O. 2014. "Macroprudential Policies in a Global Perspective", *NBER working paper 19967*, National Bureau of Economic Research.

Jiménez, G., Ongena, S., Ongena, J.-L. and Saurina, J. 2015. "Macroprudential Policy, Countercyclical Bank Capital Buffers and Credit Supply: Evidence from the Spanish Dynamic Provisioning Experiments", *Barcelona GSE working paper 628*.

Juillard, M., Freedman, C., Korshunov, D., Laxton, D., Kamenik, O., Carabenciov, I., Ermolaev, I. and Laxton, J. 2008. "A Small Quarterly Multi-Country Projection Model with Financial-Real Linkages and Oil Prices", *IMF working paper 08/280*, International Monetary Fund.

Kara, G. I. 2016. "Systemic risk, international regulation, and the limits of coordination", *Journal of International Economics*, vol. 99, pp. 192-222.

Karam, P., Pranovich, M. and Vlcek, J. 2021. "An Extended Quarterly Projection Model: Credit Cycle, Macrofinancial Linkages and Macroprudential Measures: The Case of the Philippines", *IMF working paper 21/256*, International Monetary Fund.

Kindleberger, C. P. 1978. *Manias, Panics and Crashes: A History of Financial Crises*, Palgrave Macmillan.

Korinek, A. and Sandri, D. 2016. "Capital controls or macroprudential regulation?", *Journal of International Economics*, vol. 99, pp. S27-S42.

Le Cacheux, J. 2016. "Divergences au sein de la zone euro : la centrifugeuse ?", *CATT working paper 10*, Centre d'Analyse Théorique et de Traitement des données économiques.

Ma, Y., Zhang, J. and Chen, Y. 2017. "Financial cycle and monetary policy", *Financial Research*, vol. 3, pp. 33-53.

Mæhle, N., Hlédik, T., Selander, C. and Pranovich, M. 2021. "Taking Stock of IMF Capacity Development on Monetary Policy Forecasting and Policy Analysis Systems", *IMF departmental paper 21/026*, International Monetary Fund.

Martin, P. and Philippon, T. 2017. "Inspecting the Mechanism: Leverage and the Great Recession in the Eurozone", *American Economic Review*, vol. 107(7), pp. 1904-1937.

Martin, F. and Zhang, J. 2017. "Modelling European sovereign bond yields with international portfolio effects", *Economic Modelling*, vol. 64(C), pp. 178-200.

Miranda-Agrippino, S. and Rey, H. 2020. "US monetary policy and the global financial cycle", *Review of Economic Studies*, vol. 87(6), pp. 2754-2776.

N'Goran, M. 2022. "Financial stability measure and comparison of financial risk monitoring indicators", *cahier de recherche 22/02*, Centre de Recherche en Economie de Grenoble.

OECD. 2021. "Economic Surveys: Euro area 2021", *OECD Book*.

Quint, D. and Rabanal, P. 2014. "Monetary and Macroprudential Policy in an Estimated DSGE Model of the Euro area", *International Journal of Central Banking*, vol. 10(2), pp. 169-236.

Repullo, R., Saurina, J. and Trucharte, C. 2010. "Mitigating the Pro-Cyclicality of Basel II", *Economic Policy*, vol. 64, pp. 659-702.

Rey, H. 2015. "Dilemma not Trilemma: The Global Financial Cycle and Monetary Policy Independence", *NBER working paper 21162*, National Bureau of Economic Research.

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

Schnabl, G. 2013. "Monetary Integration, Fiscal Divergence and Current Account Imbalances in Europe", *The Economists' Voice*.

Schularick, M. and Taylor, A. M. 2012. "Credit Booms Gone Bust: Monetary Policy, Leverage Cycles, and Financial Crises, 1870–2008", *American Economic Review*, vol. 102(2), pp. 1029-1061.

Smets, F. and Wouters, R. 2003. "An estimated dynamic stochastic general equilibrium model of the Euro area", *Journal of the European Economic Association*, vol. 1(5), pp. 1123-1175.

Sui, J., Liu, B. and Zhang, C. 2022. "Monetary and macroprudential policies, output, prices, and financial stability", *International Review of Economics and Finance*, vol. 78, pp. 212-233.

Svensson, L. E. 2012. "Comment on Michael Woodford "Inflation targeting and financial stability"", *Sveriges Riksbank Economic Review*, vol. 1, pp. 33-39.

Svensson, L. E. 2018. "Monetary policy and macroprudential policy: Different and separate?", *Canadian Journal of Economics*, vol. 51, pp. 802-827.

Tan, Z. and Wang, C. 2015. "House price fluctuation, monetary policy position identification and response", *Economic Research*, vol. 1, pp. 67-83.

Tunay, K. and Tunay, N. 2021. "The Effects of Financial Shocks on Macroeconomic Variables and Monetary Policy in Emerging Market Economies", *ERN: Monetary & Fiscal Policies in Emerging Markets (Topic)*.

Appendix A. Model variables

Table A1: Model description

Variable	Description
y_t	Real GDP (100*log)
$\bar{y}_t$	Trend in Real GDP (100*log)
$\hat{y}_t$	Output Gap (in %)
Δy_t	Quarterly Growth in Real GDP (in % pa)
$\Delta^4 y_t$	Real GDP Growth YoY (in % pa)
$\Delta\bar{y}_t$	Real GDP Growth YoY (in % pa)
mci_t	Real Monetary Condition Index (in % pa)
cpi_t	CPI (level, 100*log)
π_t	CPI Inflation QoQ annualized (in % pa)
$E_t\pi_{t+1}$	Expected CPI Inflation QoQ annualized (in % pa)
$E_t\pi_{t+4}$	Expected CPI Inflation YoQ (in % pa)
π_t^4	CPI Inflation YoY (in % pa)
$\bar{\pi}_t^4$	Inflation Target (in % pa)
rmc_t	Real Marginal Cost (in %)
s_t	Nominal Exchange Rate (LCY/FCY, 100*log)
Δs_t	Nominal Exchange Rate Depreciation QoQ annualized (in % pa)
$\Delta^4 s_t$	Nominal Exchange Rate Depreciation YoY (in % pa)
$prem_t$	Country Risk Premium (in % pa)
i_t	Nominal Policy Interest Rate (in % pa)
r_t	Real Interest Rate (in % pa)
$\bar{r}_t$	Trend in Real Interest Rate (in % pa)
$\hat{r}_t$	Real Interest Rate Gap (in %)
$i^{neutral}$	Nominal Policy Neutral Interest Rate (in % pa)
z_t	Real Exchange Rate (level, 100*log)
$\bar{z}_t$	Trend in Real Exchange Rate (level, 100*log)
$\hat{z}_t$	Real Exchange Rate Gap (in %)
Δz_t	Real Exchange Rate Depreciation QoQ annualized (in % pa)
$\Delta\bar{z}_t$	Trend in Real Exchange Rate Depreciation QoQ annualized (in % pa)
$\hat{y}_t^*$	Foreign Output Gap (in %)

