Optimal macroprudential and fiscal policy in a monetary union[*,†]

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Abstract

The growing concern about the financial system stability has turned macroprudential policy into a key instrument of the policy mix. Through a two-country model for a monetary union, I evaluate the optimal combinations of macroprudential and fiscal policy in terms of welfare maximization. I find that the advisability to coordinate macroprudential and fiscal policy depends on the kind of shock that drives the business cycle fluctuations. In the event of financial shocks, macroprudential-fiscal coordination at the national level entails the highest welfare improvements. Under supply and demand shocks, the best option regarding welfare, is the scenario where macroprudential and fiscal policies coordinate to stabilize union aggregate variables.

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1 INTRODUCTION

As a consequence of the severe negative impacts stemming from the Great Recession, the health of the banking sector is an issue of current concern. The 2013 Recommendations of the European Systemic Risk Board (ESRB/2013/1) declare that the safeguard of the stability in the financial system is the ultimate objective of macroprudential policy. How to implement such a macroprudential policy is still an open debate among academics as well as policymakers. Thus, the interest in optimal macroprudential policy characterizes much of the literature that followed the 2007 world financial crisis. A positive consequence of the increasing importance given to macroprudential policy is reflected in the ECB Vice-president speech of March 2021 declaring that during the COVID-19 pandemic "The banking sector has managed to support the economy through continued lending(...) compared to past crisis episodes". He explains that one of the reasons have been the lessons learned from the Great Recession, leading to implement a strong macroprudential policy which avoided an excessive deleveraging after the health crisis.

Many argue that, while monetary policy targets price stability, macroprudential measures might pursue financial stability. However, it is the case that a common central bank, through monetary policy, addresses the union-wide stability problems without taking into account each member's national economic interests. Sometimes the union's objectives are in conflict with the goals pursued by the national policies, such as fiscal policy. Therefore, taking monetary policy as given, I shed new light on the interaction between counter-cyclical macroprudential measures and fiscal policy, analyzing the advisability to coordinate their objectives. The non-coordination among policy-makers will imply certain trade-offs that might lead to economic conflicts. For instance, tightening macroprudential policies, by curbing credit, may restrain private investment and thus economic activity. This would generate a fall in the collection of taxes and the consequent fiscal imbalance (see Reis, 2020). By contrast, fiscal austerity measures may reduce private demand and therefore impair firm's sustainability. The result is an increase of financial instability and higher likelihood of a financial crisis. This provides a strong reason for the joint analysis of macroprudential and fiscal policies in this work.

This paper also evaluates who should move first. Is it better that the macroprudential authorities take as given optimal responses of national fiscal authorities? Or should the fiscal authorities take as given othe macroprudential authorities'actions?

The contribution of this analysis is threefold. First, I study the role of optimal policy in a monetary union with financial frictions and proportional taxes. To that aim, I assess the optimal macroprudential and fiscal policies that maximize national and union-wide welfare and conclude what kind of policy-mix is more advisable under different shocks that lead to an economic recession. The relevance for variety of shocks in the analysis is the fact that the recent crisis in the Euro Area have being caused not only by financial shocks (the Great Recession or the Sovereign debt crisis) but also by negative supply and demand shocks (consequence of the COVID pandemic).

Second, I analyze the interaction of optimal macroprudential and fiscal policies in countries of a monetary union, hit by asymmetric shocks. The study in de Blas and Malmierca (2020) shows that, after a credit risk shock, a negative correlation arises between private and public leverage. They call this relation the *private-public debt channel* and implies a trade-off between private and public debt stabilization. The authors find that in order to stabilize the economy, the channel needs to be offset and both variables stabilized at the same time. This motivates the analysis of the combination of optimal fiscal and optimal counter-cyclical macroprudential policy: optimal fiscal policy focuses on public debt stabilization, while optimal macroprudential policy focuses on private debt stabilization. I evaluate this interaction by obtaining the optimal value of the policy parameters in the model. Then, I provide results of the welfare gains or costs that a variety of optimal policy scenarios entail with respect to a baseline scenario, as in Rubio and

Carrasco-Gallego (2014).

Third and last, the research also contributes to the timely debate on whether economies in a monetary union should delegate the macroprudential policies to a supranational authority. Hence, I compare the case of national macroprudential authorities with that of a common macroprudential authority. The former consists of a scenario with national macroprudential rules that react to domestic financial indicators. Supranational macroprudential implementation, by contrast, represents a scenario in which a supranational authority sets a common macroprudential rule for both countries, though it reacts with different degrees of responsiveness to the financial indicator of each of them.

To these aims, I build a two-country model so that one country is the side of the union that receives the shock (hereinafter home country) and the other is the side that indirectly suffers the effects of the shock originated abroad (hereinafter foreign country). Both countries are of equal size. The home country is a net international borrower representing the periphery of the union and the foreign country is a net international lender representing the core. This setting is in line with the Euro Area case because, as explained in Bordo (2014), TARGET liabilities have increased in countries like Greece, Ireland, Portugal, and Spain (GIPS), since 2007, while TARGET claims have increased in countries like Germany.

I introduce macroprudential policy in the model as a variable that monitors the amount of loans to the private sector and reacts to steady state deviations of nominal credit growth. This is consistent with Basel III that states that the broad macroprudential goal is to prevent the financial system from excessive credit growth. More concretely, the macroprudential tool is equivalent to countercyclical capital buffers. These measures imply capital accumulation by banks during "good times", curbing credit to the real economy. During "bad times" that capital is released to provide liquidity to the private sector. According to the 2019 ESRB Review of Macroprudential policy, the macroprudential instruments used most often in 2019 in the European Economic Area (EEA) were the countercyclical capital buffers. Moreover, the ECB Vice-president declared in its speech in March 2021 that countercyclical capital buffers have been key to maintain the banking system health during the COVID-19. The releasable capital bank buffers mitigated the impact of thE health crisis on the Euro Area economy.

