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ORIGINAL RESEARCH

Fiscal and macroprudential policies in a monetary union

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Abstract
In the European Monetary Union (EMU), monetary policy is determined by the European Central Bank (ECB). This arrangement can give rise to certain national economic imbalances that may potentially be addressed through national policies. Traditionally, fiscal policy has been the primary tool to correct these imbalances. However, following the global financial crisis (GFC), a new policy tool has emerged: national macroprudential policies, which aim to mitigate financial risks. This situation raises an intriguing research question: How do macroprudential and fiscal policies interact? Through their influence on real interest rates and economic activity, discretionary macroprudential policies can impact the trajectory of public debt and may necessitate fiscal adjustments, such as tax rate increases, to stabilize the public debt-to-GDP ratio. In a monetary union, a domestic macroprudential shock generates significant cross-border financial effects and also influences the fiscal stance of foreign countries. Furthermore, discretionary government spending policies have an impact on housing prices and households debt. Therefore, the responsiveness of macroprudential policy to changes in housing prices affects the fiscal multiplier.

Keywords Monetary union · Macroprudential policy · Fiscal policy · Monetary policy · Fiscal multiplier

JEL Classification E32 · E44 · F45

1 Introduction

The global financial crisis (GFC) presented new challenges for the implementation of macro-financial policies. Risks to financial stability underscored the necessity of policies to stabilize the financial system, specifically macroprudential policies. However, these policies must coexist with existing ones, such as monetary and fiscal policies, making their coordination a crucial area of research. This issue becomes especially intriguing in the context of a monetary union, where monetary policy is centralized by a common central bank,

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and fiscal policy is decentralized to national authorities. The question of how to establish macroprudential policies in this setting has been a significant area of concern.

IIn the European Union (EU), a new macroprudential framework has emerged following extensive policy debates. While certain macroprudential tools, such as capital requirements, are internationally established under the jurisdiction of the Basel Committee, others, like the loan-to-value (LTV) ratio, are determined at the national level. These national tools are supervised by the European Systemic Risk Board (ESRB), and their settings are left to the discretion of national authorities. These authorities must make decisions regarding their settings based on both national and European financial market developments.

In the European Monetary Union (EMU), monetary policy is under the purview of the European Central Bank (ECB), meaning that countries no longer have control over setting their own monetary policies, and the exchange rate is no longer a tool for adjustment. This lack of flexibility in tools can lead to imbalances, which may need to be addressed by national policies. Traditionally, fiscal policy was the primary means of correcting these imbalances. However, following the Global Financial Crisis (GFC), national macroprudential policies have emerged as a new policy tool. This development raises several significant research questions: What is the fiscal impact of macroprudential policies? Do these policies impose fiscal costs on foreign countries, thereby strengthening the case for cross-country coordination? How can the coordination of macroprudential, fiscal, and monetary discretionary policies enhance macroeconomic outcomes? How should macroprudential rules be designed to optimize the impact of fiscal and monetary surprises? Are there trade-offs present in the design of macroprudential rules based on specific targets? What are the existing trade-offs among different shocks? Addressing these questions is essential for understanding the interactions between macroprudential, fiscal, and monetary policies in the EMU and optimizing policy frameworks for macroeconomic stability and growth.

In this paper, we develop a two-country Dynamic General Equilibrium (DGE) model within a monetary union, calibrating these two countries to match the features of Spain and Germany.[1] There are two types of agents in each economy, differing in their temporal discount rates and categorized as borrowers and lenders. We allow lenders to possess distinct preferences for national and foreign borrowers' debt, reflecting an important empirical feature in an open economy: financial transactions within and across economies. This approach follows the work of Sargent (1987) and more recent contributions by Krishnamurthy and Vissing-Jorgensen (2015) or Reis (2020). Our utility-maximizing individuals include debt in their utility function, and those with a lower temporal discount rate hold a positive asset position. This structure enables the introduction of country-specific bond preferences that encapsulate imperfect financial integration. The bond market comprises four types of bonds: lenders in both countries have access to (public and private) national

[1] The choice of a two-country setting aligns with the nature of our research question, which explores interactions between different policies within a monetary union. In our case, a multi-country setting involves two countries due to the complexity of including additional countries in a DGE model. Monetary union models addressing cross-country interactions often simplify by dividing the union into two blocks; in the Euro area, these blocks typically represent core and periphery countries (or two representative countries, as in our case). Considering two paradigmatic blocks allows us to effectively answer the research question. While some models explore a three-country setting, these typically address questions related to a third party, such as interactions between the Union countries and the US. Since our research question focuses strictly on within-union interactions, including additional countries in the model would unnecessarily complicate the setting, providing qualitatively similar results.

and foreign bonds. Our model generates a downward-sloping demand for different types of bonds.

The paper is situated within the general equilibrium literature that accommodates international lending, as seen in works like Stähler and Thomas (2012) or Kolasa (2009). In contrast to those papers where one country typically serves as a net borrower, our study introduces a more intricate scenario. The borrowing country in our model features agents who lend both domestically and abroad, while agents in the lending country may also borrow from the foreign borrowing country.

Furthermore, our paper aligns with research exploring policy interactions, including both monetary-fiscal interactions (examples include Beetsma and Jensen 2005; Ferrero 2009; Farhi and Werning 2017; Demid 2018; Bonam and Lukkezen 2019), monetary-macroprudential interactions (see Farhi and Werning 2016, for a unified approach and (Bussière et al. 2020), for a recent survey) and macroprudential-fiscal links (see de Blas and Malmierca 2020).

The work most closely related to ours is Malmierka (2022), which combines the presence of international lending in a monetary union with an analysis of monetary-fiscal-macroprudential policy interactions. It addresses the key question of whether macroprudential-fiscal policy interaction is relevant for stabilization in a monetary union where national economies cannot use monetary policy. Following a credit risk shock originating in the net borrower country, the paper analyzes the response of key macroeconomic variables under two alternative implementations of macroprudential policy (country-targeted and supranational) interacting with three different combinations of fiscal and monetary policy based on the active/passive definitions introduced by Leeper (1991). Malmierca (2023) extends the previous positive research to a welfare analysis, and Malmierca-Ordoqui (2024) contextualizes the earlier findings within the scale of the Covid shock.

While our paper shares some similarities with Malmierka (2022), it also diverges from it in other important aspects. First, in contrast to Malmierka (2022), our model features a different macroprudential policy that directly affects households and mortgage loans, rather than entrepreneurs and credit collateralized by production capital. This distinction is crucial when considering the interaction of fiscal and macroprudential policies, as the household debt and mortgage channel of fiscal policy has been extensively emphasized in the literature (see, for example, Andrés et al. 2015; Cloyne and Surico 2017; Klein 2017; Bernardini and Peersman 2018; or Klein et al. 2022). Second, our macroprudential policy rule produces a different impact on interest rates compared to Malmierca's model. While a tighter macroprudential policy that targets financial intermediate liabilities (as in Malmierca's model) tends to increase lending interest rates, a macroprudential rule that affects lenders' assets (like ours) has a negative impact on lending interest rates. For empirical evidence supporting this theoretical result, see, for example, Kim and Mehrotra (2022). Third, whereas Malmierka (2022) involves only one international asset traded between two countries, our model allows both private and public domestic bonds to be traded in either the domestic or international markets. This enables us to differentiate between the endogenous evolution of shares of public and private debt held by domestic and foreign investors. Fourth, our objective differs from that of Malmierca. While Malmierca primarily focuses on the stabilization properties of macroprudential policy under different monetary and policy regimes, our aim is to illustrate the economic mechanisms operating in two different directions: (a) from a macroprudential shock to fiscal effects and (b) from a fiscal shock to its macroeconomic effects through macroprudential policy. We investigate the transmission channels of symmetric or asymmetric discretionary policies (macroprudential, fiscal, and monetary) from one country to another within a monetary union. Our analysis underscores the criticality of coordination between countries to effectively manage these policies and their spillover effects across borders. Additionally, we explore the magnitude of the effects of such policies, contingent on the stringency of fiscal, monetary, or macroeconomic rules. Our approach also aligns with Reis (2020), who explores the fiscal footprint of macroprudential policies. Reis identifies three channels through which this effect travels: an increase in the price of government bonds, easing the government budget constraint; a reduction in activity and government revenues, tightening the government constraint; and lower bailout costs. In our paper, we present results using a fully developed two country dynamic general equilibrium model that accounts for the first two channels and introduces a cross-border lending/borrowing channel, albeit abstracting from defaults and bailouts. We show that the cross border fiscal effect of a domestic macroprudential policy can be significant.

More generally, results demonstrate that a discretionary macroprudential policy in one country has substantial cross-border effects on financial assets, real activity, and the fiscal footprint. In contrast, the spillover effects of fiscal policy are comparatively limited. We also find that for symmetric macroprudential shocks affecting both countries, a monetary surprise can replicate the results of a macroprudential shock, up to the effects on private debt. This implies that a simultaneous discretionary expansionary monetary policy by the central bank can neutralize three gaps that arise after a macroprudential policy (in output, inflation and taxes) without diminishing the desired effect on private debt.

When the reduction of inflation becomes an objective in itself, coordination between macroprudential and fiscal discretionary policies can lead to better outcomes by improving output results, without negating the inflation drop or incurring a cost in terms of higher taxes in the short run. Regarding the design of policy rules, we conclude that a combination of a tight macroprudential policy and loose monetary policy maximizes the effects of fiscal policy while minimizing the impact of technology shocks. Furthermore, a tight macroprudential rule assists fiscal policy in achieving the target of larger output and aids monetary policy in reducing inflation. However, after a productivity shock, a tight macroprudential rule diminishes the positive impact on GDP but reinforces the negative impact on inflation.

The remainder of the paper goes as follows. Section 2 presents the model setup. Section 3 shows the financial and fiscal impact of macroprudential policy. Section 4 compares the effects of coordinated discretionary macroprudential, monetary and fiscal policies. Section 5 discusses how committing to a looser or tighter rule by the different policy institutions can alter the results of discretionary policies. Section 6 concludes.

2 The model

We consider a monetary union comprising two countries, A (domestic) and B (foreign), engaged in trade of consumption and bonds. Agents in each country have the option to choose between various assets, including tradable bonds and non-tradable houses. The divergence in discount rates among households naturally divides consumers into borrowers and savers in each economy. Both governments and private entities can borrow, with borrowers able to obtain funds from either domestic or foreign lenders. Similarly, lenders have the choice of lending to national or foreign borrowers, resulting in four distinct types of bonds within the monetary union. To capture bond-specific demand functions, we incorporate country-specific preferences for bonds.

Borrowing carries an external effect in the form of a risk premium, which fluctuates based on the relative total debt-to-GDP ratio. Households in both countries purchase domestic and foreign goods, albeit without considering home bias for simplicity. Labor is employed in a competitive market as the sole factor of production. Prices of final goods exhibit stickiness in a Calvo fashion (Calvo 1983).

A progressive tax scheme, featuring a flat rate and exempt labor income, is administered by the fiscal authority to stabilize the government debt-to-GDP ratio. Macroprudential institutions oversee housing prices and determine the loan-to-value (LTV) ratio. The central bank sets the reference interest rate based on inflation within the monetary union.

The economic equations characterizing both countries are symmetrical. The relative population weights between countries are represented by ω and $(1-\omega)$ for country A and B, respectively. Within each country the share of borrowers is represented by τ and τ^*, respectively. Specifically, if we designate by N the total population in the monetary union, then $N = N_A + N_B$, where N_A and N_B denote the population in economy A and B, respectively. Consequently, we define $\omega = \frac{N_A}{N}$ and $(1-\omega) = \frac{N_B}{N}$. Assuming the populations of patient and impatient individuals in economy A are represented by N_l and N_r, respectively, we define $\tau = \frac{N_r}{N_A}$ and $(1-\tau) = \frac{N_l}{N_A}$. Similarly, for country B, $\tau^* = \frac{N_r^*}{N_B}$ and $(1-\tau^*) = \frac{N_l^*}{N_B}$.