Table A1 (continue): Model description

Variable	Description
i_t^*	Foreign Nominal Interest Rate (in % pa)
r_t^*	Foreign Real Interest Rate (in % pa)
$\bar{r}_t^*$	Trend in Foreign Real Interest Rate (in % pa)
$\hat{r}_t^*$	Foreign Real Interest Rate Gap (in %)
cpi_t^*	Foreign CPI (level, 100*log)
$\bar{\pi}_t^*$	Foreign Inflation QoQ annualized (in % pa)
vix_t	Chicago Board Options Exchange Volatility Index
ncr_t	Ratio of nominal credit to nominal GDP, percent
$\widehat{ncr}_t$	Gap in the ratio of nominal credit to nominal GDP (in %)
$\overline{ncr}_t$	Equilibrium ratio of nominal credit to nominal GDP (in %)
$\Delta\overline{ncr}_t$	Growth in trend of demand of credit (in %)
rs_t^{1y}	1-year benchmark interest rate (in%)
rs_t^L	Lending interest rate (in %)
r_t^L	Real lending interest rate (in %)
$\bar{r}_t^L$	Equilibrium real lending interest rate (in %)
$\hat{r}_t^L$	Real Lending Interest Rate Gap, (in %)
$prem_t^C$	Credit premium (in %)
ta_t	Total banks' assets to GDP ratio (in %)
bc_t	Bank capital ratio (in %)
bc_t^{TAR}	Target leverage ratio (in %)
roa_t	Banks' returns on assets ratio (in %)
sr_t	Solvency ratio (in %)
rwa_t	Risk weighted assets (in %)
em_t	Exposition measure (in %)
v_t	Countercyclical capital buffer (in %)
fs_t	Aggregate Financial Stability Index (in %)
$\widehat{fs}_t$	Aggregate Financial Stability Index GAP
$\overline{fs}_t$	Trend in Aggregate Financial Stability Index (in %)
$\varepsilon_t^{\hat{y}}$	Shock to Output gap (demand)
ε_t^{π}	Shock to CPI inflation (cost-push)

Table A1 (continue): Model description

Variable	Description
ε_t^s	Shock to Exchange rate (UIP)
ε_t^i	Shock to Interest rate (monetary policy)
$\varepsilon_t^{\bar{\pi}_t^4}$	Shock to Inflation target
$\varepsilon_t^{\bar{r}_t}$	Shock to Real interest rate
$\varepsilon_t^{\Delta z_t}$	Shock to Real exchange rate depreciation
$\varepsilon_t^{\Delta y_t}$	Shock to Potential GDP growth
$\varepsilon_t^{\hat{y}_t^*}$	Shock to Foreign output gap
$\varepsilon_t^{i_t^*}$	Shock to Foreign nominal interest rate
$\varepsilon_t^{\pi_t^*}$	Shock to Foreign inflation
$\varepsilon_t^{\bar{r}_t^*}$	Shock to Foreign real interest rate
$\varepsilon_t^{\widehat{ncr}}$	Credit demand shock, percent
$\varepsilon_t^{\overline{ncr}}$	Permanent level shifting shock to the trend in credit flow-to-GDP (%)
$\varepsilon_t^{\Delta\overline{ncr}}$	Shock to the equilibrium rate of growth in credit flow-to-GDP, (%)
$\varepsilon_t^{prem^C}$	Shock to the credit premium, percent
$\varepsilon_t^{rs^{1y}}$	Shock to the benchmark 1-year rate, percent
ε_t^{ta}	Shock to the asset side of the banks' balance sheet
ε_t^{vix}	Shock to VIX, percent
ε_t^{bc}	Shock to capital accumulation (leverage ratio), percent
$\varepsilon_t^{bc^{TAR}}$	Shock to the target level of the leverage ratio, percent
ε_t^{sr}	Shock to Solvency ratio, percent
ε_t^{rwa}	Shock to Risk weighted assets, percent
ε_t^{roa}	Shock to the return-on-assets ratio, percent
ε_t^{v}	Shock to Countercyclical capital buffer, percent
$\varepsilon_t^{\overline{fs}}$	Shock to Aggregate Financial Stability Index Trend, percent
$\varepsilon_t^{\widehat{fs}}$	Shock to Aggregate Financial Stability Index, percent

Notes: YoY is year-on-year. pa is per annum. CPI is the consumer price index. QoQ is quarter-on-quarter. LCY (respectively FCY) is local currency (respectively foreign currency). Trend is calculated by using Hodrick-Prescott filter.

Appendix B. Model equations

External sector equations

$$\pi_t^* = \rho_{\pi^*}\pi_{t-1}^* + (1+\rho_{\pi^*})\bar{\pi}_{SS}^* + \varepsilon_t^{\pi^*} \tag{B.1}$$

$$y_t^* = \rho_{y^*}y_{t-1}^* + \varepsilon_t^{y^*} \tag{B.2}$$

$$r_t^* = i_t^* - E_t\pi_{t+1}^* \tag{B.3}$$

$$i_t^* = \rho_{i^*}i_{t-1}^* + (1-\rho_{i^*})(\bar{r}_t^* + \pi_t^{4*}) \tag{B.4}$$

$$\hat{r}_t^* = r_t^* - \bar{r}_t^* \tag{B.5}$$

$$\bar{r}_t^* = \rho_{\bar{r}^*}\bar{r}_{t-1}^* + (1-\rho_{\bar{r}^*})\bar{r}_{SS}^* + \varepsilon_t^{\bar{r}^*} \tag{B.6}$$

$$vix_t = \rho^{vix}vix_{t-1} + \varepsilon_t^{vix} \tag{B.7}$$

Appendix C. Calibration

Table C.1: Calibration of the Model Coefficients

Parameters	AUS	BEL	FIN	FRA	GER	GRE	IRE	ITA	NET	POR	SPA	EUR
	Posterior mode											
Real GDP												
ρy	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800
Δyss	1.060	2.790	4.370	3.710	1.060	2.610	4.730	1.950	2.050	1.820	3.100	0.290
Inflation												
ρ_{π^T}	0.600	0.600	0.600	0.600	0.600	0.600	0.600	0.600	0.600	0.600	0.600	0.600
$\Delta^4\pi_{ss}^T$	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000
Real exchange rate												
$\rho_{\Delta\bar{z}}$	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800
$\Delta\bar{z}_{ss}$	0.690	0.280	0.960	0.850	0.690	1.130	1.160	0.850	0.460	0.860	0.710	0.850
Monetary policy: Interest rate												
g_1	0.710	0.710	0.710	0.710	0.710	0.710	0.710	0.710	0.710	0.710	0.710	0.710
g_2	0.650	0.650	0.650	0.650	0.650	0.650	0.650	0.650	0.650	0.650	0.650	0.650
g_3	0.540	0.540	0.540	0.540	0.540	0.540	0.540	0.540	0.540	0.540	0.540	0.540
g_4	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480
Real interest rate												
$\rho_{\bar{r}}$	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800
$\bar{r}_{ss}$	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500