The results show that, according to the findings of Quint and Rabanal (2014), optimal policies affect each country's welfare differently. First, following Leeper (1991)'s active/passive definitions, active fiscal policies are usually preferred to maximize welfare. From a welfare perspective, although national macroprudential policy is advisable after financial shocks, in the case of supply and demand shocks, the best option implies delegating macroprudential policy to a supranational authority. The macroprudential-fiscal coordination brings welfare benefits under financial and supply shocks but not under demand shocks.

The paper is organized as follows. In Section 2, I review the existing literature more closely related to this study. Section 3 describes the two-country model used for the analysis of the baseline and optimal policy scenarios. Section 4 contains the equilibrium and market clearing conditions of the model. The calibration is included in Section 5. In Section 6, I explain how the optimal policy analysis is undertaken and display the results. Section 7 concludes.

2 RELATED LITERATURE

This research contributes to the existing literature that analyzes the optimal policy mix in a monetary union, specifically the welfare implications of the coordination of macroprudential and fiscal policies.

One novelty of this paper is the analysis of the optimal fiscal and macroprudential policy interaction in a monetary union, taking monetary policy as given. I follow Schmitt-

Grohé and Uribe (2004) to solve the model using a second order approximation of the equilibrium equations and measure welfare as the conditional expectation of lifetime utility. Like them, I then compare this measure by calculating the welfare costs of different optimal fiscal-macroprudential regimes. Quint and Rabanal (2014), Rubio and Carrasco-Gallego (2016) or Cantore et al. (2017) are other examples of this methodology.

There is an extensive number of papers highlighting the need to maintain price stability through optimal monetary policy (Galí and Monacelli, 2005 or Ferrero, 2005). For this reason, I include a Taylor rule that reacts to changes in inflation and then evaluate, given that common monetary strategy, the optimal alternative measures of the policy mix. In the Euro Area, during the post crisis, the interest rate remained at the zero lower bound for a long period. Nevertheless, the European Central Bank induced price stability using other unconventional monetary policy instruments. However, I model active monetary policy (based on Leeper, 1991) with a Taylor rule as modeling non-conventional monetary policies lies beyond the scope of this paper.

Leith and Wren-Lewis (2006) also apply Leeper's definitions of active and passive policies to a two-country model for a monetary union. According to them, to attain a determinate equilibrium when monetary policy is active, i.e inflation targeting, each economy of the union needs to stabilize its public debt through passive fiscal policy. This provides a rationale for the Stability and Growth Pact of the EMU, while the European Central Bank seeks for inflation stabilization throughout the union. Thus, in this analysis, as monetary policy is active, national fiscal policies must be passive.

Galí and Monacelli (2005), Ferrero (2005) or, more recently, Gomis-Porqueras and Zhang (2019) are some examples of the optimal monetary and fiscal policy mix analysis in a monetary union. But there is also an extensive literature on the optimal macroprudential-monetary policy coordination both for closed economies (Farhi and Werning, 2016 or Freixas and Pérez-Reyna, 2021 among others) and for open economies (see, for instance, Quint and Rabanal, 2014 or Basu et al., 2020). Angelini, Neri and Panetta (2012) propose a monetary policy that cooperates with macroprudential policy sharing broader objectives other than just price stability. Their results show that macroprudential policy brings very modest benefits in terms of macroeconomic stability after supply shocks, while it becomes key under financial shocks. Kannan, Rabanal and Scott (2012) stress that when macroprudential policies complement monetary policy reacting to financial shocks, a less aggressive response of the latter is required. But they find no role for macroprudential policy under technology shocks. In line with them, I conclude that the source of the economic fluctuation is crucial for policymakers to take decisions on optimal macroprudential policy.

Rubio and Carrasco-Gallego (2016) build a two-country model and also take monetary policy as given to focus on the optimal analysis of macroprudential policy and its coordination with the latter. They state that, although macroprudential policy coordination achieves the highest welfare gains, all countries also benefit from the implementation of non-coordinated macroprudential policy with respect to a no-macroprudential world. Lambertini, Mendicino and Punzi (2013) find larger stabilization benefits when macroprudential policies, rather than monetary measures, stabilize the financial sector. I share their belief that there is a need to complement monetary policy with macroprudential policy. Nevertheless, I also find optimal fiscal measures essential for the policy mix.

To finish with the review of the monetary-macroprudential interaction literature, Quint and Rabanal (2014), in a two-country model with financial frictions for a monetary union, observe that an anti-inflationary monetary policy cannot contain the accelerator effects of the economy. They find that macroprudential policy delivers economic stability and reduces the accelerator effects, requiring a smaller response of interest rates. As opposed to them, I also assess the optimal fiscal policy, which plays an important role in this model as proportional taxes and the private-public debt channel (de Blas and Malmierca, 2020) contribute to the propagation of shocks.

Regarding the macroprudential authority, Dehmej and Gambacorta (2017) compare national macroprudential policies versus a supranational macroprudential policy in a monetary union. They state that supranational macroprudential policy ignores asymmetric shocks so national macroprudential measures are more effective. My results confirm that supranational macroprudential policy usually brings lower welfare than national macroprudential policy, in the event of financial shocks. But as opposed to them, I find that in the event of supply or demand shocks, a supranational macroprudential policy implies higher welfare gains or lower welfare costs than a national one. Rubio (2014) also compares a centralized macroprudential policy against a decentralized macroprudential policy, in the context of a heterogeneous monetary union. The empirical work of Poutineau and Vermandel (2017) also finds evidence on the higher welfare gains brought to the European Monetary Union by a country-specific macroprudential policy with respect to a union-wide measure. Unlike these papers, I allow the supranational macroprudential policy to target the financial indicators of each country with different intensities. Although the results do not change significantly, I find this design of the supranational macroprudential policy more appropriate for the optimal analysis framework as it takes spillovers between countries into account.