Next, we outline the model, presenting the most relevant equations and deferring the remaining details to Appendix 1. The equivalent equations for country B are omitted for brevity.

2.1 Households

2.1.1 Patient households

Patient households discount the future at a lower rate $\left(\frac{1}{\beta^l}\right)$ than impatient households.This fact drives them to be the lenders in the economy as they assign relatively greater value to future consumption compared to the borrower population.

In our notation, in general, lower-case letters represent real variables, while capital letters denote nominal variables. Patient households optimize their utility function by solving the following maximization problem:

$$U^l = E_0 \sum_{i=0}^{\infty} \beta^{li} \begin{pmatrix} \ln c_{t+i}^l + \gamma_h \ln h_{t+i}^l \\ +\gamma_{b_{At}}(\bullet) \ln(b_{At}^l) + \chi_B \ln(b_{Bt}^l) \\ +\gamma_{b_{At}}^g(\bullet) \ln(b_{At}^g) + \chi_B^g \ln(b_{Bt}^g) - \frac{(n_{t+i}^l)^{1+\eta}}{1+\eta} \end{pmatrix}.$$

Variables are written relative to the population of lenders N_l, that is, c_t^l can be interpreted as total consumption of lenders divided by the total amount of lenders in economy A. In the same vein, n^l stands for per capita working hours and h^l represents the stock per capita of houses owned by lenders. Parameters η, γ_h, relate to the elasticity of labor supply with respect to wages and the preferences for housing, respectively. The utility function distinguishes between four types of bonds that capture different financial alternatives for lenders. Bonds issued by national borrowers in hands of national lenders are denoted by b_{At}^l, where $b_{At}^l = \frac{B_{At}^l}{P_{At}}$ and B_{At}^l stands for the nominal value of bonds, which pay a gross nominal interest rate R_{At}. Similarly, bonds bought by national lenders from the home government are called b_{At}^g, whereas b_{Bt}^l and b_{Bt}^g stand for bonds issued by foreign households and government.

Preferences vary between public and private bonds due to differences in safety and/or liquidity, and also between domestic and foreign bonds, owing to imperfect financial market integration. This assumption is grounded in the idea that different assets offer non-pecuniary services to households, a concept generalized from models found in Sargent (2009), Krishnamurthy and Vissing-Jorgensen (2015), or Reis (2020).

Within this framework, as the total debt-to-output ratio in economy A increases relative to that in economy B, bonds in economy B become more appealing. Specifically, preferences for bonds evolve over time in response to changes in the ratio of total debt-to-output in economy A compared to economy B. Hence, we assume

$$\gamma_{b_{At}}(\bullet) = \chi_A + \vartheta\left(\frac{b_t^*}{b_t}\frac{y_t}{y_t^*} - 1\right),$$

and

$$\gamma_{b_{At}}^g(\bullet) = \chi_A^g + \vartheta\left(\frac{b_t^*}{b_t}\frac{y_t}{y_t^*} - 1\right),$$

where b_t and b_t^* represent aggregate debt (to be defined more precisely below) in country A and B, respectively, and ϑ is a positive parameter. Notice that the difference $\gamma_A^g - \gamma_A$ and $\chi_B^g - \chi_B$ captures the existence of a public-private bond bias, whilst the presence of a country bias would be reflected by $\gamma_A^g - \chi_B^g$ and $\gamma_A - \chi_B$.

We assume that patient households do not internalize the impact of their lending decisions on the ratios $\frac{b_t}{y_t}$ and $\frac{b_t^*}{y_t^*}$, meaning they do not take into account how their lending choices may influence the aggregates b_t and b_t^*.

The budget constraint, in real terms, is

$$\begin{aligned} c_{At}^l &+ \frac{P_{Bt}}{P_{At}}c_{Bt}^l + q_t\left(h_t^l - h_{t-1}^l\right) + b_{At}^l + \frac{P_{Bt}}{P_{At}}b_{Bt}^l + b_{At}^g + \frac{P_{Bt}}{P_{At}}b_{Bt}^g \\ &\leq \left(1 - x_t^l\right)w_t n_t^l + \frac{R_{At-1}}{\pi_{At}}b_{At-1}^l + \frac{P_{Bt}}{P_{At}}\frac{R_{Bt-1}}{\pi_{Bt}}b_{Bt-1}^l \\ &+ \frac{R_{At-1}^g}{\pi_{At}}b_{At-1}^g + \frac{P_{Bt}}{P_{At}}\frac{R_{t-1}}{\pi_{Bt}}b_{Bt-1}^g + d_t. \end{aligned} \tag{1}$$

c_{At}^l and c_{Bt}^l represent the per capita consumption of domestically and foreign-produced goods, respectively.. P_{At} and P_{Bt} denote the producer price indexes in countries A and B. The numeraire is P_{At}, which is used to deflate all nominal variables, including loans, wages, and profits. $\frac{P_{Bt}}{P_{At}}$ represents the inverse of the terms of trade and q_t denotes the relative price of houses, h_t^l. A positive value for b_{At}^l and b_{Bt}^l signifies to a lending amount, while a negative value indicates a borrowing amount. For patient households both are positive. Bonds yield an interest rate, which varies depending on the type, with government bonds in country B yielding an interest rate R_t equivalent to the policy rate. d_t represents profits derived from the monopolistically competitive firms owned by lenders. We assume that labor income ($w_t n_t^l$, i.e. wages multiplied by per capita working hours,) is subject to taxation. The average tax rate on labor income for lenders, x_t^l is defined as $\frac{t_{At}^l}{w_t n_t^l}$, where t_{At}^l represents the per capita amount of taxes paid by these households,

$$t^l_{At} = m_{At}(w_t n^l_t - \overline{t_A}). \tag{2}$$

The preceding equation presupposes a progressive tax scheme, accomplished by introducing a per capita tax-exempt income, denoted as $\overline{t_A}$, and a flat tax rate on labor income, m_{At}. Consequently, the average tax rate rises with income, bolstering the automatic stabilizer aspect of the tax system. As elucidated below, m_{At} will serve as the tool employed by the fiscal authority to maintain a constant ratio of public debt to GDP over the long term. A higher m_{At} implies a more progressive tax structure.

The inflation rate on the domestically produced goods, π_{At}, and foreign goods, π_{Bt}, are defined as

$$\pi_{At} = \frac{P_{At}}{P_{At-1}}, \tag{3}$$

$$\pi_{Bt} = \frac{P_{Bt}}{P_{Bt-1}}. \tag{4}$$

The consumption basket for lenders is defined as

$$c^l_t = (c^l_{At})^{\omega}(c^l_{Bt})^{1-\omega} \tag{5}$$

Patient households maximize with respect to c^l_{At}, c^l_{Bt}, h^l_t and n^l_t (leading to standard first order conditions, as can be seen the Appendix 1), and also over the four financial assets (b^l_{At}, b^l_{Bt}, b^g_{At}, and b^g_{Bt}). Optimal decisions regarding bonds should satisfy the following conditions:

$$\lambda^l_t = \beta^l E_t\left[\lambda^l_{t+1}\frac{R_{At}}{\pi_{At+1}}\right] + \frac{\chi_A}{b^l_{At}} + \frac{\vartheta}{b^l_{At}}\left(\frac{b^*_t}{b_t}\frac{y_t}{y^*_t} - 1\right), \tag{6}$$

$$\lambda^l_t = \beta^l E_t\left[\lambda^l_{t+1}\frac{R_{Bt}}{\pi_{At+1}}\right] + \frac{P_{At}}{P_{Bt}}\frac{\chi_B}{b^l_{Bt}}, \tag{7}$$

$$\lambda^l_t = \beta^l E_t\left[\lambda^l_{t+1}\frac{R^g_{At}}{\pi_{At+1}}\right] + \frac{\chi^g_A}{b^g_{At}} + \frac{\vartheta}{b^g_{At}}\left(\frac{b^*_t}{b_t}\frac{y_t}{y^*_t} - 1\right), \tag{8}$$

$$\lambda^l_t = \beta^l E_t\left[\lambda^l_{t+1}\frac{R_t}{\pi_{At+1}}\right] + \frac{P_{At}}{P_{Bt}}\frac{\chi^g_B}{b^g_{Bt}}, \tag{9}$$

where λ^l_t is the Lagrangian multiplier associated with the restriction (1). From these conditions, we can obtain non-arbitrage conditions among the four assets. Differences in interest rates between different bonds depend on three factors. First, the amount of bonds held by households, as captured by the second term on the right-hand side of the above expressions. Other things being equal, a decrease in the price of a particular type of bond (an increase in its interest rate) increases the desired amount of that bond type held by households vis-à-vis other bonds. Thus, there is a downward-sloping demand for bonds. Second, the term related to the endogenous risk premium. As the debt-to-GDP ratio increases in the domestic economy with respect to the foreign one, the domestic interest rate increases relative to the foreign one. Third, a factor capturing the terms of trade, $\frac{P_{At}}{P_{Bt}}$, that indicates that nominal interest rate differentials between the two countries are related to price differentials. From Eqs. (8) and (9) let us define this risk premium term as

$$\phi_t \equiv -\frac{\pi_A \vartheta}{b_A^g \beta^l \lambda^l}\left(\frac{b_t^*}{b_t}\frac{y_t}{y_t^*} - 1\right), \tag{10}$$

which represents the increase in $R_{At}^g - R_t$ to a given change in $\left(\frac{b_t^*}{b_t}\frac{y_t}{y_t^*} - 1\right)$. Notice that, *caeteris paribus*, it increases with the ratio of total debt-over-output in country A.

Together with the demand for bonds from foreign households, the above expressions produce induced effects of economic policies on the desired composition of bonds in the portfolio of lenders households. These effects translate into changes in the decisions of private/public and national/foreign borrowers.

2.1.2 Impatient households

Impatient households have a higher discount rate than patient households $\left(\frac{1}{\beta^r} > \frac{1}{\beta^l}\right)$, which drives them to be the borrowers of the economy. These agents sell bonds to the lenders of both economies, paying the corresponding interest rates. Impatient households solve the following optimization problem, maximizing the utility function

$$U_0^r = E_0 \sum_{i=0}^{\infty} \beta^{ri} \left(\ln c_{t+i}^r + \gamma_h \ln h_{t+i}^r - \frac{\left(n_{t+i}^r\right)^{1+\eta}}{1+\eta} \right),$$

subject to

$$\begin{aligned} & c_{At}^r + \frac{P_{Bt}}{P_{At}} c_{Bt}^r + q_t\left(h_t^r - h_{t-1}^r\right) + \frac{R_{At-1}}{\pi_{At}} b_{t-1}^r \\ & \leq \left(1 - x_t^r\right) w_t n_t^r + b_t^r. \end{aligned} \tag{11}$$

c_t^r can be interpreted as total consumption of borrowers divided by the total amount of borrowers in economy A. $b_t^r = \frac{B_t^r}{P_{At}}$ expresses the total real private borrowing in country A from domestic and foreign lenders, and is defined as a positive variable. Similarly to impatient households, x_t^r is defined as $\frac{t_{At}^r}{w_t n_t^r}$, where

$$t_{At}^r = m_{At}(w_t n_t^r - \overline{t_A}). \tag{12}$$

Hence, the average tax rate will differ between borrowers and lenders given that, although wages will be common across households, working hours may be different.

Additionally, these consumers face a borrowing constraint of the form

$$E_t\left[\frac{R_{At}}{\pi_{At+1}} b_t^r\right] \leq E_t\left[k_{At} q_{t+1} h_t^r\right], \tag{13}$$

where k_{At} can be interpreted as a loan-to-value ratio (LTV) and will be the instrument for the macroprudential policy. Notice that keeping constant the rest of variables, an increase in the price of b_t^r (a fall in R_{At}) will increase the supply of private bonds.