Table C.1 (continue): Calibration of the Model Coefficients

Parameters	AUS	BEL	FIN	FRA	GER	GRE	IRE	ITA	NET	POR	SPA	EUR
Credit cycle and Lending rate												
$prem^{TERM}$	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500
$\rho^{\varepsilon^{\widehat{ncr}}}$	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
$\rho^{\overline{\Delta ncr}}$	0.650	0.650	0.650	0.650	0.650	0.650	0.650	0.650	0.650	0.650	0.650	0.650
$\Delta\overline{ncr}^{ss}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Macroprudential policy block												
ta^{wedge}	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000
ρ^{bc}	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030
ρ^{sr}	0.085	0.085	0.085	0.085	0.085	0.085	0.085	0.085	0.085	0.085	0.085	0.085
ρ^{rwa}	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350
$cost^{adj}$	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
ρ^{ν}	0.734	0.734	0.734	0.734	0.734	0.734	0.734	0.734	0.734	0.734	0.734	0.734
bc_{ss}^{TAR}	6.170	5.580	5.840	5.420	4.690	7.710	8.940	7.150	4.780	7.120	5.920	6.820
$\rho^{bc^{TAR}}$	0.975	0.975	0.975	0.975	0.975	0.975	0.975	0.975	0.975	0.975	0.975	0.975
ϕ^{ν}	0.218	0.218	0.218	0.218	0.218	0.218	0.218	0.218	0.218	0.218	0.218	0.218
$\rho^{\varepsilon^{\nu}}$	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440
Financial stability block												
$\overline{fs}_{ss}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$\rho^{\varepsilon^{fs}}$	0.450	0.450	0.450	0.450	0.450	0.450	0.450	0.450	0.450	0.450	0.450	0.450

Table C.1 (continue): Calibration of the Model Coefficients

Parameters	AUS	BEL	FIN	FRA	GER	GRE	IRE	ITA	NET	POR	SPA	EUR
External block												
ρ^{y^*}	0.799	0.795	0.802	0.799	0.794	0.805	0.808	0.802	0.785	0.801	0.800	0.805
ρ^{r^*}	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800
$\rho^{\Delta\pi^*}$	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800
$\rho^{\bar{r}^*}$	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800
$\Delta\pi^*_{ss}$	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000
$\bar{r}^*_{ss}$	-0.610	-0.610	-0.610	-0.610	-0.610	-0.610	-0.610	-0.610	-0.610	-0.610	-0.610	-0.610
ρ^{vix}	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350

Notes: See text for country codes. See Appendix A for description of the variables.