The basic modeling framework is an open economy version of the Fernández-Villaverde (2010a) new Keynesian model, with financial frictions as in Bernanke, Gertler and Gilchrist (1999), proportional taxes and a government spending rule. The model differs from the one in Fernández-Villaverde (2010a) in the open economy dimension and the introduction of macroprudential instruments. In particular, this paper lays out a two-country model for a monetary union with an international goods market and incomplete international financial markets, in line with Quint and Rabanal (2014). But unlike theirs, the financial accelerator mechanism of this model is based on Bernanke, Gertler and Gilchrist (1999), while Quint and Rabanal (2014) abstract from asymmetric information. Asymmetric information makes financial intermediaries pay an auditing cost to verify that borrowers do not lie about their return, implying a direct loss in aggregate national output. In line with this, there is a large literature studying financial frictions and crisis in open economy micro-founded models (Neumeyer and Perri (2005), Bianchi and Mendoza (2018), Benigno et al. (2013), Bassanin, Faia and Patella (2021), among others). But the novelty of this work is the study of the effect on welfare not only of macroprudential policy but also of fiscal measures, in an open economy framework with both domestic and international financial frictions.

The macroprudential instrument of the model is in line with the one proposed by Quint and Rabanal (2014) because it controls the amount of loans in the economy. Based on Basel III statement "national authorities should monitor credit growth" which is "an indicator that signals a build-up of system-wide risk", I make macroprudential instruments react to the nominal credit growth as the financial indicator. Following the ECB Vice-president speech of March 2021, about how important has been the release of countercyclical capital buffers to face the consequences of the COVID-19 pandemic, the macroprudential tool in this paper is equivalent to countercyclical capital buffers.

Finally, there is a significantly scarce literature on the interaction between macroprudential and fiscal policies, to which this work specially contributes. Alpanda and Zubairy (2017) build a DSGE model to compare the effectiveness of monetary, fiscal and macroprudential policy in reducing house indebtedness. Claessens (2014) comments on the need for macroprudential and fiscal authorities to coordinate because he states that some tax policies can contribute to systemic risk by encouraging private leverage. Estrada and Saurina (2016) argue that fiscal policy can contribute to financial stability by strengthening the incentives to capital financing and can also help to stabilize the business cycle when used counter-cyclically. They find that fiscal policy cannot face the fluctuations of the business cycle by itself. Reis (2020), explains that macroprudential policy, through its effects on real activity, might be responsible for a lower collection of taxes and thus potential fiscal crisis. I also find that fiscal and macroprudential policies need to cooperate, given that, in a currency area, monetary policy cannot be used for national purposes.

3 THE MODEL

I consider a two-country economy for a monetary union with financial frictions, as in Bernanke, Gertler and Gilchrist (1999), an international financial market and a market for consumption goods that are internationally traded. The model that follows closely the economy model of Malmierca (2021). Capital and labor are non-mobile across the two countries. The home country is of size n and the foreign country of size $1-n$. Each economy is composed of households, intermediate good producers, final good producers, entrepreneurs, capital goods producers and domestic financial intermediaries. There is a single monetary authority for the currency union, while fiscal authorities are national. Macroprudential authorities are either national or supranational depending on the scenario being analyzed. To model the international financial market, in line with Quint and Rabanal (2014), this model includes international financial intermediaries that connect the domestic financial intermediaries of both countries. In what follows, variables and parameters for the foreign country are denoted with superscript $*$.

3.1 Households

There is a continuum of households with infinite life. Households consume, work and save. The representative household maximizes its utility function, choosing total consumption, c_t, of foreign or domestic goods, time devoted to work, l_t, and financial assets that can be either deposits, a_t, or government bonds, d_t, both in positive amounts.

The individual's utility function is given by

$$E_t \sum_{t=0}^{\infty} \beta^t e^{\phi_t} \left[\log\left(c_t - hc_{t-1}\right) - \psi \frac{l_t^{1+\vartheta}}{1+\vartheta} \right], \tag{1}$$

where $\beta \in (0,1)$ is the discount factor; $h \geq 0$ reflects the degree of habit persistence; $\psi > 0$ denotes the magnitude of the labor disutility relative to consumption utility; and $\vartheta > 0$ is the inverse of the Frisch elasticity of labor supply. Variable ϕ_t represents an intertemporal preference shock with law of motion

$$\phi_t = \rho_d \phi_{t-1} + \sigma_\phi \varepsilon_{\phi,t} \text{ where } 0 < \rho_d < 1 \text{ and } \varepsilon_{\phi,t} \backsim N(0,1). \tag{2}$$

Parameter ρ_ϕ is the persistence coefficient and σ_ϕ the volatility of the preference shock.

The representative household makes decisions subject to the following budget constraint:

$$\begin{aligned}(1+\tau_c)\, c_t + \frac{a_t}{p_t} + \frac{d_t}{p_t} = (1-\tau_l)\, w_t l_t + \left[1 + (1-\tau_R)\left(R_{t-1} - 1\right)\right] \frac{a_{t-1}}{p_t} \\ + R_{t-1}^d \frac{d_{t-1}}{p_t} + T_t + F_t + tre_t. \end{aligned} \tag{3}$$