The consumption basket for borrowers is defined as

$$c_t^r = (c_{At}^r)^{\omega}(c_{Bt}^r)^{1-\omega}. \tag{14}$$

The impatient household maximizes with respect to c_{At}^r, c_{Bt}^r, h_t^r, n_t^r, and b_t^r. The derivative with respect to b_t^r yields

$$\lambda_t^r = \beta^r E_t\left[\lambda_{t+1}^r \frac{R_{At}}{\pi_{At+1}}\right] + \xi_t R_{At}, \tag{15}$$

where λ_t^r and ξ_t are the Lagrangian multiplier associated with the restrictions (11) and 13. Borrowers in country A will pay the interest rate R_{At}, regardless who provides the funds (domestic or foreign lenders). According to this equation, a tighter macroprudential policy (an increase in ξ_t driven by a reduction in the LTV) would reduce the interest rate borne by borrowers, as borrowers would demand a higher price for the bond in order to maintain their consumption.

2.2 Firms

We have J firms of mass 1. Each firm j produces a differentiated good and takes decisions subject to three constraints: a constant returns production technology; a downward sloping demand curve, and a perfect competition labor market. In all that follows all variables are represented in per capita terms of total population in the economy. The optimization problem can be written as:

$$\min \mathrm{W}_t n_t(j),$$

subject to:

$$y_t(j) = z_t n_t(j), \tag{16}$$

$$y_t(j) = \left(\frac{P_{At}(j)}{P_{At}}\right)^{-\varepsilon} y_t, \tag{17}$$

where W_t is the nominal wage and z_t is the technical level, both common to all firms.

Optimization with respect to employment yields the following standard labor demand in real terms:

$$w_t = mc_t \frac{y_t}{n_t}. \tag{18}$$

Optimal prices are obtained assuming a Calvo scheme:

$$\max_{p_{At}(j)} \Pi_0 = E_t \sum_{i=0}^{\infty} \lambda_{t+i}^l (\beta^l \theta)^i \left[\left(\prod_{r=1}^{i} \frac{(\pi_{At+r-1})^{\zeta}}{\pi_{At+r}} p_{At}(j) - mc_{t+i}\right) y_{t+i}(j)\right],$$

subject to the variety demand function,

$$y_{t+i}(j) = \left(\prod_{r=1}^{i} \frac{(\pi_{At+r-1})^{\zeta}}{\pi_{At+r}} p_{At}(j)\right)^{-\varepsilon} y_{t+i}. \tag{19}$$

A proportion θ of firms do not reset prices optimally at t and adjust them according to a simple indexation rule to catch up with lagged inflation: $P_{jt} = \left(\pi_{t-1}\right)^{\zeta} P_{jt-1}$. We are assuming that firms that are not allowed to change prices optimally reset prices each period according to inflation. $p_{At}(j)$ stands for the relative price $\frac{P_{At}(j)}{P_{At}}$. Taking into account that all firms will set the same optimal price, the solution to the above problem renders the following New Keynesian Phillips curve,

$$\left(\frac{1-\theta(\pi_{At})^{\varepsilon-1}}{1-\theta}\right)^{\frac{1}{1-\varepsilon}} = \frac{\varepsilon}{\varepsilon-1}\frac{E_t\sum_{i=0}^{\infty}\lambda_{t+i}^{l}(\beta^{l}\theta)^{i}mc_{t+i}y_{t+i}\left(\prod_{r=1}^{i}\frac{(\pi_{At+r-1})^{\zeta}}{(\pi_{At+r})}\right)^{-\varepsilon}}{E_t\sum_{i=0}^{\infty}\lambda_{t+i}^{l}(\beta^{l}\theta)^{i}y_{t+i}\left(\prod_{r=1}^{i}\frac{(\pi_{At+r-1})^{\zeta}}{(\pi_{At+r})}\right)^{1-\varepsilon}}. \tag{20}$$

2.3 Aggregation

There are some restrictions linking debt. In the domestic economy, bonds issued by domestic borrowers (total private debt) may be in hands of either domestic or foreign lenders:

$$b_t^r = \frac{(1-\tau)}{\tau}b_{At}^l + \frac{(1-\omega)}{\omega}\frac{(1-\tau^*)}{\tau}b_{At}^{*l}, \tag{21}$$

where b_{At}^{*l} is economy B's lenders holdings of bonds issued by economy A's borrowers.

With respect to public debt,

$$b_t^g = (1-\tau)b_{At}^g + (1-\tau^*)\frac{(1-\omega)}{\omega}b_{At}^{*g}. \tag{22}$$

where b_{At}^{*g} is economy B's holdings of bonds issued by economy A's government.

Total debt, i.e. the sum of public and private debt, in economy A can be defined as:

$$b_t = b_t^g + \tau b_t^r \tag{23}$$

Aggregation over housing results in:

$$\tau h_t^r + (1-\tau)h_t^l = h, \tag{24}$$

where h is an exogenous variable representing the per capita stock of housing in economy A.

Consumption can also be aggregated using the shares of lenders and borrowers in each economy. Consumption in country A of goods produced in country A:

$$c_{At} = \tau c_{At}^r + (1-\tau)c_{At}^l. \tag{25}$$

Consumption in country A of goods produced in country B (imports–exports- by country A–B):

$$c_{Bt} = \tau c_{Bt}^r + (1-\tau)c_{Bt}^l. \tag{26}$$

Total consumption in country A can be defined as

$$c_t = \tau c_t^r + (1-\tau)c_t^l = c_{At} + \frac{P_{Bt}}{P_{At}} c_{Bt}, \tag{27}$$

where

$$c_t^l = c_{At}^l + \frac{P_{Bt}}{P_{At}} c_{Bt}^l, \tag{28}$$

and

$$c_t^r = c_{At}^r + \frac{P_{Bt}}{P_{At}} c_{Bt}^r. \tag{29}$$

Employment is aggregated as

$$n_t = \tau n_t^r + (1-\tau)n_t^l. \tag{30}$$

Total government revenues are characterized by,

$$t_t = (1-\tau)t_{At}^l + \tau t_{At}^r = m_A(w_t n_t - \overline{t_A}). \tag{31}$$

The aggregate production function for the domestic economy is,

$$y_t = z_t n_t. \tag{32}$$

2.4 Fiscal, monetary and macroprudential rules

We assume an exogenous amount of non-productive government consumption g_t for the domestic economy and g_t^* for economy B. Public debt evolves according to

$$b_t^g = \frac{R_{At-1}^g}{\pi_{At}} b_{t-1}^g + (g_t - t_t). \tag{33}$$

$$b_t^{*g} = \frac{R_{t-1}}{\pi_{Bt}} b_{t-1}^{*g} + (g_t^* - t_t^*). \tag{34}$$

Common monetary policy is characterized by a simple Taylor rule. The central bank takes into account the weighted average of the monetary union countries' inflation:

$$R_t = R_{t-1}^{\rho} \left[\left(\pi_{At}^{\omega} \pi_{Bt}^{1-\omega} \right)^{\Phi} \overline{R} \right]^{1-\rho}. \tag{35}$$

Each country uses the flat tax as the instrument to stabilize the ratio of total public debt-over-GDP in the long run. Then, the fiscal policy rule can be represented as:

$$m_{At} = m_{At-1} + \psi_1 f_t \left(\frac{b_t^g}{y_t} - \overline{\left(\frac{b^g}{y} \right)} \right) + \psi_2 f_t \left(\frac{b_t^g}{y_t} - \frac{b_{t-1}^g}{y_{t-1}} \right), \tag{36}$$

where the parameter ψ_1 captures the speed of adjustment from the current ratio to the desired ratio, and f_t is a dummy variable that controls for the time period in which the fiscal rule is initially inactive. Similarly, for country B,

$$m_{Bt} = m_{Bt-1} + \psi_1^* f_t^* \left(\frac{b_t^{*g}}{y_t^*} - \overline{\left(\frac{b^{*g}}{y^*} \right)} \right) + \psi_1^* f_t^* \left(\frac{b_t^{*g}}{y_t^*} - \frac{b_{t-1}^{*g}}{y_{t-1}^*} \right). \tag{37}$$

As an approximation for a realistic macroprudential policy, we consider an adaptive rule for the loan-to-value ratio (LTV), akin to a Taylor rule for monetary policy. In traditional models, the LTV ratio remains a fixed parameter unaffected by economic conditions. However, regulations governing LTV ratios can be viewed as a means to moderate credit booms. When the LTV ratio is high, the collateral constraint is less stringent, allowing borrowers to access more credit. Conversely, lowering the LTV ratio tightens the constraint, restricting the amount of bonds they can issue.

Recent research on macroprudential policies has proposed adaptive rules for the LTV ratio, wherein it reacts inversely to variables such as the growth rates of GDP, credit, the credit-to-GDP ratio, or house prices. These rules serve as a simple illustration of how a macroprudential policy might operate in practice. We consider a decentralized macroprudential policy, wherein each country can implement its own LTV rule, reflecting the setup within the EU:

$$k_{At} = k_{SSA} \left(\frac{q_t}{\overline{q}} \right)^{-\phi_{Aq}^k}, \tag{38}$$

$$k_{Bt} = k_{SSB} \left(\frac{q_t^*}{\overline{q^*}} \right)^{-\phi_{Bq}^k}, \tag{39}$$

where k_{SS} and $\overline{q}$ are the steady-state values for the loan-to-value ratio and house prices in country A. $\phi_{Aq}^k \geq 0$ and $\phi_{Bq}^k \geq 0$ measure the response of the LTV to house prices in country A and B. This type of rule would deliver a lower LTV ratio in booms, when house prices are high, therefore restricting the credit in the economy and mitigating a credit boom derived from good economic conditions.

2.5 GDP and balance of payments

The total resource constraint should satisfy the condition that total production y_t should be equal to the sum of factor incomes or total final demand in the economy. That is,

$$y_t = w_t n_t + (1 - \tau) d_t, \tag{40}$$

or

$$y_t = c_{At} + \frac{(1 - \omega)}{\omega} c_{At}^* + g_t. \tag{41}$$

To find an expression for aggregate firm's profits in economy A, we can combine expressions (40) and (18) to obtain:

$$(1 - \tau) d_t = \left(\frac{1}{mc_t} - 1 \right) w_t n_t. \tag{42}$$

To derive an expression for the balance of payments, first, we multiply the household budget constraints (1) and (11) by their respective shares in population $(1-\tau)$ and τ and aggregate them. Then, substituting $g_t = y_t - c_{At} - \frac{(1-\omega)}{\omega} c^*_{At}$ into the previous expression results in:

$$\begin{aligned}
&(1-\tau)\frac{P_{Bt}}{P_{At}}\left(b^l_{Bt} + b^g_{Bt}\right) + (1-\tau)b^g_{At} - (1-\tau^*)\frac{(1-\omega)}{\omega}b^{*l}_{At} \\
&= \left(\frac{(1-\omega)}{\omega}c^*_{At} - \frac{P_{Bt}}{P_{At}}c_{Bt}\right) + \left(g_t - t_t\right) \\
&\quad + (1-\tau)\frac{P_{Bt}}{P_{At}}\left(\frac{R_{Bt-1}}{\pi_{Bt}}b^l_{Bt-1} + \frac{R_{t-1}}{\pi_{Bt}}b^g_{Bt-1}\right) + (1-\tau)\frac{R^g_{At-1}}{\pi_{At}}b^g_{At-1} \\
&- (1-\tau^*)\frac{(1-\omega)}{\omega}\frac{R_{At-1}}{\pi_{At}}b^{*l}_{At-1},
\end{aligned} \tag{43}$$

with $x_t = \frac{t_t}{w_t n_t}$. Notice that all the previous variables are in terms of total population in economy A (they are divided by N_A).

An alternative understanding of the balance of payment condition can be grasped if we obtain the steady state version of (43)

$$\begin{aligned}
&(1-\tau^*)\frac{(1-\omega)}{\omega}b^{*l}_A\left(\frac{R_A}{\pi_A} - 1\right) - (1-\tau)\frac{P_B}{P_A}b^l_B\left(\frac{R_B}{\pi_B} - 1\right) \\
&\quad + (1-\tau^*)\frac{(1-\omega)}{\omega}b^{*g}_A\left(\frac{R^g_A}{\pi_A} + 1\right) - (1-\tau)\frac{P_B}{P_A}b^g_B\left(\frac{R}{\pi_B} + 1\right) \\
&= \left(\frac{(1-\omega)}{\omega}c^*_A - \frac{P_B}{P_{At}}c_B\right),
\end{aligned} \tag{44}$$

In expression (44), the left-hand side represents the difference in the rates of return of the net foreign asset position, which reflects the disparity between the real interest rates of bonds owned abroad (both private and public) and those of domestic bonds (both private and public) held by foreigners. The right-hand side denotes the current account balance. Accordingly, the difference in the rates of return of foreign and domestic assets of a negative net asset position should be compensated by a current account surplus in the steady state.