Appendix D. Impulse Response Functions (IRF) to different shocks

Figure D.1: Credit demand shock

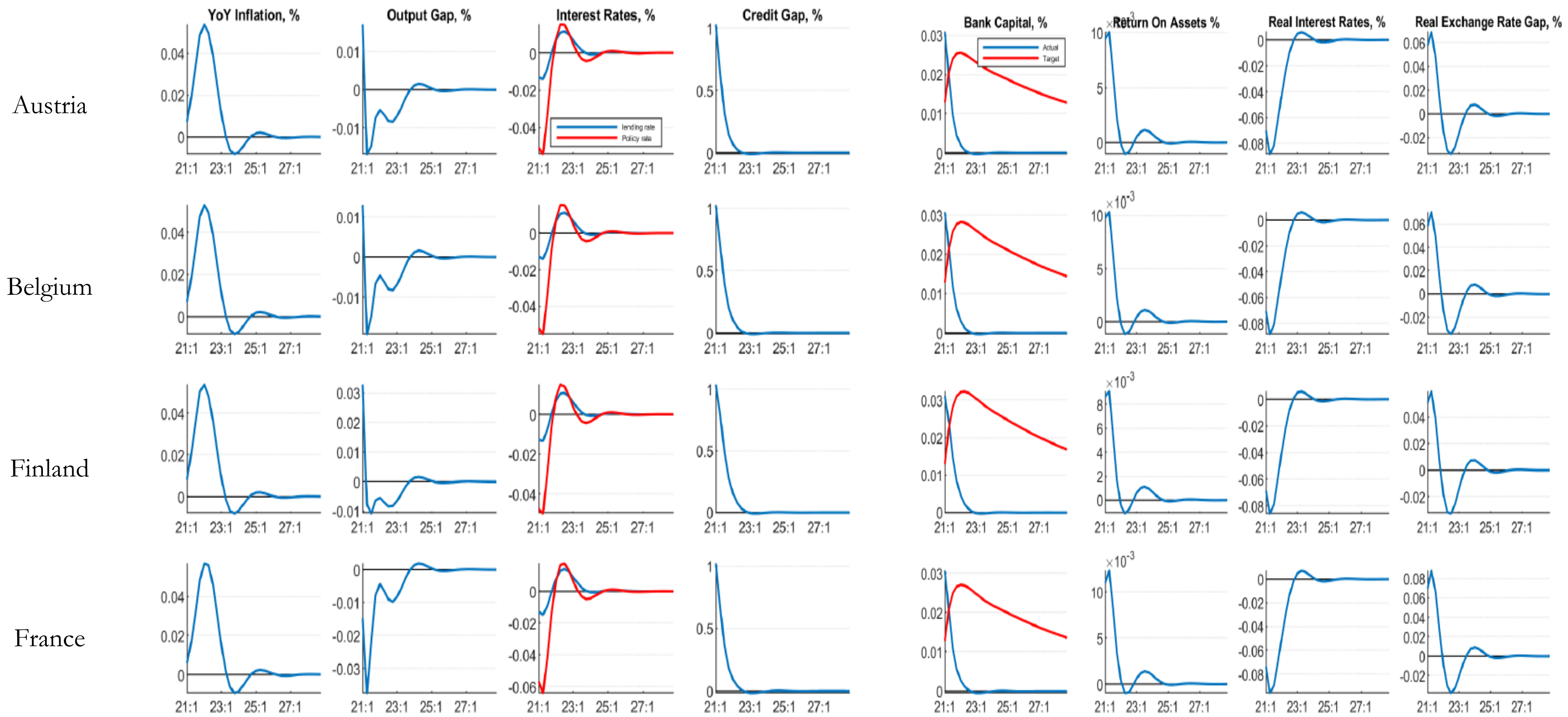


Figure D.1 (continue): Credit demand shock

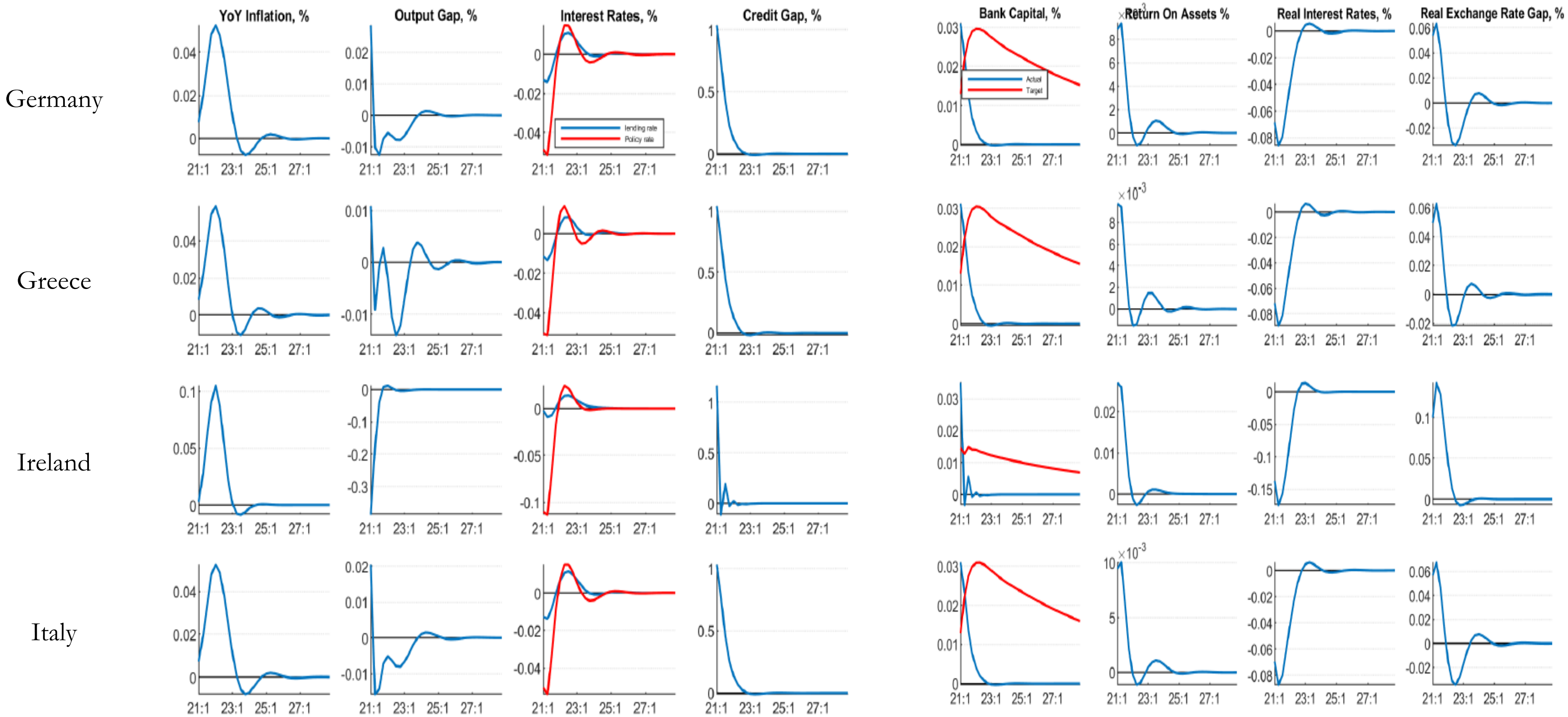