The left hand side of equation (3) represents the household's expenditures in real terms. The right hand side describes the sources of income to the household: labor income, $w_t l_t$, where w_t is the real wage; interests on last period investment on deposits, $R_{t-1} a_{t-1}$ and on public assets, $R_{t-1}^d d_{t-1}$; and net transfers that households receive from the government, T_t. The model includes proportional taxes on real consumption, τ_c, on labor income, τ_l and on net returns on deposits, τ_R. Returns on sovereign debt are not taxed because, as Fernández-Villaverde (2010) says, otherwise the government would have to pay a higher interest rate on public debt to compensate for the lower net return that households would receive due to the tax, thus the effect would be the same. Dividends are paid by firms to households, F_t; and tre_t is a net transfer that households receive from entrepreneurs, defined as follows:

$$tre_t = (1 - \gamma^e)\, n_t - w^e, \tag{4}$$

where $\gamma^e = \frac{1}{1+e^{-\bar{\gamma}^e}}$ is the rate of entrepreneurs that survives from one period to the next one. Then the net wealth of the dead entrepreneurs, $\left(1 - \frac{1}{1+e^{-\bar{\gamma}^e}}\right) n_t$, is paid back to households and these transfer w^e to incoming entrepreneurs. This constitutes the initial real net wealth of the new entrepreneurs.

The first order conditions obtained from the representative household's problem are

$$e^{\phi_t} \frac{1}{c_t - hc_{t-1}} - \beta E_t \frac{h}{c_{t+1} - hc_t} = \lambda_t \left(1 + \tau_c\right), \tag{5}$$

$$\lambda_t = \beta E_t \lambda_{t+1} \frac{\left[1 + \left(1 - \tau_R\right)\left(R_t - 1\right)\right]}{\Pi_{t+1}}, \tag{6}$$

$$\lambda_t = \beta E_t \lambda_{t+1} \frac{R_t^d}{\Pi_{t+1}}, \tag{7}$$

$$e^{\phi_t} \psi l_t^{\vartheta} = \left(1 - \tau_l\right) w_t \lambda_t, \tag{8}$$

where λ_t is the Lagrange multiplier that represents the marginal value of wealth of households.

Foreign households also maximize lifetime utility subject to their corresponding budget constraint.

As this model has an international goods market, domestic goods and foreign goods in the form of imports compose consumption by domestic households. The domestic consumption index follows the form:

$$c_t = \left[(1-\varphi)^{\frac{1}{\zeta}} \left(c_{H,t}\right)^{\frac{\zeta-1}{\zeta}} + \varphi^{\frac{1}{\zeta}} \left(c_{F,t}\right)^{\frac{\zeta-1}{\zeta}}\right]^{\frac{\zeta}{\zeta-1}}, \tag{9}$$

where $c_{H,t}$ is the consumption of domestic goods and $c_{F,t}$ is the amount of imports. The parameter $\varphi \in [0,1]$ is a measure of the degree of openness and therefore $1-\varphi$ represents the home bias in consumption. The degree of substitutability between domestic and foreign goods is given by $\zeta > 0$. Total consumption expenditures are given by

$$p_t c_t = p_{H,t} c_{H,t} + p_{F,t} c_{F,t}, \tag{10}$$

the price of domestic goods, $p_{H,t}$, and the price of foreign goods, $p_{F,t}$ compose the home consumer price index, p_t. For simplicity, I assume that the law of one price holds so the prices of the goods produced at the foreign country are the same across countries and so are the prices of the goods produced at the home country. That is, $p_{H,t} = p^*_{H,t}$ and $p_{F,t} = p^*_{F,t}$. As this model represents a monetary union all prices are expressed in the same monetary units.

Households choose their allocations between home and foreign goods maximizing the consumption index subject to total expenditures.

To express the degree of competitiveness of one country with respect to the other, the variable terms of trade, t_t, relates the price of the domestically produced goods to the price of the goods produced in the foreign country. An increase in t_t implies that home country goods are more competitive than foreign country goods and a reduction of t_t means that the foreign country increases its competitiveness with respect to the home country,

$$t_t = \frac{p_{F,t}}{p_{H,t}}. \tag{11}$$

3.2 Intermediate goods producers

These agents produce differentiated goods that are then sold in a monopolistically competitive market to final good producers, who use them in their production process. Each intermediate good producer, i, chooses labor, l_{it}, and capital, k_{it-1}, as factors of production and they create their output, y_{it}, through the following constant returns to scale Cobb-Douglas production function:

$$y_{it} = e^{z_t} k_{it-1}^{\alpha} l_{it}^{1-\alpha}, \tag{12}$$

where $0 \leq \alpha \leq 1$ is the capital share of the intermediate production function.

Technology follows an exogenous AR(1) process $z_t = \rho_z z_{t-1} + \sigma_z \varepsilon_{z,t}$ where $0 < \rho_z < 1$ and $\varepsilon_{z,t} \backsim N(0,1)$, being ρ_z the persistence coefficient and σ_z the volatility of the technology shock.

Labor is hired from households in exchange for real wages w_t. Capital is rented from entrepreneurs at a real interest rate r_t. Cost minimization implies

$$k_{it-1} = \frac{\alpha}{1-\alpha} \frac{w_t}{r_t} l_{it} \frac{p_t}{p_{H,t}}. \tag{13}$$

These firms reset their prices through a Calvo pricing mechanism. Each period, a fraction $1-\theta$ of producers can change their price, while a fraction θ has to keep the previous period's price which is then indexed to past inflation.