2.6 Calibration

The values assigned to the parameters of the model use information for Spain (country A) and Germany (country B). We impose some parameters and use the equations of the steady state of the model to calibrate the rest. In this way, we are able to reproduce relevant observable economic facts of the two countries. Table 1 reflects the parameters that have been initially set and the sources used, while Table 2 reproduces the calibrated parameters and the targets obtained with the model.

The weight of Spain, ω, has been set according to Eurostat population statistics. The parameter ϑ, the reaction of the risk premium to changes in the ratio of debt-to-GDP, takes a value of 0.09. It comes from an estimation of a 4.5 basis points increase in the risk premium (the difference between interest rates on public debt in Spain and Germany) for

Table 1 Parameters imposed in the model

Parameter	Value	Description	Source
ω	0.35	Weight domestic country	Eurostat
ϑ	0.09	Risk premium reaction to the debt/GDP	European Commission, IMF
Φ	1.5	Inflation parameter Taylor rule	Sauer and Sturm (2007)
ρ	0.8	Persistence interest rate Taylor rule	Sauer and Sturm (2007)
η	1.74	Inverse Frisch elasticity A	Casares and Vázquez (2018)
η^*	1.59	Inverse Frisch elasticity B	Casares and Vázquez (2018)
τ	0.5	Share of borrowers A	Gali et al. (2004)
τ^*	0.36	Share of borrowers B	FRED
θ	0.86	Price Calvo probability A	Casares and Vázquez (2018)
θ^*	0.56	Price Calvo probability B	Casares and Vázquez (2018)
ε	3.17	Monopolistic competition elasticity A	Deutsche Bundesbank (2017)
ε^*	3.56	Monopolistic competition elasticity B	Deutsche Bundesbank (2017)
k_{SSA}	0.80	LTV A	(Westig and Bertalot 2017)
k_{SSB}	0.76	LTV B	(Westig and Bertalot 2017)
$\psi_1 = \psi_1^*$	$\frac{1}{6}$	Fiscal reaction to SS deviation	
$\psi_2 = \psi_2^*$	1.1	Fiscal adjustment speed	
$\phi_{Aq}^k = \phi_{Bq}^k$	0	Macropru reaction parameter	
ζ	0.44	Inflation indexation A	Casares and Vázquez (2018))
ζ^*	0.21	Inflation indexation B	Casares and Vázquez (2018)

Table 2 Parameters calibrated from model equations

Parameter	Value	Target	Source
β^{*l}	0.985	$(R-1)*4*100 = 1.9\%$	Bundesbank
β^l	0.985		Assumed
β^{*r}	0.965		Iacoviello (2005)
β^r	0.965		Iacoviello (2005)
χ_A	0.0901	$(R_A-1)*4*100 = 3.2\%$	ECB
χ_A^g	0.0606	$(R_A^g-1)*4*100 = 2.2\%$	BdE
χ_B	0.0375	$\frac{b_B^{*l}}{b^{*r}} = 0.71$	Bundesbank
χ_B^g	0.0413	$\frac{b^*}{y^*} = 8.8$	OECD
χ_A^*	0.0532	$\frac{b}{y} = 12.7$	OECD
χ_A^{*g}	0.0399	$\frac{b_A^g}{b_t^g} = 0.58$	BdE
χ_B^*	0.0454	$(R_b-1)*4*100 = 3.5\%$	ECB
χ_B^{*g}	0.0189	$\frac{b_B^{*g}}{b_t^{*g}} = 0.48$	Bundesbank
$\overline{t_A}$	0.04	$m_A = 0.31$	European Commission
$\overline{t_B}$	0.24	$m_B = 0.37$	European Commission
γ_h	0.6785	$\frac{h}{4y} = 0.65$	BdE
γ_h^*	0.7156	$\frac{h}{4y} = 0.65$	Deloitte (2016)

every one percentage point increase in the debt-to-GDP ratio.[2] To obtain the value of 0.09 we use equation (10). The Taylor rule parameters Φ and ρ fall within the standard range. The first value is consistent with the original parameters proposed by Taylor in 1993. The latter value reflects a realistic degree of interest-rate smoothing (see McCallum 2001). They are also consistent with recent estimations of Taylor rules (see for example, Sauer and Sturm 2007). The inverse of Frisch elasticities, the Calvo price probabilities, and the inflation indexation are the ones estimated for Spain and Germany by Casares and Vázquez (2018). As regards the share of credit constrained consumers, we guess a value of $\tau = 0.5$ for Spain,[3] To set τ^* we correct τ using the relationship between the ratio of household debt-over-GDP in Germany and the same ratio in Spain. The value of the elasticity of substitution among different goods in the German monopolistic sector has been calculated for a price–cost margin of 39%, according to the Deutsche Bundesbank (2017). We assume that the price–cost margin in Spain is halfway between the estimates for Germany and Italy in this study. We use the European Mortgage Federation information (Westig and Bertalot 2017) to set the value for the LTV. Also, we assume the same intensity of reaction between Spain and Germany in the fiscal rule.

Table 2 shows the values of some parameters related to the targeting of different empirical facts. In our model, steady-state interest rates depend on the discount rate and preference parameters for different types of bonds. We chose β^{*l} so that, given the value of the bond preference parameters, the annual interest rate of the German government bond is 1.9%.

Then, we set the impatient discount rate for Spanish lenders at the same figure. Notice that this does not imply that the interest rate of the Spanish public debt is the same as that of Germany, due to the different country preferences for bonds and the existence of a risk premium. We consider that the borrower's discount rate is 2 percentage points lower, in the range of values observed in the literature (see Iacoviello 2005 for a discussion on the calibration of this parameter). There are four preference parameters that affect the demand for bonds in Spain (χ_A, χ_A^g, χ_B, χ_B^g) and the respective ones for Germany (χ_A^*, χ_A^{*g}, χ_B^*, χ_B^{*g}). We calibrate these values so that the steady-state model solution reproduces two sets of facts: (*a*) a set of interest rates (the 1–2 year Spanish government bond, R_A^g, and the mortgage interest rates in Spain and Germany, R_A and R_b); (*b*) a set of debt ratios (the ratio of Spanish public debt in the hands of Spanish households, the ratio of German public debt in German households' hands, the ratio of German private debt in German households' hands, total Spanish debt-over-GDP, and total German debt-over-GDP). The housing preference parameter for Spain has been chosen to obtain the residential stock-over-GDP according to Bank of Spain (BdE). Following Deloitte (2016) report, the number of dwellings per citizen in Spain is roughly the same as in Germany. Thus, we set the value of this parameter for Germany to replicate the same ratio as in Spain. The values for tax-exempt income $\overline{t_A}$ and $\overline{t_b}$ guarantee that the flat rates for Spain and Germany are 0.31 and 0.37, respectively.[4]

As shown in Table 3, we normalize the steady-state per capita aggregate income in Spain to 1, and the German per capita income to 1.3, according to Eurostat. Government consumption represents 18.5% of GDP in Spain and 18.8% in Germany. The targeted long-run public debt-over-GDP is set to an annual 60 and 85 per cent in Germany

[2] See European Commission (2018) and IMF (2017)).

[3] Gali et al. (2004), in a model with only Ricardian and rule-of-thumb consumers, consider that the best guess for the share of non Ricardian consumers is in the neighbourhood of 1/2.

[4] These tax rates are approximated using data on taxation from the European Commission.

Table 3 Normalizations and exogenous variables

Variable	Value	Source
y	1	Normalization
y^*	1.3	Eurostat
$\frac{g}{y}$	0.185	World Bank
$\frac{g^*}{y^*}$	0.188	World Bank
$\frac{b^g}{4y}$	0.85	EU's Stability and Growth Pact corrected
$\frac{b^{*g}}{4y^*}$	0.6	EU's Stability and Growth Pact

and Spain, respectively. The German figure is in accordance with the the EU's Stability and Growth Pact, while the Spanish one is close to the average along the last decade. Table 4 shows the model steady-state values for aggregate demand and bonds.

Table 4 Steady state (in country per capita values on a quarterly basis)

Spain		
y	1.00	GDP in country A
c_A	0.29	Consumption in A of goods produced in A
c_A^*	0.53	Exports of A
b^g	3.40	Government bonds issued in A
τb^r	9.22	Private bonds issued in A
$(1-\tau)b_A^l$	5.09	Private bonds issued in A held by A's lenders
$(1-\tau)b_B^l$	4.46	Private bonds issued in B held by A's lenders
$(1-\tau)b_A^g$	1.97	Public bonds issued in A held by A's lenders
$(1-\tau)b_B^g$	3.01	Public bonds issued in B held by A's lenders
Germany		
y^*	1.30	GDP in country B
c_B^*	0.69	Consumption in country B of goods produced in country B
c_B	0.37	Exports of country B
b^{*g}	3.12	Government bonds issued in B
$\tau^* b^{*r}$	8.28	Public bonds issued in B
$(1-\tau^*)b_A^{*l}$	2.23	Private bonds issued in A held by B's lenders
$(1-\tau^*)b_B^{*l}$	5.88	Private bonds issued in B held by B's lenders
$(1-\tau^*)b_A^{*g}$	0.77	Public bonds issued in A held by B's lenders
$(1-\tau^*)b_B^{*g}$	1.50	Public bonds issued in B held by B's lenders

3 The financial and fiscal impact of macroprudential policy

Macroprudential policy aims at stabilizing financial risks, primarily impacting the level of private debt in the economy. However, it can also have repercussions on public debt and taxation. In this section, we examine the dynamics illustrated by the model following a macroprudential policy that involves a permanent reduction in Spain's loan-to-value (LTV) ratio by two percentage points, from 0.80 to 0.78. Although this intervention is asymmetric, we also investigate its cross-border effects on the German economy. Here, we assume that the macroprudential rule is inactive, with $\phi^k_{Aq} = \phi^k_{Bq} = 0$.