Figure D.1 (continue): Credit demand shock

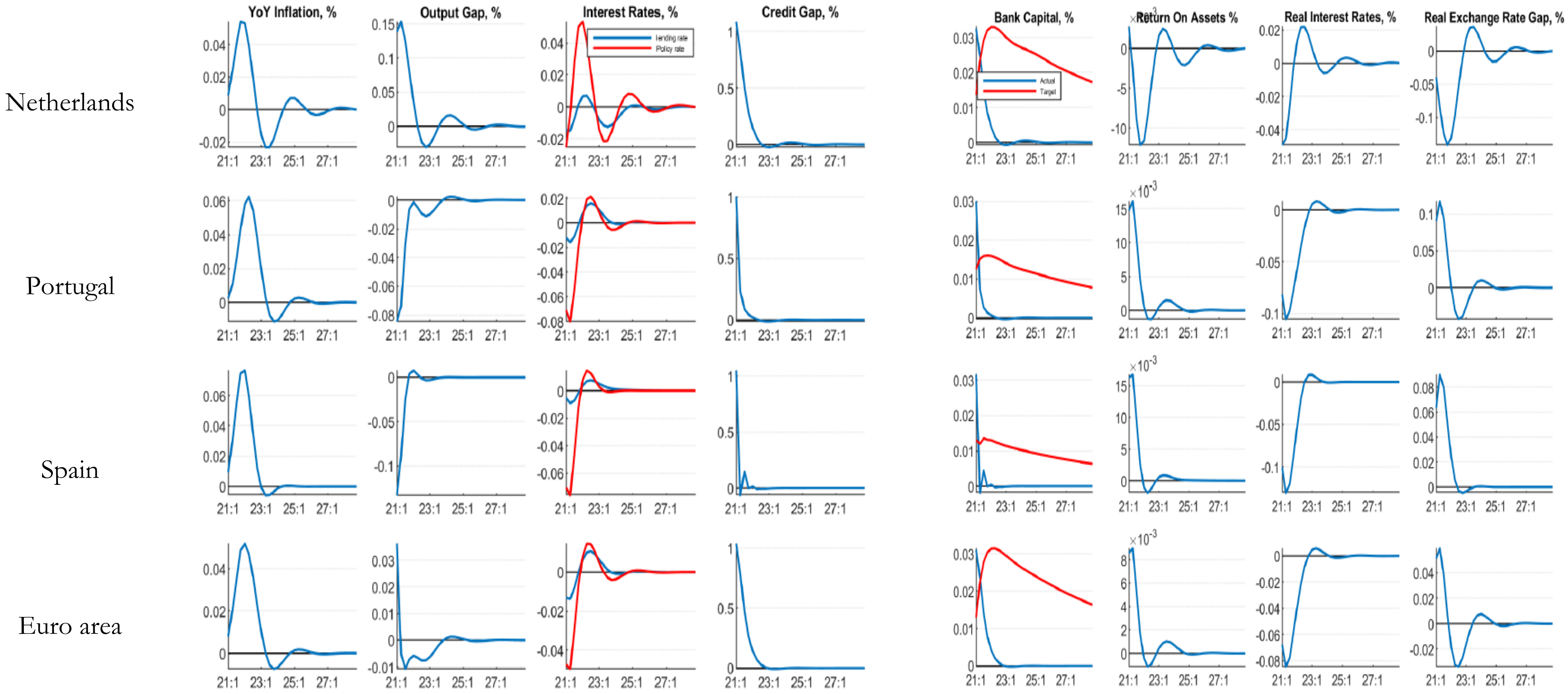


Figure D.2: Solvency ratio shock

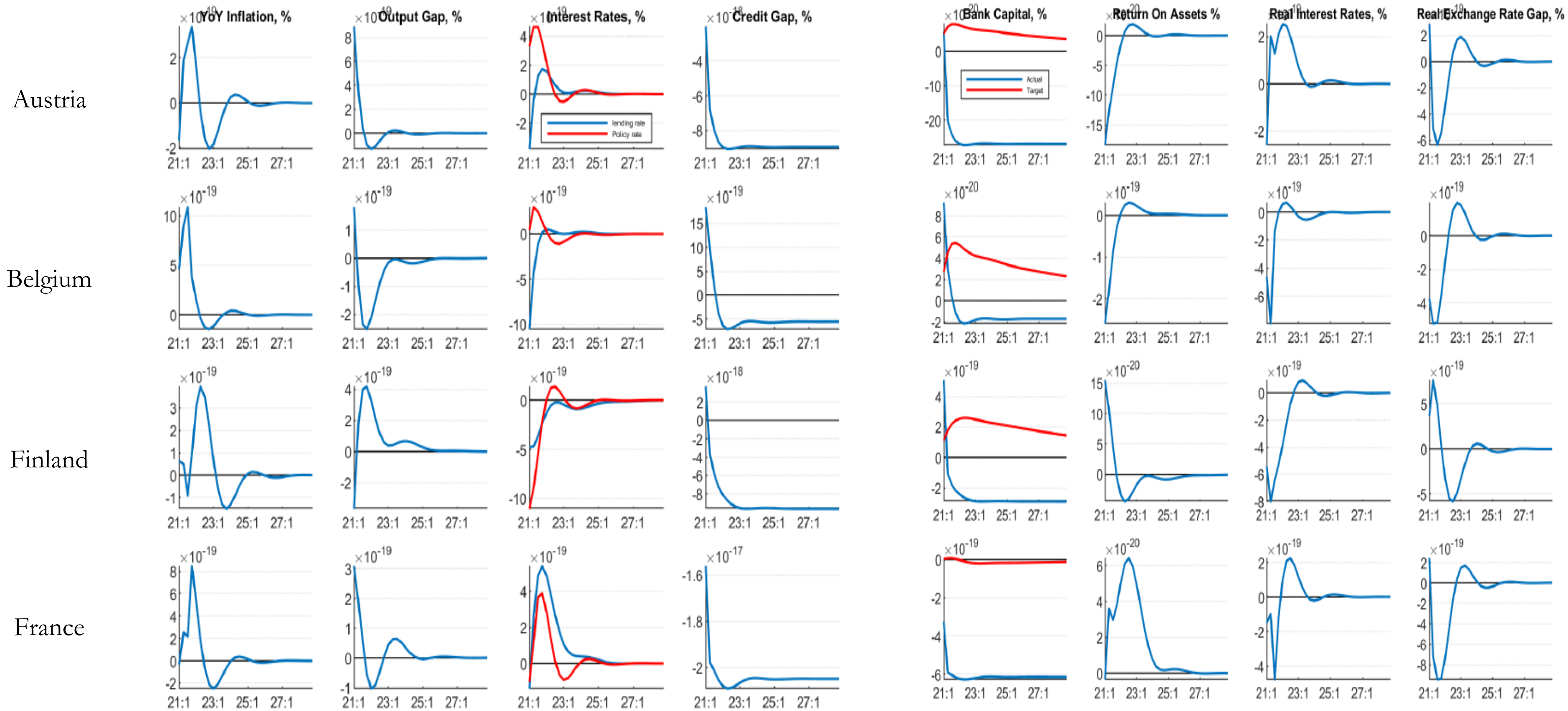


Figure D.2 (continue): Solvency ratio shock