Firms resetting their price in period t maximize the following expression: The expression represents the discounted sum of the difference between the optimizing firm's revenues and its marginal cost, that is, the discounted profits.

$$E_t \sum_{\tau=0}^{\infty} (\beta\theta)^{\tau} \frac{\lambda_{t+\tau}}{\lambda_t} \left[\left(\prod_{s=1}^{\tau} \frac{\Pi_{H,t+s-1}^{\chi}}{\Pi_{H,t+s}} \frac{p_{H,it}}{p_{H,t}} - mc_{t+\tau} \right) y_{it+\tau} \right], \tag{14}$$

subject to a sequence of demand functions

$$y_{it+\tau} = \left(\prod_{s=1}^{\tau} \frac{\Pi_{H,t+s-1}^{\chi}}{\Pi_{H,t+s}} \frac{p_{H,it}}{p_{H,t}} \right)^{-\varepsilon} y_{t+\tau}. \tag{15}$$

In the expressions above, $\frac{\lambda_{t+\tau}}{\lambda_t}$ is the stochastic discount factor, taken as given by the monopolistically competitive firm; mc_t denotes the marginal cost of the intermediate good producer; $p_{H,it}$ is the price set in period t by the domestic intermediate firm i; $p_{H,t}$ is the aggregate domestic price level; $\Pi_{H,t}$ denotes domestic inflation and therefore $\frac{\Pi_{H,t+s-1}^{\chi}}{\Pi_{H,t+s}}$ represents the degree of indexation of prices to past inflation; $y_{it+\tau}$ denotes output in period $t+\tau$ for a firm that last reset its price in period t; $y_{t+\tau}$ is the aggregate level of output in time $t+\tau$ and $\varepsilon \geq 1$ is the elasticity of substitution across goods. Let the domestic reset price relative to the domestic price level be $\bar{\Pi}_{H,t} = \frac{\bar{p}_{H,t}}{p_{H,t}}$.

The first order conditions for these intermediate firms are: Since all intermediate good producers face the same prices and because of market clearing, subscript i can be removed from the previous expression, meaning that all the monopolistically competitive producers choose the same ratio for the production factors they use $\frac{k_{it-1}}{l_{it}}$, so that capital and labor will be expressed in aggregate levels.

$$\frac{k_{t-1}}{l_t} = \frac{\alpha}{1-\alpha} \frac{w_t}{r_t} \frac{p_t}{p_{H,t}}, \tag{16}$$

$$mc_t = \left(\frac{1}{1-\alpha} \right)^{1-\alpha} \left(\frac{1}{\alpha} \right)^{\alpha} \frac{w_t^{1-\alpha} r_t^{\alpha}}{e^{z_t}} \left(\frac{p_t}{p_{H,t}} \right)^{1-\alpha}, \tag{17}$$

$$\varepsilon f_t^1 = (\varepsilon - 1) f_t^2, \tag{18}$$

where

$$f_t^1 = \lambda_t mc_t y_t + \beta\theta E_t \left(\frac{\Pi_{H,t}^{\chi}}{\Pi_{H,t+1}}\right)^{-\varepsilon} f_{t+1}^1, \tag{19}$$

and

$$f_t^2 = \lambda_t \bar{\Pi}_{H,t} y_t + \beta\theta E_t \left(\frac{\Pi_{H,t}^{\chi}}{\Pi_{H,t+1}}\right)^{1-\varepsilon} f_{t+1}^2 \left(\frac{\bar{\Pi}_{H,t}}{\bar{\Pi}_{H,t+1}}\right). \tag{20}$$

where, following Fernández Villaverde (2010), f_t^1 and f_t^2 are two auxiliary variables.

Taking into account the Calvo's pricing mechanism, the aggregate price index can be expressed as follows:

$$1 = \theta \left(\frac{\Pi_{H,t-1}^{\chi}}{\Pi_{H,t}}\right)^{1-\varepsilon} + (1-\theta)\,\bar{\Pi}_{H,t}^{(1-\varepsilon)}. \tag{21}$$

3.3 Final goods producers

Final goods producers buy intermediate goods from intermediate goods producers and combine them to obtain the homogeneous final good according to the following Dixit-Stiglitz technology function:

$$y_t = \left(\int_0^1 y_{it}^{\frac{\varepsilon-1}{\varepsilon}} di\right)^{\frac{\varepsilon}{\varepsilon-1}}, \tag{22}$$

where y_t is the aggregate demand of the economy, and $\varepsilon > 1$ is the elasticity of substitution across goods. The final good is sold to households, in the form of private consumption, or to the government, in the form of public consumption, in a perfectly competitive market. These firms maximize profits taking both the price of the intermediate good $p_{H,it}$ and the price of the final good $p_{H,t}$ as given. The domestic price level is given by

$$p_{H,t} = \left(\int_0^1 p_{H,it}^{1-\varepsilon} di\right)^{\frac{1}{1-\varepsilon}}. \tag{23}$$

3.4 Capital goods producers

These agents operate in a perfectly competitive market and create new capital, x_{t+1}, using investment, i_t, and installed capital, x_t, via the following production function:

$$x_{t+1} = x_t + \left(1 - S\left[\frac{i_t}{i_{t-1}}\right]\right) i_t, \tag{24}$$

where $S\left[\frac{i_t}{i_{t-1}}\right]$ denotes adjustment costs, such that $S'[\cdot] > 0; S''[\cdot] > 0; S[1] = 0$; and $S'[1] = 0$. Installed capital is previously purchased from entrepreneurs. Let q_t denote the relative price of capital, then discounted profits are given by

$$E_0 \sum_{t=0}^{\infty} \beta^t \frac{\lambda_t}{\lambda_0} \left[q_t \left(1 - S\left[\frac{i_t}{i_{t-1}}\right]\right) i_t - i_t\right]. \tag{25}$$

Market clearing implies that $x_t = (1-\delta)\, k_{t-1}$, where $\delta \in [0,1]$ is the capital depreciation rate.

The first order condition is the following:

$$q_t \left(1 - S\left[\frac{i_t}{i_{t-1}}\right] - S'\left[\frac{i_t}{i_{t-1}}\right] \frac{i_t}{i_{t-1}}\right) + \beta E_t \frac{\lambda_{t+1}}{\lambda_t} q_{t+1} S'\left[\frac{i_{t+1}}{i_t}\right] \left[\frac{i_{t+1}}{i_t}\right]^2 = 1. \tag{26}$$

The law of motion of capital is given by

$$k_t = (1-\delta)k_{t-1} + \left(1 - S\left[\frac{i_t}{i_{t-1}}\right]\right) i_t. \tag{27}$$

3.5 Entrepreneurs

Entrepreneurs are in charge of transforming installed capital, x_t, into inputs for use by intermediate goods producers, k_{t-1}. Each period, entrepreneurs buy new capital, k_t, from capital goods producers at a price q_t, to undertake their investment.