Figures 1, 2, 3 and 4 illustrate the percentage deviations of several macroeconomic variables from their steady state values following the implementation of the policy. The macroprudential policy significantly reduces the level of private debt in the economy (Fig. 1). As a less indebted economy emerges, there is a noticeable decrease in the risk premium (Fig. 2), leading to an increase in the demand for both public and private Spanish bonds. Figure 1 demonstrates the impact on bond holdings, revealing a surge in German holdings of Spanish government bonds while Spanish lenders favor investments in housing over bonds. Figure 3 depicts a diversion in housing demand from borrowers, who face stricter

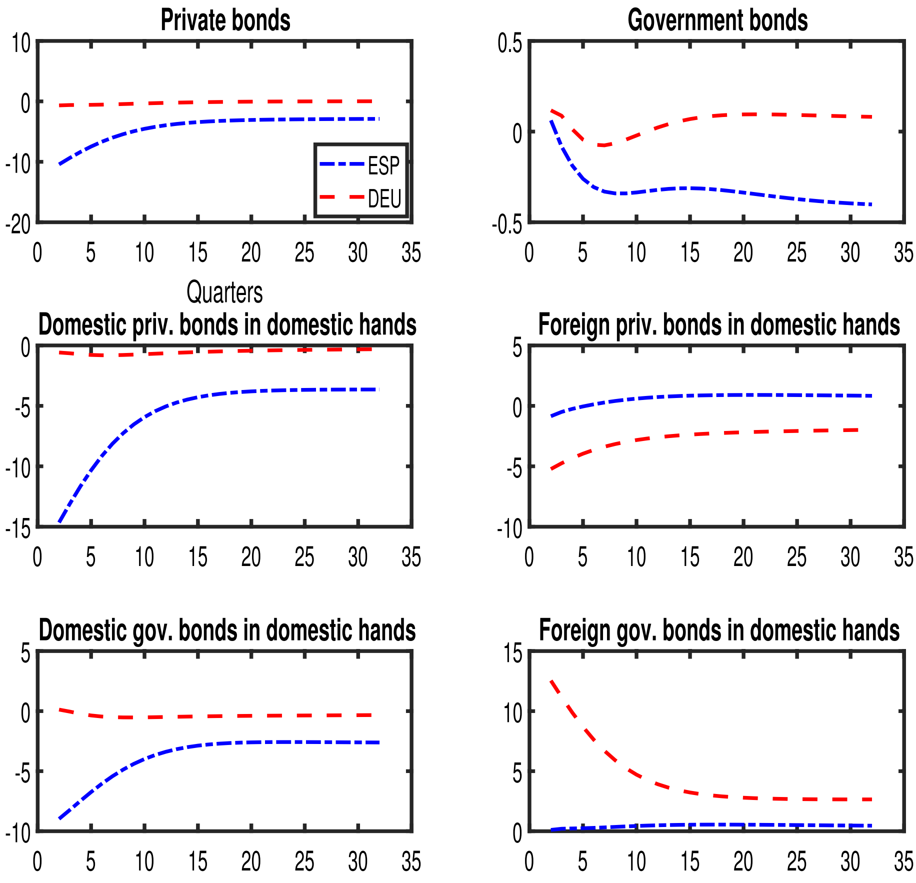

Fig. 1 Macroprudential policy in Spain: bonds

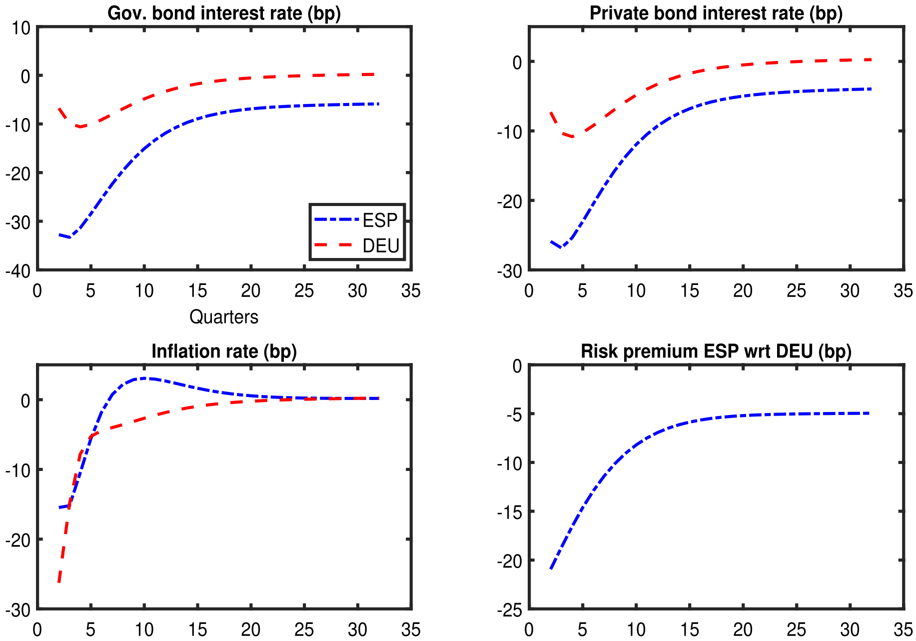

Fig. 2 Macroprudential policy in Spain: interest rates

collateral constraints, to lenders, resulting in a shift in the asset portfolios of Spanish lenders towards housing. Notably, this effect is absent in Germany due to the non-tradable nature of houses. The reduction in the supply of Spanish private bonds exerts downward pressure on the equilibrium interest rate of household bonds, as indicated by Eq. (13). Overall, Fig. 2 shows that these changes in the supply and demand for Spanish bonds lead to a decrease of 26 basis points (bp) in the private bond interest rate and 33 bp in the government bond interest rate. Furthermore, Fig. 2 highlights a reduction in the inflation rate in both countries, stemming from the decline in GDP illustrated in Fig. 3, which is a consequence of the macroprudential policy.

The lower inflation rates and weakened economic activity cause an increase in government debt at period t (Fig. 1). The rise in the government-debt-to-GDP ratio is even more pronounced, prompting the fiscal authority to respond by increasing the marginal tax rate in accordance with its fiscal rule. Thus, employing Reis' semantics (Reis 2020), the macroprudential policy intervention leaves a positive fiscal footprint on our model economy. Interestingly, the policy generates significant cross-border effects not only in terms of financial assets, as previously observed, but also on real activity and fiscal outcomes. German GDP experiences a decline almost as severe as that of Spain for five quarters, but unlike Spain, GDP gradually recovers thereafter. The primary reason for this is the notable decrease in German exports (Fig. 3). The escalation in the public-debt-to-GDP ratio compels the German government to raise the tax rate (Fig. 4), a policy that has a relatively greater adverse impact on the income of borrowers compared to lenders.

The tightening of macroprudential policy in Spain prompts tighter fiscal policies in response to higher debt-to-GDP ratios in both countries. Consequently, fiscal policy does not act countercyclically but rather procyclically in this scenario. This result appears to diverge from the standard findings of other papers on topics such as monetary/fiscal

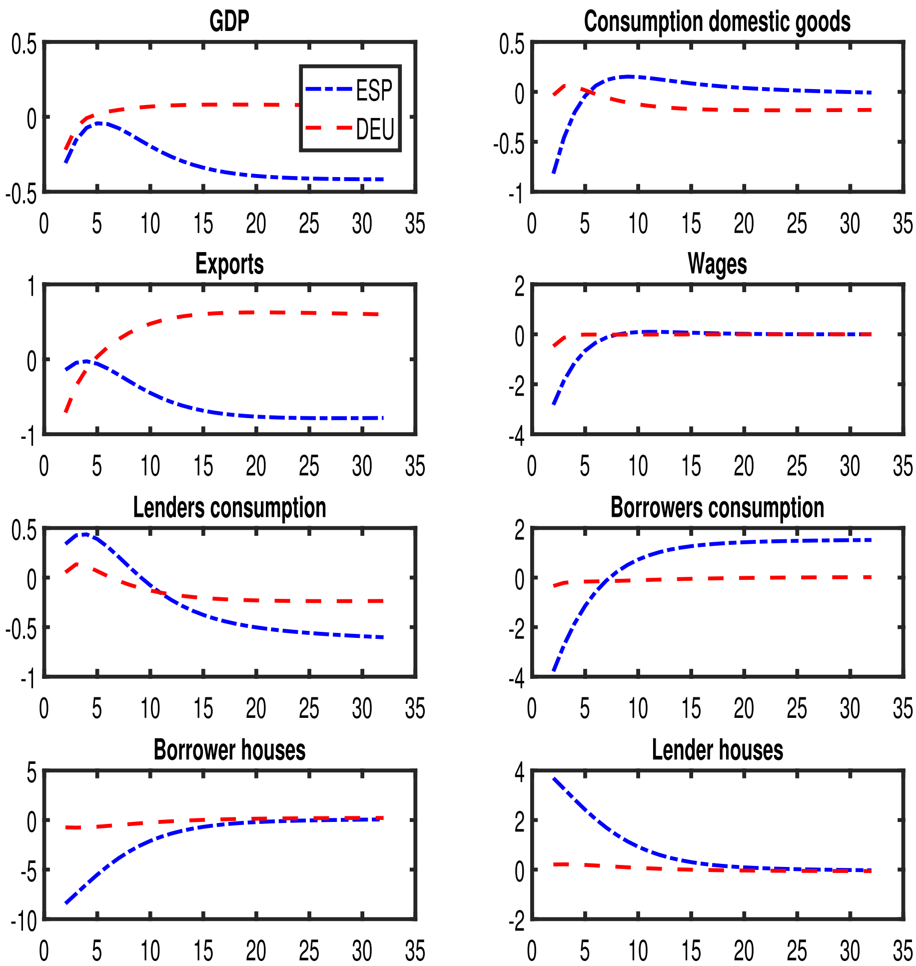

Fig. 3 Macroprudential policy in Spain: real activity

policy coordination. Typically, these papers suggest that a contractionary shock from one policy may trigger a countercyclical response from the other. Indeed, in our model, when fiscal policy is tightened, resulting in lower output and inflation, there is a monetary countercyclical response characterized by the lowering of interest rates via the Taylor rule.

The fact that utilizing Spanish macroprudential policy to reduce the stock of private debt alters the macroeconomic outcomes of the other country in the monetary union highlights the need for supranational coordination of these policies. Our results indicate that macroeconomic policy in Spain not only has a positive fiscal impact in Spain but also in Germany, thereby imposing an economic and potentially political cost on the neighboring country. If the German government is cognizant of this situation, it could opt to react in two ways. First, it could partially relax borrowing constraints, which in our model involves increasing the LTV. This action would prioritize financial stability over relieving the fiscal burden. Second, it might choose to retaliate against the Spanish government through a

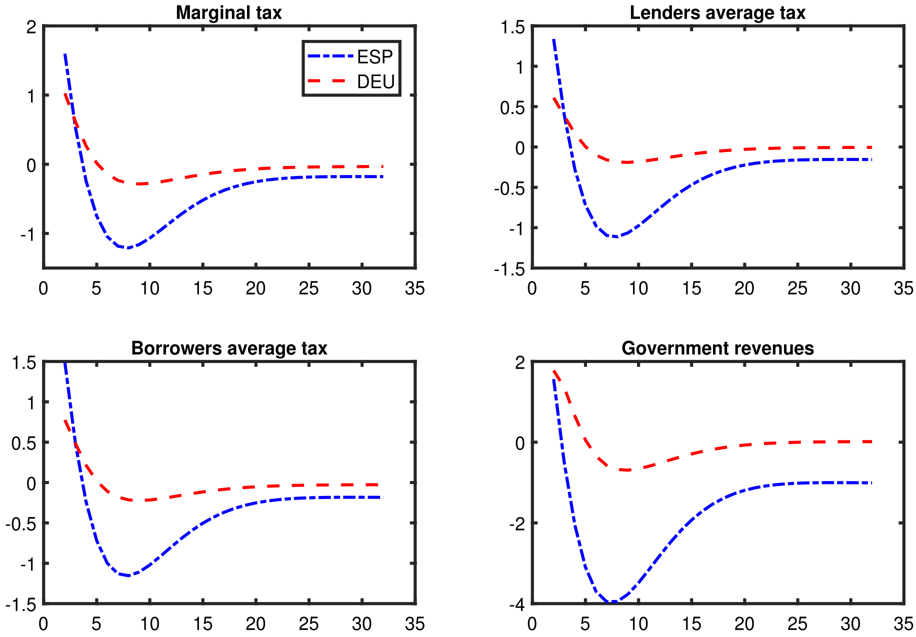

Fig. 4 Macroprudential policy in Spain: taxes

tighter macroprudential policy, akin to a trade war scenario, which would ultimately lead to both economies facing significantly higher tax rates.

4 Discretionary symmetric policies

In this section, we study the possibilities that arise in our model for policy coordination among policymakers in both countries. To start with, we assume that governments in the two countries coordinate their actions in such a way that the direction and intensity in the use of macroprudential and fiscal policy in both countries are the same. We call this a symmetric macroprudential and fiscal policy intervention. Also, we introduce a discretionary monetary policy conducted by the central bank.[5]

The left-hand column of Fig. 5 shows the response after a permanent 2 percentage point drop in LTV in Germany and Spain, which is symmetrically equivalent to the macroprudential policy in Spain studied above. Compared to the one-country policy, the simultaneous intervention of macroprudential authorities in both economies produces a non-linear additional increment in the fiscal footprint of both countries, understood as the increase in the tax rate necessary to accomplish the fiscal rule and stabilize public debt to GDP. This result can be explained by cross spillover effects.

[5] Given our assumption of a symmetric response between countries, our focus is on studying coordination among monetary, fiscal, and macroprudential policies from a positive perspective. Complementary to this approach, Agénor et al. (2021) examine international macroprudential coordination from a normative perspective.