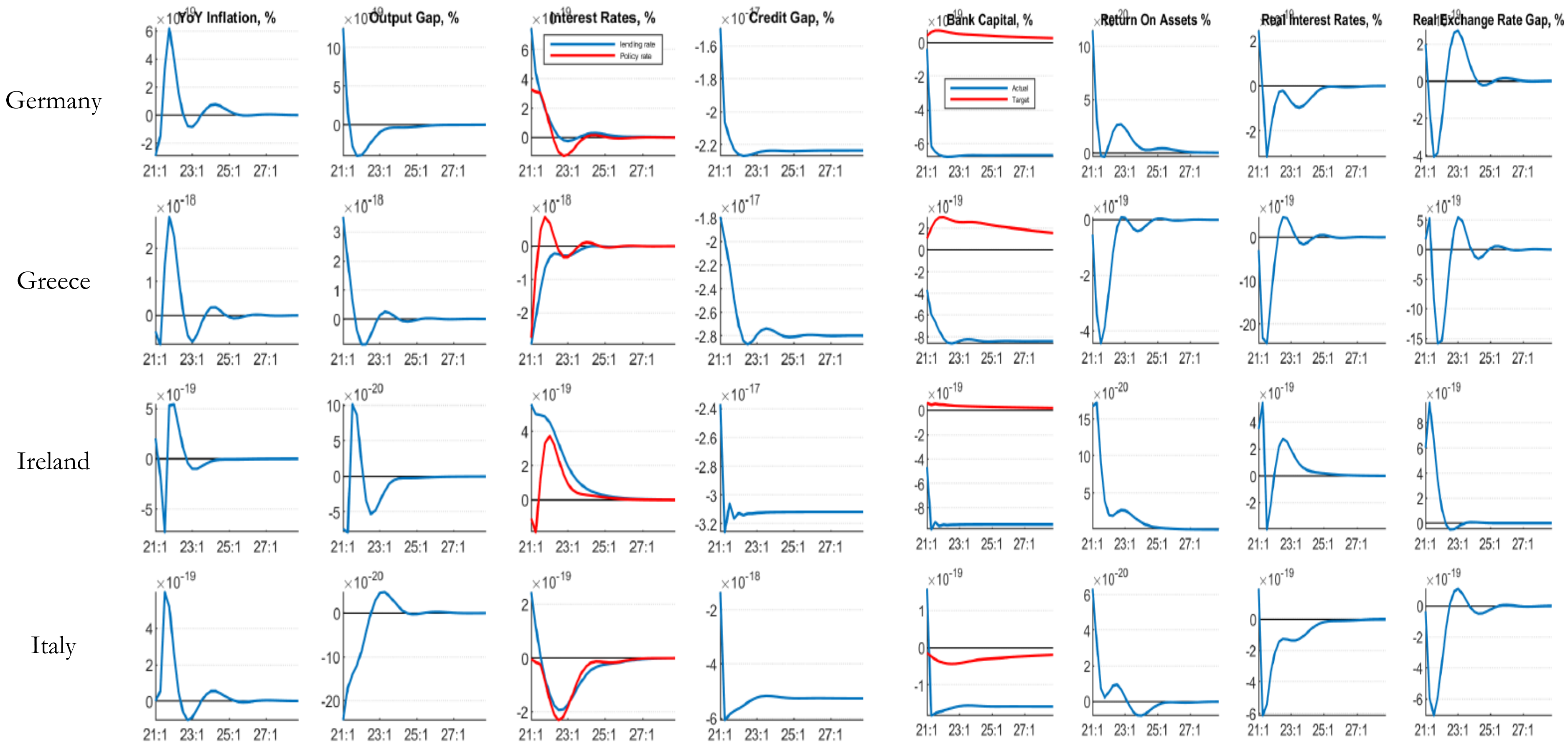


Figure D.2 (continue): Solvency ratio shock

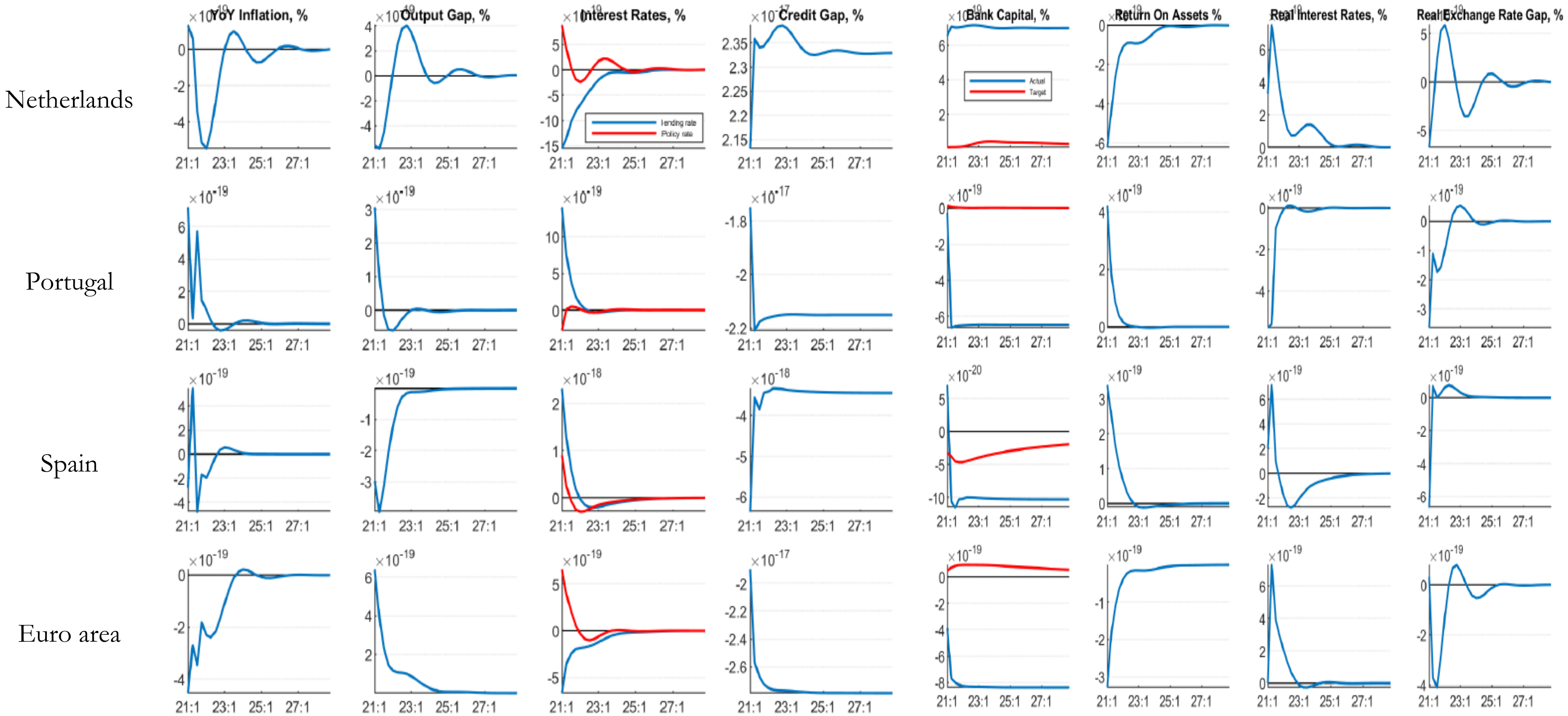


Figure D.3: Countercyclical capital buffer shock

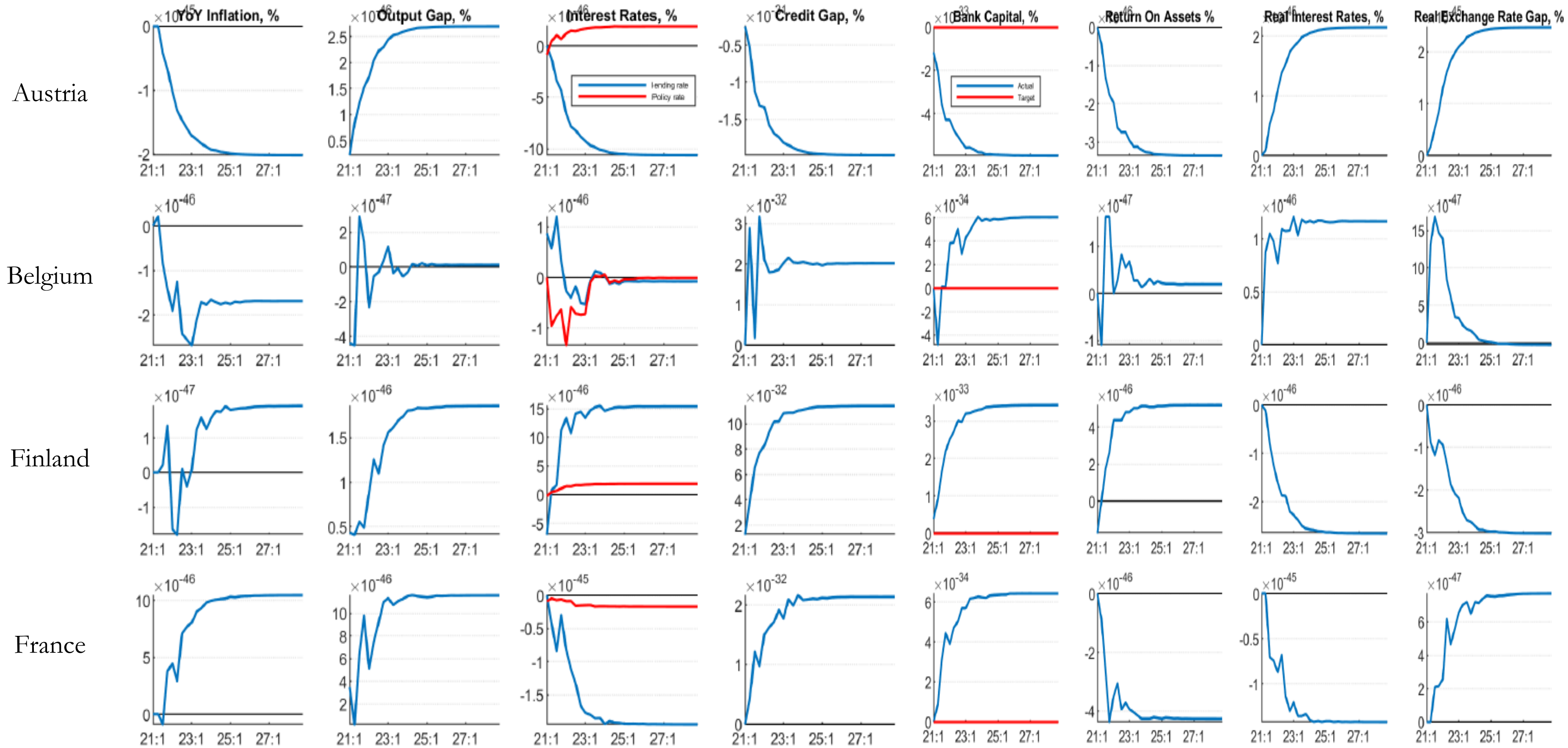