Entrepreneurs use both internal and external funds for the purchase of the newly installed capital, $q_t k_t$. Internal funds are composed of the end-of-period net worth (or equity of the entrepreneurs), n_t; while external funds consist of loans (or liabilities of the entrepreneurs) borrowed from financial intermediaries, b_t. Therefore the amount they borrow is given by

$$\frac{b_t}{p_t} = q_t k_t \frac{p_{H,t}}{p_t} - n_t. \tag{28}$$

Notice that this expression means that the contract is set in nominal terms, what implies that the debt deflation channel may affect the entrepreneurs' networth.

Their technology is affected by an idiosyncratic shock, ω_{t+1}, which is lognormally distributed with cumulative distribution $F(\omega, \sigma_{\omega,t})$ with parameters $\mu_{\omega,t}$ and $\sigma_{\omega,t}$. I assume that $E_t \omega_{t+1} = 1$ for all t. The dispersion, $\sigma_{\omega,t}$, represents the credit risk of the model and is assumed to follow:

$$\frac{\sigma_{\omega,t}}{\sigma_\omega} = \left(\frac{\sigma_{\omega,t-1}}{\sigma_\omega}\right)^{\rho_{\sigma_\omega}} \exp\left(\eta_{\sigma_\omega \varepsilon_{\sigma_\omega,t}}\right) \text{ where } \varepsilon_{\sigma_\omega,t} \backsim N(0,1). \tag{29}$$

Parameter $\rho_{\sigma_\omega} \in [0,1]$ is the persistence coefficient and η_{σ_ω} is the volatility of the shock, revealed at the end of the period, just before the investment decisions for $t+1$ are taken. This credit risk may arise from household overborrowing or from risk-taking in financial markets.

Let r_{t+1} be the price that the entrepreneur charges to the intermediate good producer per unit of capital rented, and let $q_{t+1}(1-\delta)$ be the cost that the capital good producer assumes for the repurchase of the old non-depreciated capital, paid to the entrepreneur at the end of the period. The ex-post average return of the entrepreneur per unit of investment between t and $t+1$, R^k_{t+1}, can be defined as

$$R^k_{t+1} = \Pi_{H,t+1} \frac{r_{t+1} + q_{t+1}(1-\delta)}{q_t}. \tag{30}$$

The realization of ω_{t+1} is private information to entrepreneurs, and the contract with financial intermediaries is signed before it is known. This private information leads to a moral hazard problem with costly state verification that is solved via a standard debt contract. As in Bernanke et al. (1999), I consider a costly state verification (CSV) problem: entrepreneurs observe their outcome for free, but financial intermediaries need to pay a cost, proportional to the gross payoff of the entrepreneur's capital.

The standard debt contract specifies a state-contingent non-default repayment, R^l_{t+1}, (dependent on the ex-post realization of R^k_{t+1}) that the entrepreneur promises to pay to the financial intermediary in case of success of the investment project, that is, as long as the return is enough to meet the payment obligations with the financial intermediary. Otherwise the entrepreneur will default.

At the moment of the debt contract agreement there is aggregate uncertainty because R^k_{t+1} is not known yet. Once the entrepreneur has decided on the amount of capital to purchase, $q_t k_t \frac{p_{H,t}}{p_t}$, and therefore the amount of external funds it needs, the entrepreneur and the financial intermediary agree to sign a one period contract given the ex-ante values of $q_t k_t \frac{p_{H,t}}{p_t}$ and $\frac{b_t}{p_t}$. The threshold value of the idiosyncratic shock, ϖ_{t+1}, below which the entrepreneur defaults, is given by

$$R^l_{t+1} b_t = \varpi_{t+1} R^k_{t+1} p_{H,t} q_t k_t. \tag{31}$$

Summarizing, after the idiosyncratic shock is realized there are two possible scenarios:

- if $\omega_{t+1} > \varpi_{t+1}$ the financial intermediary will get $R^l_{t+1} b_t$ and the entrepreneur will keep the difference between his revenue and the interest payment on the loan, $\omega_{t+1} R^k_{t+1} p_{H,t} q_t k_t - R^l_{t+1} b_t$;
- if $\omega_{t+1} < \varpi_{t+1}$ the entrepreneur defaults and gets nothing while the financial intermediary gets $(1-\mu)\,\omega_{t+1} R^k_{t+1} p_{H,t} q_t k_t$, where $\mu \omega_{t+1} R^k_{t+1} p_{H,t} q_t k_t$ is the cost of moni-

toring.

If the entrepreneur defaults, it gets nothing. The financial intermediary takes the remaining fraction $(1-\mu)$ of the entrepreneur's return after paying bankruptcy procedures (a fraction μ). Hence, the CSV problem is designed to ensure that whenever the entrepreneur has generated enough revenue to pay its obligations, it has an incentive to do so and to report truthfully. This is what Freixas and Rochet (2008) call the revelation mechanism.

The debt contract also establishes the return R^l_{t+1} the financial intermediary gets from the entrepreneur, arising from the zero profit condition

$$\left[1-F\left(\varpi_{t+1},\sigma_{\omega,t}\right)\right]R^l_{t+1}b_t+\left(1-\mu\right)\int_0^{\varpi_{t+1}}\omega dF\left(\omega,\sigma_{\omega,t}\right)R^k_{t+1}p_{H,t}q_tk_t=s_tR_t\left(a_t+B_t\right), \tag{32}$$

Equation (32) shows that expected revenues obtained from lending activities must equal the cost of funds the domestic financial intermediary has to pay back to households.