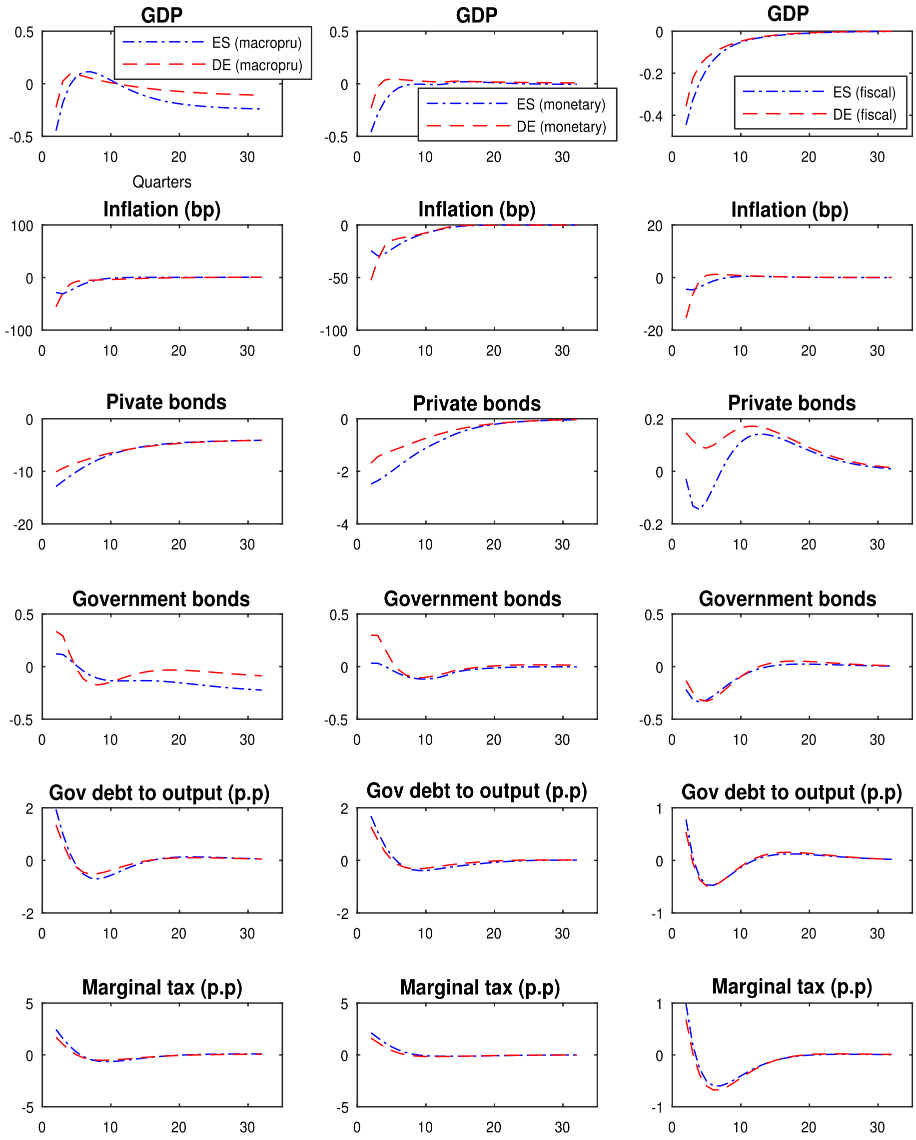

Fig. 5 Symmetric shocks: macroprudential, monetary and fiscal

In the middle column, we illustrate the response of macroeconomic variables to a contractionary monetary policy shock. Specifically, we assume that the central bank adjusts the interest rate to replicate the same impact on Spanish GDP as the macroprudential policy.[6] Compared to the macroprudential policy, the monetary shock generates very similar

[6] In the model, this shock precisely entails a 44 basis point positive surprise in the interest rate lasting for three years.

results for GDP, inflation, and government bonds.[7] It also produces an almost identical fiscal footprint (increase in the tax rate), with the main difference lying in the size of the effects on private bonds, which is more pronounced in the case of a macroprudential symmetric intervention.

In the right column, we depict a contractionary fiscal policy. This policy involves a permanent drop in government spending equivalent to 0.5 percentage points of GDP in both countries. Despite causing a similar drop in GDP, fiscal policy results in a smaller reduction in inflation, a more modest effect on the tax rate, which soon turns negative, and virtually no effect on private debt.

The similarities and differences in the effects among the three policies raise the possibility of utilizing a different policy mix to achieve various combinations of targets. Assuming policymakers pursue four targets, including output, inflation, financial stability, and a political goal of minimizing increases in the tax rate due to rising government debt, there may be strategic adjustments in policy choices. For instance, if macroprudential institutions detect a need for financial correction and lower the LTVs in both countries, this action may lead to lower output, a deviation from inflation rate targets, and higher taxes. However, a simultaneous discretionary expansionary monetary policy by the central bank could potentially mitigate these effects by neutralizing the gaps in output, inflation, and taxes, without undermining the desired countercyclical effect on private debt.

Now, let's consider a scenario where the central bank deems it necessary not only to address financial imbalances but also to reduce the inflation rate. In this case, the central bank may opt for a no-surprise policy, allowing the monetary rule and the macroprudential shock to operate. This approach would replicate the effects observed in the first column. By doing so, the central bank achieves the goal of lowering inflation, while the macroprudential authority succeeds in reducing private debt. However, this comes at the cost of weaker output and higher taxes.

Nevertheless, coordination with governments could lead to improved outcomes. If governments implement expansionary fiscal policies simultaneously with macroprudential measures, it can boost output without compromising the reduction in inflation or imposing additional tax burdens in the short run.

The key takeaway from this discussion is that different policymakers, including macroprudential, fiscal, and monetary authorities, can leverage their discretionary leeway to coordinate actions and enhance macroeconomic outcomes.

5 Policy rules and policy interplay

In all the discussions so far, we have maintained the policy rule parameters at their benchmark values. This implies that the fiscal and monetary policy rules were operational, but the macroprudential rule did not play any role, given that the benchmark values are $\phi^k_{Aq} = \phi^k_{Bq} = 0$. n this section, we relax these assumptions and study how committing to a looser or tighter rule by the different policy institutions can alter the results of discretionary policies. Figure 6 illustrates the results.

[7] The monetary policy dimesnion of macroprudential policy has been emphasized by Monnet and Vari (2023).

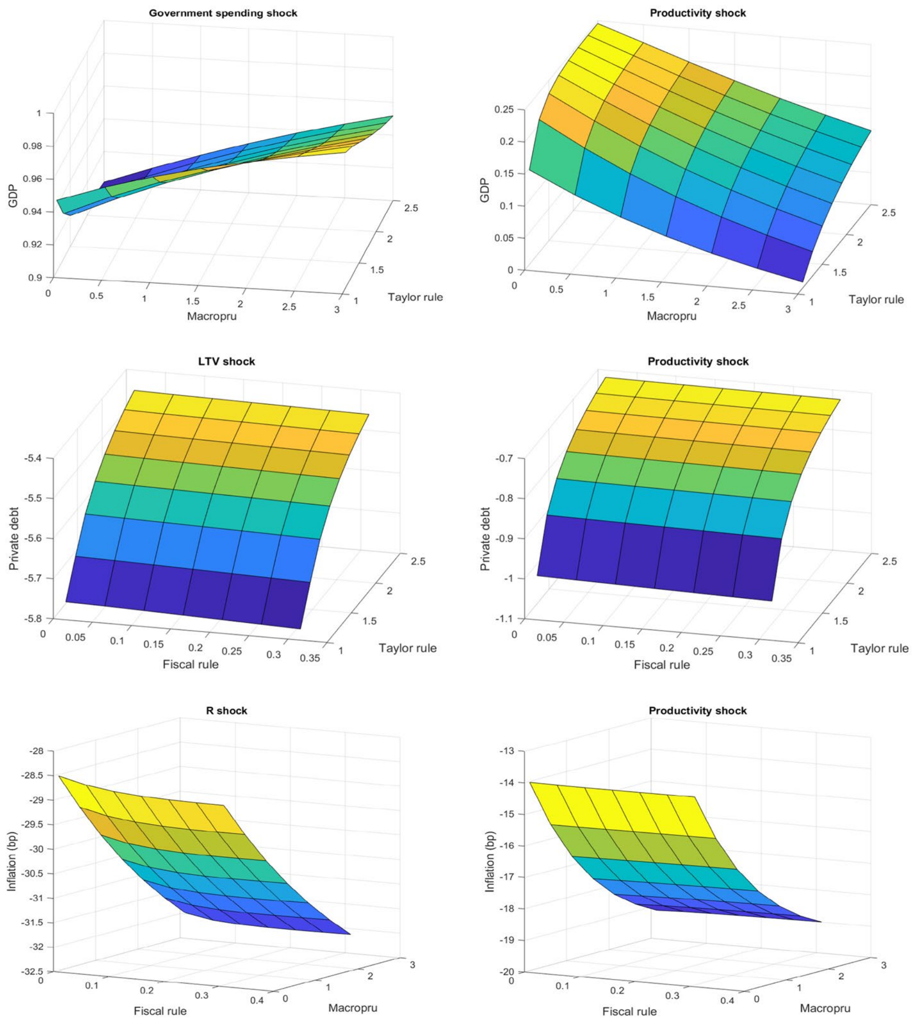

Fig. 6 Policy shocks and policy rules: impact effects

Figure 6 illustrates the impact effects in Spain under different parameterizations of monetary, macroprudential, and fiscal rules. Higher values of the parameters indicate, respectively, a more intense reaction in the interest rate to changes in inflation, a larger movement in the LTV for a given variation in the price of housing, or a greater change in the tax rate following deviations in public debt over GDP from its long-run target. Thus, larger values of Φ, ϕ^k_{Aq}, and ψ_1 are associated with tighter monetary, macroprudential and fiscal rules.

Figure 6 studies the effectiveness of fiscal, macroprudential and monetary discretionary policies to influence their main targets: GDP, private debt, and inflation. More particularly, we analyze the interaction between a given discretionary policy and the policy rules related with the other two policies. In all three cases we compare the results with those observed when the economy experiences a permanent increase in productivity of one percentage point (second column in Fig. 6). Both, discretionary policies and productivity shocks, as well as induced changes in rules, only occur in Spain.

For instance, let's consider the impact of a government consumption policy in Spain (first row and first column in Fig. 6). Here, both monetary and macroprudential rules interact with the effects of this policy. Following a permanent increase in government spending of one percentage point of GDP, there is an uptick in output. The monetary and macroprudential rules play a role in shaping the impact of the policy. Notably, a combination of loose monetary policy and a tight macroprudential rule maximizes the fiscal multiplier. An increase in public spending policy negatively influences housing prices, and when macroprudential policy is tight, the LTV increases by more, impacting positively private debt and leading to a greater increase in borrowers' consumption. Consequently, a tight macroprudential policy amplifies the fiscal multiplier. In our analysis, the multiplier increases by 9 percent compared to the minimum value observed when the macroprudential rule is inactive and the monetary rule is the tightest among those considered. However, the policy combination that maximizes the effect of a fiscal shock is the same as the one that minimizes the impact of a productivity shock on GDP. This suggests a trade-off between the policy mix preferred by fiscal authorities to enhance the effectiveness of their policy and the economic benefits the economy would derive from a technology shock under that combination.

In the subsequent row, we examine the impact of a discretionary macroprudential policy, entailing a 1 percentage point reduction in the Spanish LTV, on private debt. Here, our focus shifts to the interplay with fiscal and monetary policies, as indicated by their respective policy rules. Concerning private debt, the LTV shock exhibits minimal interaction with the fiscal rule and a mild interaction with the monetary rule. Specifically, the efficacy of the policy varies by approximately 5 percent, contingent upon whether the monetary policy is loose (yielding maximum effect) or tight (yielding minimum effect). Interestingly, in this scenario, the preferred policy mix identified by the macroprudential institution aligns with the combination that maximizes the impact on private debt resulting from a technology shock.