Figure D.3 (continue): Countercyclical capital buffer shock

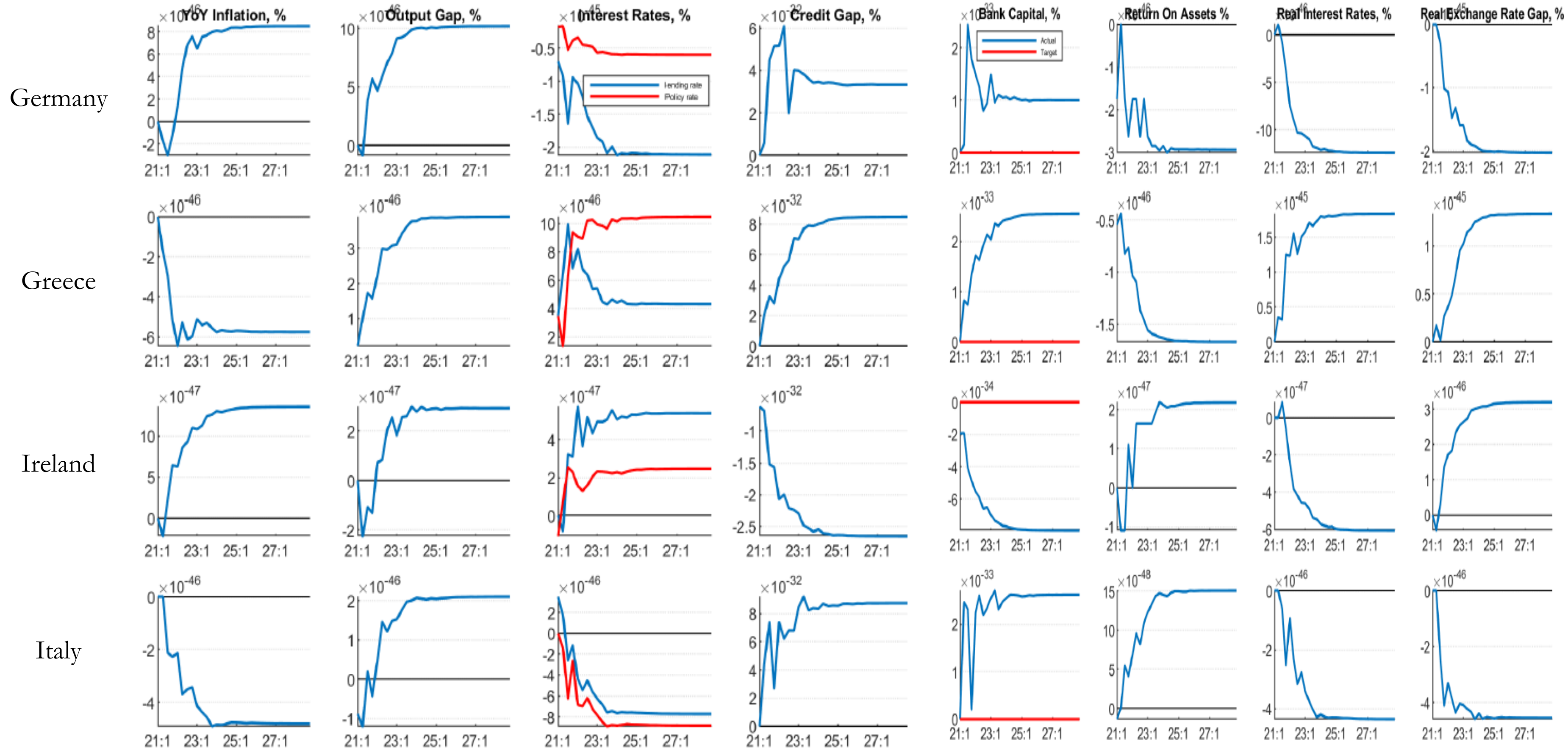


Figure D.3 (continue): Countercyclical capital buffer shock

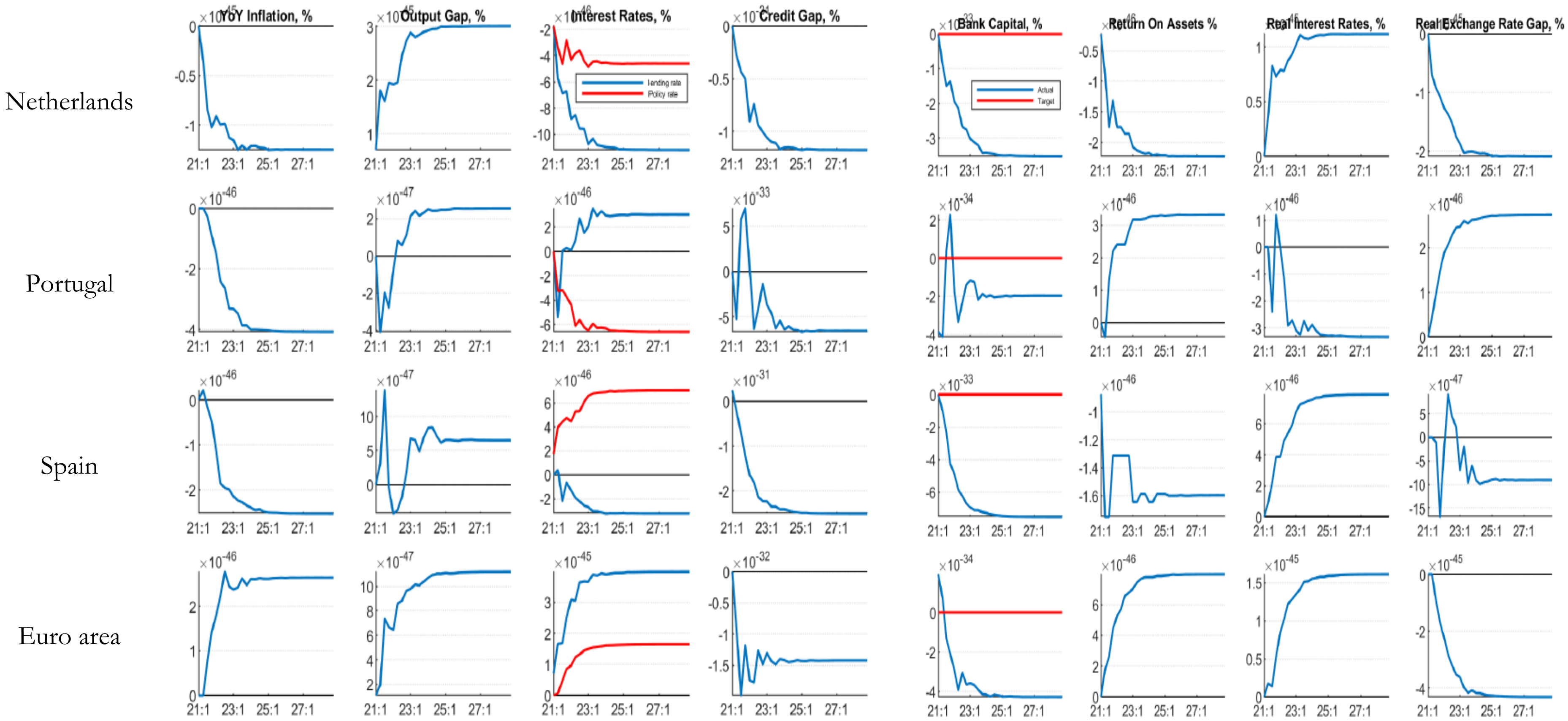