Following Fernández-Villaverde (2010), the problem of the entrepreneur is to choose both the leverage ratio and the schedule for ϖ_{t+1} by maximizing its expected net worth

$$\max_{\frac{\frac{b_t}{p_t}}{n_t},\varpi_{t+1}}\frac{R^k_{t+1}}{R_t}\left[1-\Gamma\left(\varpi_{t+1},\sigma_{\omega,t}\right)\right]\left(1+\frac{\frac{b_t}{p_t}}{n_t}\right), \tag{33}$$

subject to the zero profit condition of the financial intermediary,

$$\left[\frac{R^k_{t+1}}{R_t}\left[\Gamma\left(\varpi_{t+1},\sigma_{\omega,t}\right)-\mu G\left(\varpi_{t+1},\sigma_{\omega,t}\right)\right]\left(1+\frac{\frac{a_t+B_t}{p_t}}{n_t}\right)-\frac{\frac{a_t+B_t}{p_t}}{n_t}\right], \tag{34}$$

and given that in equilibrium $a_t+B_t=\eta_tb_t$, where η_t denotes the macroprudential instrument explain in detail in Section 3.10. In the equations above, $F\left(\varpi_{t+1},\sigma_{\omega,t}\right)$ denotes the probability of default and

$$G\left(\varpi_{t+1},\sigma_{\omega,t}\right)=\int_{0}^{\varpi_{t+1}}\omega dF\left(\omega,\sigma_{\omega,t}\right). \tag{35}$$

Function $\Gamma\left(\varpi_{t+1},\sigma_{\omega,t}\right)$ stands for the share of entrepreneurial earnings accrued to the financial intermediary

$$\Gamma\left(\varpi_{t+1},\sigma_{\omega,t}\right)=\varpi_{t+1}\left[1-F\left(\varpi_{t+1},\sigma_{\omega,t}\right)\right]+G\left(\varpi_{t+1},\sigma_{\omega,t}\right). \tag{36}$$

The first order conditions are given by

$$\begin{aligned} & E_t\frac{R_{t+1}^k}{R_t}\left[1-\Gamma\left(\varpi_{t+1},\sigma_{\omega,t}\right)\right] \\ +\xi_t & \left\{\frac{R_{t+1}^k}{R_t}\left[\Gamma\left(\varpi_{t+1},\sigma_{\omega,t}\right)-\mu G\left(\varpi_{t+1},\sigma_{\omega,t}\right)\right]-\eta_t\right\}=0,\end{aligned} \tag{37}$$

and

$$-\Gamma_\omega\left(\varpi_{t+1},\sigma_{\omega,t}\right)+\xi_t\left[\Gamma_\omega\left(\varpi_{t+1},\sigma_{\omega,t}\right)-\mu G\left(\varpi_{t+1},\sigma_{\omega,t}\right)\right]=0, \tag{38}$$

where ξ_t is the Lagrangian multiplier.

After some algebra, I get

$$q_tk_t\frac{p_{H,t}}{p_t}=\left[\frac{\xi_t\eta_t}{E_t\frac{R_{t+1}^k}{R_t}\left[1-\Gamma\left(\varpi_{t+1},\sigma_{\omega,t}\right)\right]}\right]n_t, \tag{39}$$

where $q_tk_t\frac{p_{H,t}}{p_t}$ are purchases of capital, as explained before, and where $\frac{R_{t+1}^k}{R_t}$ is the external finance premium, inversely related to the net wealth of the entrepreneur. Everything else equal, a rise in the external finance premium, $efp=\frac{R_{t+1}^k}{R_t}$, that initially reduces the expected probability of default, makes the entrepreneur take on more debt. This generates a decrease in net worth relative to external funds and therefore ends up increasing the expected probability of default.

As mentioned in the description of the households' problem, at the end of every period a fraction γ^e of entrepreneurs survives while the rest die. Capital demand and capital return by entrepreneurs depend on the evolution of their net worth. And at the same time, entrepreneurs' net worth (equity) depends on their earnings net of interest payments to financial intermediaries. Therefore it is necessary to assume that entrepreneurs have some initial networth, w^e, in order to begin operating. The net wealth of the exiting entrepreneurs, $(1-\gamma^e)\,n_t$, is paid back to households. The new entrepreneurs replacing exiting ones enter the economy with initial net worth w^e.

The average net wealth (equal to the wealth of the entrepreneur since the leverage ratio is the same for all entrepreneurs) is

$$n_t = \gamma^e \frac{1}{\Pi_t} \left\{ \left[1 - \mu G\left(\varpi_t, \sigma_{\omega,t-1}\right)\right] R_t^k q_{t-1} k_{t-1} \frac{p_{H,t-1}}{p_{t-1}} - s_{t-1} R_{t-1} \frac{b_{t-1}}{p_{t-1}} \eta_t \right\} + w^e. \tag{40}$$

3.6 Domestic Financial Intermediaries

Domestic financial intermediaries operate in a perfectly competitive market, receiving deposits from households, a_t, and lending loans to entrepreneurs, b_t. They also make use of the international financial market. In case the demand for loans exceeds the amount of domestic deposits, domestic financial intermediaries obtain funds from the international financial market, $B_t > 0$, that are lent to entrepreneurs in the form of loans. When there is a surplus of domestic deposits relative to the amount of loans that entrepreneurs want to borrow, domestic financial intermediaries deposit the excess of funds in the international financial markets, $B_t < 0$. As markets are incomplete in this model, the international bond is uncontingent, meaning that there is not an outcome for each state of nature. Incomplete markets also imply that the interest rate in one country is not the same as the interest rate of the other country.