Lastly, we assess the efficacy of a 50 basis point monetary surprise aimed at reducing inflation, examining its interaction with fiscal and macroprudential rules. Interestingly, the intensity of the tax rate's response, as measured by the fiscal rule, plays a marginal role in influencing the impact on inflation. Instead, the macroprudential policy emerges as a more significant determinant. In our model, a tighter macroprudential policy may enhance the effectiveness of the monetary surprise in lowering inflation by 13 percent.[8] Notably, this policy alignment also coincides with the most effective approach to leveraging a productivity shock in terms of inflation management.

In summary, a stringent macroprudential rule appears beneficial in attaining the objectives of discretionary fiscal and monetary policies. However, following a productivity shock, a tight macroprudential rule reduces the positive effect on GDP while amplifying

[8] In a different but related dimension, the monetary policy strategy review completed by the ECB in 2021 (ECB 2021) concluded that monetary policy and macroprudential policy are interrelated and should be considered in combination. In a low interest rate/low inflation environment, macroprudential tightening allows monetary policy to remain accommodative for longer. Our results demonstrate that more stringent macroprudential policy would assist the central bank in creating inflation. Additionally, as stated by , macroprudential policy has proven to be helpful during periods of low inflation. The experiments undertaken in Sects. 3 to 5 provide valuable insights into the interaction between both policies. We thank an anonymous referee for bringing this point to our attention.

the negative impact on inflation. Notably, the fiscal rule's influence on modifying outcomes of other policies is marginal at best.

6 Conclusions

We have constructed a two-country general equilibrium model within a monetary union, incorporating both borrowers and lenders in each economy. Public and private borrowers face a downward-sloping bond-specific demand function. By calibrating the model to represent Spain and Germany, exemplars of periphery and core countries within the eurozone, we explore the interactions between macroprudential and fiscal policies.

Following the implementation of a macroprudential policy in Spain, we observe a shift in the asset portfolios of Spanish lenders towards houses from bonds. Additionally, there is a redistribution of Spanish bond holdings from domestic to foreign investors. This policy leads to lower inflation rates and reduced economic activity, resulting in an uptick in government debt. The rise in the government-debt-to-GDP ratio triggers the fiscal authority to respond by increasing the marginal tax rate in accordance with fiscal rules. Concomitantly, German exports decline due to weakened demand from Spain, leading to an aggregate output decrease. The higher public-debt-to-GDP ratio compels the German government to raise the tax rate. Consequently, an asymmetric macroprudential intervention generates a noteworthy positive footprint across the entire monetary union.

A symmetric macroprudential intervention in the monetary union, along with the resulting fiscal footprint, can be replicated, up to the effect on private debt, through a positive shock on interest rates by the European Central Bank. This underscores the importance of coordination between macroprudential and monetary policy. A coordinated European macroprudential and monetary intervention promotes financial stabilization while neutralizing fiscal footprints in European countries and mitigating undesired effects on output and inflation.

Furthermore, we uncover a connection between discretionary fiscal policy and macroprudential policy, as captured by a rule. A negative public spending policy positively influences housing prices, and when macroprudential policy is tight, private debt is more impacted, leading to a greater decline in borrowers' consumption. Consequently, a tight macroprudential policy amplifies the fiscal multiplier. Moreover, a tight macroprudential rule enhances the impact of a monetary surprise on inflation. However, after a permanent productivity shock, a tight macroprudential rule diminishes the positive impact of productivity on GDP and reinforces the negative impact on inflation.

Our study is policy-oriented with robust empirical applications, incorporating fiscal policies and housing market dynamics. Thus, any public policy affecting housing markets will have repercussions on housing values and prices, consequently influencing monetary and macroprudential policies. Additionally, our findings provide valuable insights into addressing asymmetric shocks or disparities in housing markets. For instance, a direct application of the model for a potential extension would be to explore the optimal combination of policies to address supply-side shocks or disparities arising from events like the Covid pandemic impacting Eurozone (EMU) countries differentially.

While the model encompasses both standard and innovative elements crucial to our research inquiry, it remains a simplified abstraction of reality. One notable assumption is the localization of housing markets, wherein borrowers are restricted to purchasing homes within their own country. Labor markets are characterized by wage flexibility, with no provision for unemployment. Interest rates are limited to short-term considerations, with fixed or long-term rates falling beyond the model's scope. The model exclusively incorporates labor taxes, omitting consumption or capital taxes. Additionally, it features a Woodford-type cashless economy governed by an interest-rate rule independent of money supply considerations. Incorporating some of these mechanisms into the model could enhance our understanding of the intricate relationships between macroprudential, fiscal, and monetary policies, and stands as a priority for future research endeavors.

Appendix 1

In this Appendix 1, we show all the equations of the model

National economy households equations

The patient households

$$\gamma_{b_{At}}(\bullet) = \chi_A + \vartheta\left(\frac{b_t^*}{b_t}\frac{y_t}{y_t^*} - 1\right) \tag{45}$$

$$\gamma_{b_{At}}^g(\bullet) = \chi_A^g + \vartheta\left(\frac{b_t^*}{b_t}\frac{y_t}{y_t^*} - 1\right) \tag{46}$$

$$\begin{aligned} & c_{At}^l + \frac{P_{Bt}}{P_{At}}c_{Bt}^l + q_t\left(h_t^l - h_{t-1}^l\right) + b_{At}^l + \frac{P_{Bt}}{P_{At}}b_{Bt}^l + b_{At}^g + \frac{P_{Bt}}{P_{At}}b_{Bt}^g \\ & \leq \left(1 - x_t^l\right)w_t n_t^l + \frac{R_{At-1}}{\pi_{At}}b_{At-1}^l + \frac{P_{Bt}}{P_{At}}\frac{R_{Bt-1}}{\pi_{Bt}}b_{Bt-1}^l \\ & + \frac{R_{At-1}^g}{\pi_{At}}b_{At-1}^g + \frac{P_{Bt}}{P_{At}}\frac{R_{t-1}}{\pi_{Bt}}b_{Bt-1}^g + d_t, \end{aligned} \tag{47}$$

$$t_{At}^l = m_{At}(w_t n_t^l - \overline{t_A}) \tag{48}$$

$$x_t^l = \frac{t_{At}^l}{w_t n_t^l} \tag{49}$$

$$\pi_{At} = \frac{P_{At}}{P_{At-1}} \tag{50}$$

$$c_t^l = c_{At}^l + \frac{P_{Bt}}{P_{At}}c_{Bt}^l \tag{51}$$

$$\lambda_t^l = \frac{\omega}{c_{At}^l} \tag{52}$$

$$\frac{c_{At}^{l}}{c_{Bt}^{l}} = \frac{\omega P_{Bt}}{(1-\omega)P_{At}} \tag{53}$$

$$\frac{\gamma_h}{h_t^l} = \lambda_t^l q_t - \beta E_t\left[\lambda_{t+1}^l q_{t+1}\right] \tag{54}$$

$$w_t = \frac{c_{At}^l}{\omega}\left(n_t^l\right)^{\eta} \tag{55}$$

$$\lambda_t^l = \beta^l E_t\left[\lambda_{t+1}^l \frac{R_{At}}{\pi_{At+1}}\right] + \frac{\chi_A}{b_{At}^l} + \frac{\vartheta}{b_{At}^l}\left(\frac{b_t^*}{b_t}\frac{y_t}{y_t^*} - 1\right) \tag{56}$$

$$\lambda_t^l = \beta^l E_t\left[\lambda_{t+1}^l \frac{R_{Bt}}{\pi_{At+1}}\right] + \frac{P_{At}}{P_{Bt}}\frac{\chi_B}{b_{Bt}^l} \tag{57}$$

$$\lambda_t^l = \beta^l E_t\left[\lambda_{t+1}^l \frac{R_{At}^g}{\pi_{At+1}}\right] + \frac{\chi_A^g}{b_{At}^g} + \frac{\vartheta}{b_{At}^g}\left(\frac{b_t^*}{b_t}\frac{y_t}{y_t^*} - 1\right) \tag{58}$$

$$\lambda_t^l = \beta^l E_t\left[\lambda_{t+1}^l \frac{R_t}{\pi_{At+1}}\right] + \frac{P_{At}}{P_{Bt}}\frac{\chi_B^g}{b_{Bt}^g} \tag{59}$$

$$\phi_t \equiv -\vartheta\left(\frac{b_t^*}{b_t}\frac{y_t}{y_t^*} - 1\right) \tag{60}$$

The impatient households

$$\begin{aligned} & c_{At}^r + \frac{P_{Bt}}{P_{At}}c_{Bt}^r + q_t\left(h_t^r - h_{t-1}^r\right) + \frac{R_{At-1}}{\pi_{At}}b_{t-1}^r \\ & \leq \left(1 - x_t^r\right)w_t n_t^r + b_t^r. \end{aligned} \tag{61}$$

$$t_{At}^r = m_{At}(w_t n_t^r - \overline{t_A}) \tag{62}$$

$$x_t^r = \frac{t_{At}^r}{w_t n_t^r} \tag{63}$$

$$E_t\left[\frac{R_{At}}{\pi_{At+1}}b_t^r\right] \leq E_t\left[k_{At}q_{t+1}h_t^r\right], \tag{64}$$

$$c_t^r = c_{At}^r + \frac{P_{Bt}}{P_{At}} c_{Bt}^r \tag{65}$$

$$\lambda_t^r = \frac{\omega}{c_{At}^r} \tag{66}$$

$$\frac{c_{At}^r}{c_{Bt}^r} = \frac{\omega P_{Bt}}{(1-\omega)P_{At}} \tag{67}$$

$$\frac{\gamma_h}{h_t^r} = q_t \lambda_t^r - E_t\left[\beta^r q_{t+1} \lambda_{t+1}^r + \xi_t k_{At} q_{t+1} \pi_{At+1}\right] \tag{68}$$

$$w_t = \frac{c_{At}^r}{\omega}\left(n_t^r\right)^\eta \tag{69}$$

$$\lambda_t^r = \beta^r E_t\left[\lambda_{t+1}^r \frac{R_{At}}{\pi_{At+1}}\right] + \xi_t R_{At} \tag{70}$$

The foreign country's households

The patient households

$$\gamma_{b_{At}}^*(\bullet) = \chi_A^* + \vartheta\left(\frac{b_t^*}{b_t}\frac{y_t}{y_t^*} - 1\right) \tag{71}$$

$$\gamma_{b_{At}}^{*g}(\bullet) = \chi_A^{*g} + \vartheta\left(\frac{b_t^*}{b_t}\frac{y_t}{y_t^*} - 1\right) \tag{72}$$

$$\begin{aligned} &\frac{P_{At}}{P_{Bt}} c_{At}^{*l} + c_{Bt}^{*l} + q_t^*\left(h_t^{*l} - h_{t-1}^{*l}\right) + \frac{P_{At}}{P_{Bt}} b_{At}^{*l} + b_{Bt}^{*l} + \frac{P_{At}}{P_{Bt}} b_{At}^{*g} + b_{Bt}^{*g} \\ &\le \left(1 - x_t^{*l}\right) w_t^* n_t^{*l} + \frac{P_{At}}{P_{Bt}} \frac{R_{At-1}}{\pi_{At}} b_{At-1}^{*l} + \frac{R_{Bt-1}}{\pi_{Bt}} b_{Bt-1}^{*l} \\ &+ \frac{P_{At}}{P_{Bt}} \frac{R_{At-1}^g}{\pi_{At}} b_{At-1}^{*g} + \frac{R_{t-1}}{\pi_{Bt}} b_{Bt-1}^{*g} + d_t^* \end{aligned} \tag{73}$$