Figure D.4: Financial stability shock

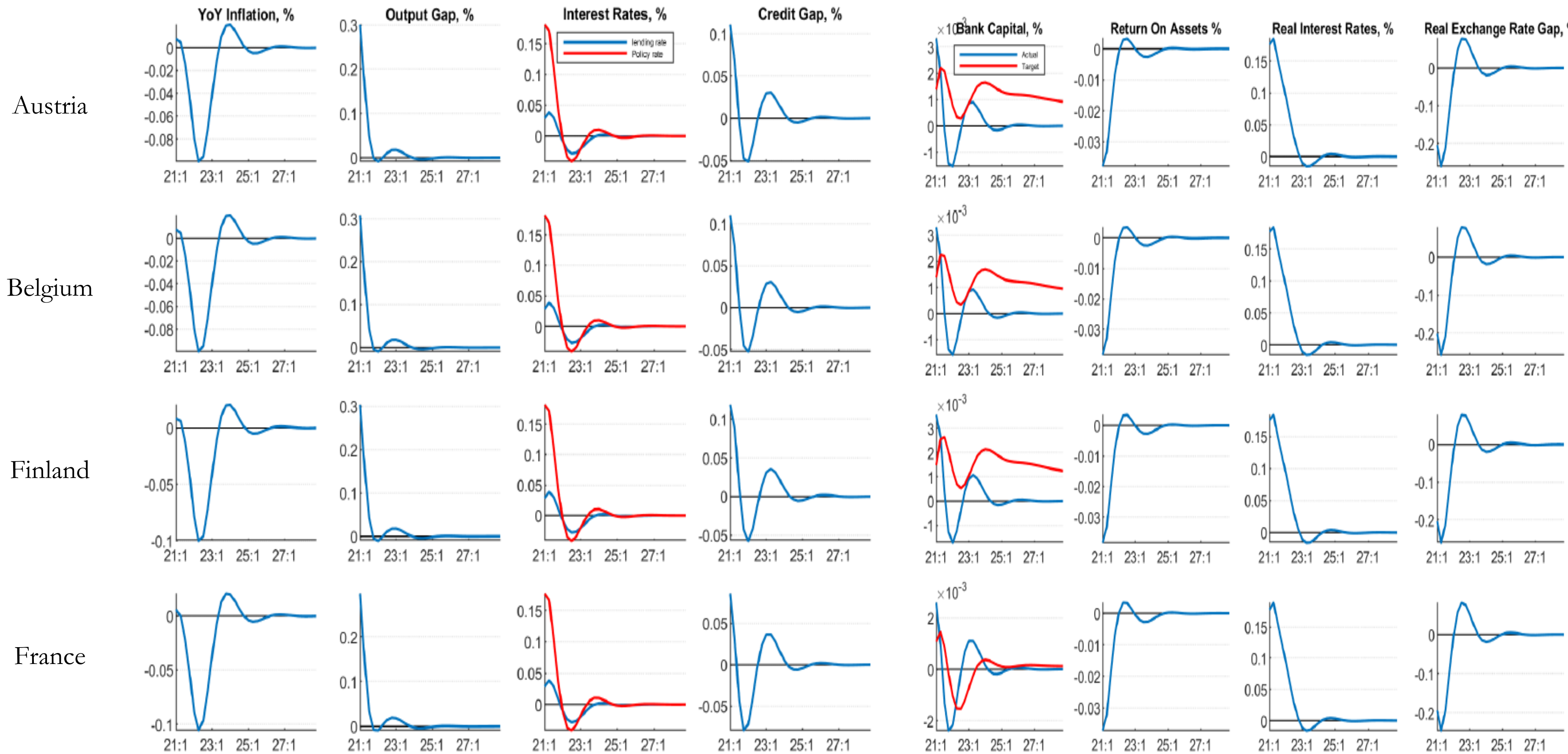


Figure D.4 (continue): Financial stability shock

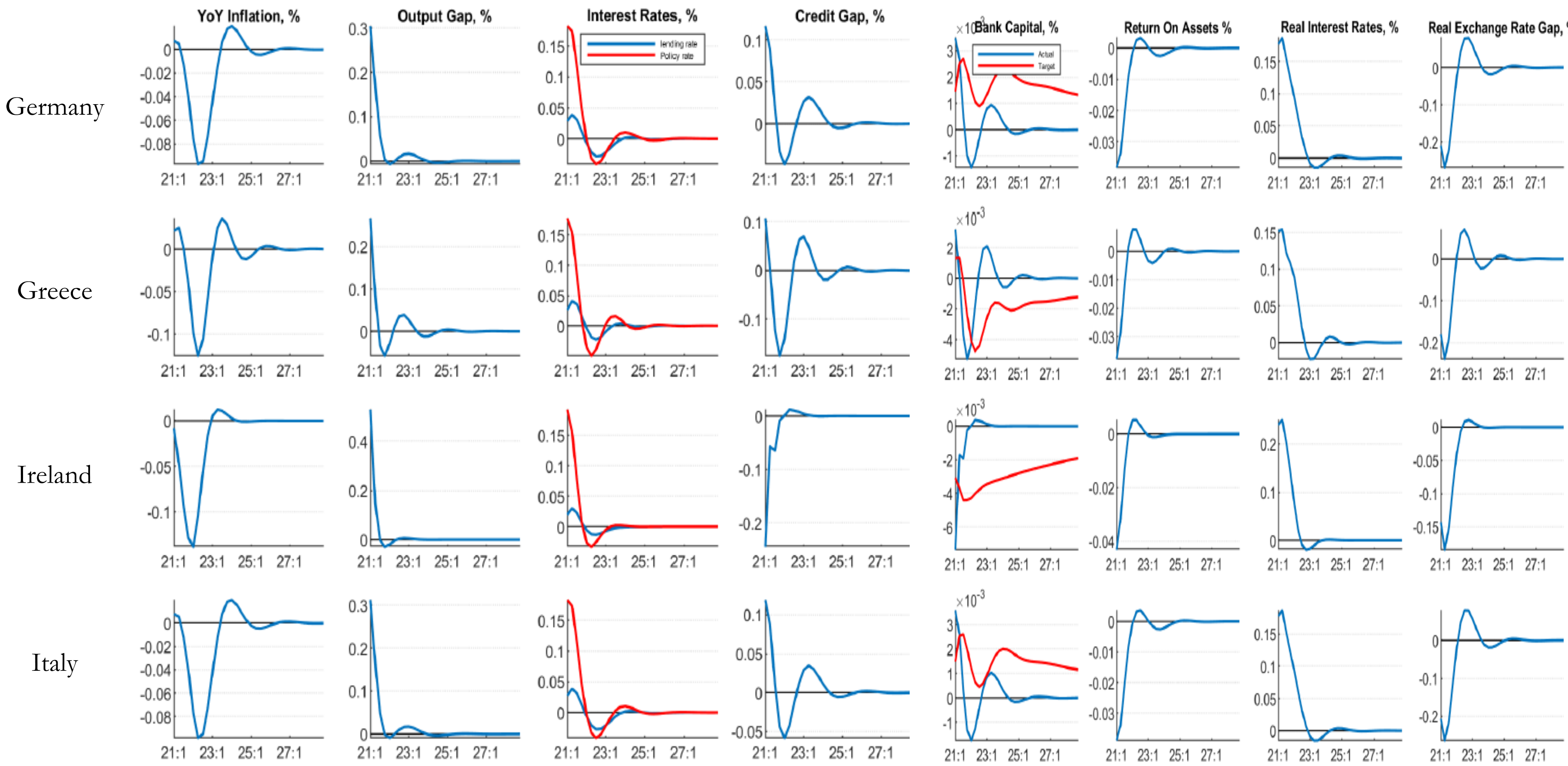


Figure D.4 (continue): Financial stability shock