$$t_{Bt}^l = m_{Bt}(w_t^* n_t^{*l} - \overline{t_B}) \tag{74}$$

$$x_t^{*l} = \frac{t_{Bt}^l}{w_t^* n_t^{*l}} \tag{75}$$

$$c_t^{*l} = \frac{P_{At}}{P_{Bt}} c_{At}^{*l} + c_{Bt}^{*l} \tag{76}$$

$$\pi_{Bt} = \frac{P_{Bt}}{P_{Bt-1}} \tag{77}$$

$$\lambda_t^{*l} = \frac{1-\omega}{c_{Bt}^{*l}} \tag{78}$$

$$\frac{c_{At}^{*l}}{c_{Bt}^{*l}} = \frac{\omega}{(1-\omega)} \frac{P_{Bt}}{P_{At}} \tag{79}$$

$$\frac{\gamma_h^*}{h_t^{*l}} = \lambda_t^{*l} q_t^* - \beta^{*l} E_t \left[\lambda_{t+1}^{*l} q_{t+1}^* \right] \tag{80}$$

$$w_t^* = \frac{c_{Bt}^{*l}}{1-\omega} \left(n_t^{*l} \right)^{\eta^*} \tag{81}$$

$$\lambda_t^{*l} = \beta^{*l} E_t \left[\lambda_{t+1}^{*l} \frac{R_{At}}{\pi_{Bt+1}} \right] + \frac{P_{Bt}}{P_{At}} \frac{\chi_A^*}{b_{At}^{*l}} + \frac{\vartheta}{b_{At}^{*l}} \frac{P_{Bt}}{P_{At}} \left(\frac{b_t^*}{b_t} \frac{y_t}{y_t^*} - 1 \right) \tag{82}$$

$$\lambda_t^{*l} = \beta^{*l} E_t \left[\lambda_{t+1}^{*l} \frac{R_{Bt}}{\pi_{Bt+1}} \right] + \frac{\chi_B^*}{b_{Bt}^{*l}} \tag{83}$$

$$\lambda_t^{*l} = \beta^{*l} E_t \left[\lambda_{t+1}^{*l} \frac{R_{At}^g}{\pi_{Bt+1}} \right] + \frac{P_{Bt}}{P_{At}} \frac{\chi_A^{*g}}{b_{At}^{*g}} + \frac{P_{Bt}}{P_{At}} \frac{\vartheta}{b_{At}^{*g}} \left(\frac{b_t^*}{b_t} \frac{y_t}{y_t^*} - 1 \right) \tag{84}$$

$$\lambda_t^{*l} = \beta^{*l} E_t \left[\lambda_{t+1}^{*l} \frac{R_t}{\pi_{Bt+1}} \right] + \frac{\chi_B^{*g}}{b_{Bt}^{*g}} \tag{85}$$

Impatient households

$$\begin{aligned} &\frac{P_{At}}{P_{Bt}} c_{At}^{*r} + c_{Bt}^{*r} + q_t^* \left(h_t^{*r} - h_{t-1}^{*r} \right) + \frac{R_{Bt-1}}{\pi_{Bt}} b_{t-1}^{*r} \\ &= \left(1 - x_t^{*r} \right) w_t^* n_t^{*r} + b_t^{*r} \end{aligned} \tag{86}$$

$$t_{Bt}^r = m_{Bt} (w_t^* n_t^{*r} - \overline{t_B}) \tag{87}$$

$$x_t^{*r} = \frac{t_{Bt}^r}{w_t^* n_t^{*r}} \tag{88}$$

$$E_t\left[\frac{R_{Bt}}{\pi_{Bt+1}}b_t^{*r}\right] \leq E_t\left[k_{Bt}q_{t+1}^{*}h_t^{*r}\right] \tag{89}$$

$$c_t^{*r} = \frac{P_{At}}{P_{Bt}}c_{At}^{*r} + c_{Bt}^{*r} \tag{90}$$

$$\lambda_t^{*r} = \frac{1-\omega}{c_{Bt}^{*r}} \tag{91}$$

$$\frac{c_{At}^{*r}}{c_{Bt}^{*r}} = \frac{\omega P_{Bt}}{(1-\omega)P_{At}} \tag{92}$$

$$\frac{\gamma_h^*}{h_t^{*r}} = q_t^*\lambda_t^{*r} - E_t\left[\beta^{*r}q_{t+1}^*\lambda_{t+1}^{*r} + \xi_t^*k_{Bt}q_{t+1}^*\pi_{Bt+1}\right] \tag{93}$$

$$w_t^* = \frac{c_{Bt}^{*r}}{(1-\omega)}\left(n_t^{*r}\right)^{\eta^*} \tag{94}$$

$$\lambda_t^{*r} = \beta^{*r}E_t\left[\lambda_{t+1}^{*r}\frac{R_{Bt}}{\pi_{Bt+1}}\right] + \xi_t^*R_{Bt} \tag{95}$$

The national firms

$$w_t = mc_t\frac{y_t}{n_t} \tag{96}$$

$$\left(\frac{1-\theta\left(\frac{\pi_{At}}{\pi_{At-1}^{\zeta}}\right)^{\varepsilon-1}}{1-\theta}\right)^{\frac{1}{1-\varepsilon}} = \frac{\varepsilon}{\varepsilon-1}\frac{V_t}{F_t} \tag{97}$$

$$V_t = \lambda_t^l mc_t y_t + E_t(\beta^l\theta)\left(\frac{\pi_{At}^{\zeta}}{\pi_{At+1}}\right)^{-\varepsilon}V_{t+1} \tag{98}$$

$$F_t = \lambda_t^l y_t + E_t(\beta^l\theta)\left(\frac{\pi_{At}^{\zeta}}{\pi_{At+1}}\right)^{1-\varepsilon}F_{t+1} \tag{99}$$

The foreign firms

$$w_t^* = mc_t^* \frac{y_t^*}{n_t^*} \tag{100}$$

$$\left(\frac{1 - \theta \left(\frac{\pi_{Bt}}{\pi_{Bt-1}^{\zeta}} \right)^{\varepsilon^* - 1}}{1 - \theta} \right)^{\frac{1}{1-\varepsilon^*}} = \frac{\varepsilon^*}{\varepsilon^* - 1} \frac{V_t^*}{F_t^*} \tag{101}$$

$$V_t^* = \lambda_t^{*l} mc_t^* y_t^* + E_t(\beta^{*l} \theta^*) \left(\frac{\pi_{Bt}^{\zeta}}{\pi_{Bt+1}} \right)^{-\varepsilon} V_{t+1}^* \tag{102}$$

$$F_t^* = \lambda_t^{*l} y_t^* + E_t(\beta^{*l} \theta^*) \left(\frac{\pi_{Bt}^{\zeta}}{\pi_{Bt+1}} \right)^{1-\varepsilon} F_{t+1}^* \tag{103}$$

Aggregation

$$b_t^r = \frac{(1-\tau)}{\tau} b_{At}^l + \frac{(1-\omega)}{\omega} \frac{(1-\tau^*)}{\tau} b_{At}^{*l}, \tag{104}$$

$$b_t^{*r} = \frac{\omega}{(1-\omega)} \frac{(1-\tau)}{\tau^*} b_{Bt}^l + \frac{(1-\tau^*)}{\tau^*} b_{Bt}^{*l}, \tag{105}$$

$$b_t^g = (1-\tau) b_{At}^g + (1-\tau^*) \frac{(1-\omega)}{\omega} b_{At}^{*g}. \tag{106}$$

$$b_t^{*g} = (1-\tau) \frac{\omega}{(1-\omega)} b_{Bt}^g + (1-\tau^*) b_{Bt}^{*g}, \tag{107}$$

$$b_t = b_t^g + \tau b_t^r \tag{108}$$

$$b_t^* = b_t^{*g} + \tau^* b_t^{*r} \tag{109}$$

$$\tau h_t^r + (1-\tau) h_t^l = h \tag{110}$$

$$\tau^* h_t^{*r} + (1-\tau^*) h_t^{*l} = h^* \tag{111}$$

$$c_{At} = \tau c_{At}^r + (1-\tau) c_{At}^l \tag{112}$$

$$c_{Bt}^{*} = \tau^{*} c_{Bt}^{*r} + (1 - \tau^{*}) c_{Bt}^{*l} \tag{113}$$

$$c_{Bt} = \tau c_{Bt}^{r} + (1 - \tau) c_{Bt}^{l} \tag{114}$$

$$c_{At}^{*} = \tau^{*} c_{At}^{*r} + (1 - \tau^{*}) c_{At}^{*l} \tag{115}$$

$$c_t = \tau c_t^r + (1 - \tau) c_t^l = c_{At} + \frac{P_{Bt}}{P_{At}} c_{Bt} \tag{116}$$

$$c_t^{*} = \tau c_t^{*r} + (1 - \tau) c_t^{*l} = c_{Bt}^{*} + \frac{P_{At}}{P_{Bt}} c_{At}^{*} \tag{117}$$

$$n_t = \tau n_t^r + (1 - \tau) n_t^l \tag{118}$$

$$n_t^{*} = \tau^{*} n_t^{*r} + (1 - \tau^{*}) n_t^{*l} \tag{119}$$

$$t_t = (1 - \tau) t_{At}^{l} + \tau t_{At}^{r} \tag{120}$$

$$t_t^{*} = (1 - \tau^{*}) t_{Bt}^{l} + \tau^{*} t_{Bt}^{r} \tag{121}$$

$$y_t = z_t n_t \tag{122}$$

$$y_t^{*} = z_t^{*} n_t^{*} \tag{123}$$

Fiscal, monetary and macroprudential policies

$$b_t^g = \frac{R_{At-1}^g}{\pi_{At}} b_{t-1}^g + (g_t - t_t) \tag{124}$$

$$b_t^{*g} = \frac{R_{t-1}}{\pi_{Bt}} b_{t-1}^{*g} + (g_t^{*} - t_t^{*}) \tag{125}$$

$$R_t = R_{t-1}^{\rho} \left[\left(\pi_{At}^{\omega} \pi_{Bt}^{1-\omega} \right)^{\Phi} \overline{R} \right]^{1-\rho} \tag{126}$$

$$m_{At} = m_{At-1} + \psi f_t \left(\frac{b_t^g}{y_t} - \overline{\left(\frac{b^g}{y} \right)} \right) \tag{127}$$

$$m_{Bt} = m_{Bt-1} + \psi^* f_t^* \left(\frac{b_t^{*g}}{y_t^*} - \overline{\left(\frac{b^{*g}}{y^*} \right)} \right) \tag{128}$$

$$k_{At} = k_{SSA} \left(\frac{q_t}{\overline{q}} \right)^{-\phi_{Aq}^k} \tag{129}$$

$$k_{Bt} = k_{SSB} \left(\frac{q_t^*}{\overline{q}^*} \right)^{-\phi_{Bq}^k} \tag{130}$$

GDP and balance of payments restriction

$$\begin{aligned}
&(1-\tau)\frac{P_{Bt}}{P_{At}}\left(b_{Bt}^l + b_{Bt}^g\right) + (1-\tau)b_{At}^g - (1-\tau^*)\frac{(1-\omega)}{\omega}b_{At}^{*l} = \\
&\left(\frac{(1-\omega)}{\omega}c_{At}^* - \frac{P_{Bt}}{P_{At}}c_{Bt}\right) + \left(g_t - t_t\right) + \\
&+ (1-\tau)\frac{P_{Bt}}{P_{At}}\left(\frac{R_{Bt-1}}{\pi_{Bt}}b_{Bt-1}^l + \frac{R_{t-1}}{\pi_{Bt}}b_{Bt-1}^g\right) + (1-\tau)\frac{R_{At-1}^g}{\pi_{At}}b_{At-1}^g \\
&- (1-\tau^*)\frac{(1-\omega)}{\omega}\frac{R_{At-1}}{\pi_{At}}b_{At-1}^{*l}.
\end{aligned} \tag{131}$$

$$y_t = c_{At} + \frac{(1-\omega)}{\omega}c_{At}^* + g_t \tag{132}$$

$$(1-\tau)d_t = \left(\frac{1}{mc_t} - 1\right)w_t n_t \tag{133}$$

$$y_t^* = c_{Bt}^* + \frac{\omega}{(1-\omega)}c_{Bt} + g_t^* \tag{134}$$

$$(1-\tau^*)d_t^* = \left(\frac{1}{mc_t^*} - 1\right)w_t^* n_t^* \tag{135}$$

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