Their objective function is given by

$$\left\{ \left[1 - F\left(\varpi_{t+1}, \sigma_{\omega,t}\right)\right] R^{l}_{t+1} b_t + (1-\mu) \int_0^{\varpi_{t+1}} \omega dF\left(\omega, \sigma_{\omega,t}\right) R^{k}_{t+1} p_{H,t} q_t k_t - s_t R_t \left(a_t + B_t\right) \right\}, \tag{41}$$

which shows expected returns in case of a successful project, plus revenues in case of default, minus the costs in terms of deposits for the financial intermediary.[1] Variable s_t is a spread that domestic financial intermediaries also pay under the concept of intermediation costs and that is paid back to households in a lump-sum way. Also, following Fernández-Villaverde (2010)

$$s_t = 1 + e^{\overline{s} + \widetilde{s}_t}, \tag{42}$$

and

$$\widetilde{s}_t = \rho_s \widetilde{s}_{t-1} + \sigma_s \varepsilon_{s,t} \text{ where } 0 < \rho_s < 1 \text{ and } \varepsilon_{s,t} \backsim N(0,1). \tag{43}$$

Parameter ρ_s is the persistence coefficient and σ_s is the volatility of the shock.

3.7 International financial intermediaries

Following Quint and Rabanal (2014), the model incorporates intermediaries between domestic financial intermediaries of the home country and domestic financial intermediaries of the foreign country: international financial intermediaries. These agents borrow from the country with excess loanable funds to lend them to the country that has a shortage of loanable funds. They pay to the lending country a rate equal to the interest on deposits of that country and receive from the borrowing country a rate equal to the interest on deposits of that other country. Incomplete markets in this model imply that the interest rate differs across countries. Thus, the differential between the deposit interest rates of both countries equals the profits made by international financial intermediaries. In this

[1]Be aware that given that the domestic financial intermediary operates in a perfectly competitive market, this objective function will be equal to zero according to equation (32)

line, I introduce an interest rate that is increasing in the level of debt. This differential, also known as country debt premium, is given by

$$R_t - R_t^* = \kappa_t e^{\Omega\left(\frac{B_t}{p_t y} - \frac{B}{py}\right)} - 1. \tag{44}$$

For simplicity, as in Quint and Rabanal (2014), I take the home country as the reference so that the debt premium depends on the ratio of real international debt, $\frac{B_t}{p_t}$, to steady state real GDP, y, of the home country. In what follows I will denote real international debt by $\bar{B}_t$ and real private debt by $\bar{b}_t$. If the home country borrows from the international market, $B_t > 0$ and $R_t > R_t^*$. The parameter $\Omega > 0$ denotes the elasticity of the debt premium, and κ_t is a debt premium shock that follows

$$\kappa_t = \rho_\kappa \kappa_{t-1} + \sigma_\kappa \varepsilon_{\kappa,t}, \tag{45}$$

where $\rho_\kappa \in [0,1]$ is the persistence parameter; and σ_κ is the volatility of the shock, $\varepsilon_{\kappa,t} \backsim N(0,1)$.

The international financial intermediaries obtain profits that are distributed proportionally across households of both countries.

3.8 Fiscal Authority

There is a national fiscal authority (or government) that finances its expenditures via taxes and public debt, according to the following budget constraint:

$$\frac{d_t}{p_t} = g_t + R_{t-1}^d \frac{d_{t-1}}{p_t} - tax_t, \tag{46}$$

where d_t denotes current issue of public debt; g_t is government spending; and tax_t denotes tax revenues defined by

$$tax_t = \tau_c c_t + \tau_l w_t l_t + \tau_R \left(R_{t-1} - 1\right) \frac{a_{t-1}}{p_t}. \tag{47}$$

As in Fernández Villaverde (2010a), I assume that government spending evolves by the following fiscal rule:

$$\frac{g_t}{g} = \left(\frac{g_{t-1}}{g}\right)^{\gamma_g} \exp\left(d_g \frac{d_{t-1}}{\Pi_t y_t} - \frac{d}{\Pi y}\right) \exp\left(\sigma_g \varepsilon_{g,t}\right), \text{ where } \varepsilon_{g,t} \backsim N(0,1). \tag{48}$$

Parameter $d_g \leq 0$ is the sensitivity of government expenditure to changes in the ratio of debt over output, its sign reflects the objective of public debt stabilization; $\gamma_g \in [0,1]$ is the persistence coefficient; and σ_g is the volatility of the government spending shock.

3.9 Monetary Authority

The monetary authority or central bank is common for both countries and uses monetary policy to stabilize the monetary union gross inflation rate, Π_t^{MU}, and real output, y_t^{MU}. With that aim, the central bank sets the monetary policy instrument, or interest rate for the union. This analysis takes into account the active/passive definitions introduced by Leeper (1991). Leeper explains that an active policy is the one unconstrained by sovereign debt and a passive policy is the one constrained by current budgetary conditions and active authority actions. I consider the scenario where different national passive fiscal policies are combined with a single active monetary policy that stabilizes inflation at the union level.

Monetary union inflation is given by

$$\Pi_t^{MU} = \frac{p_t^{MU}}{p_{t-1}^{MU}}, \tag{49}$$

where

$$p_t^{MU} = (p_t)^n (p_t^*)^{1-n}, \tag{50}$$

and monetary union real output is

$$y_t^{MU} = (y_t)^n (y_t^*)^{1-n}. \tag{51}$$

The central bank follows a standard Taylor Rule:

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\gamma_R} \left(\left(\frac{\Pi_t^{MU}}{\Pi^{MU}}\right)^{\gamma_\Pi} \left(\frac{y_t^{MU}}{y^{MU}}\right)^{\gamma_y}\right)^{(1-\gamma_R)} \exp(\sigma_m \varepsilon_{m,t}), \tag{52}$$

where $\gamma_R \in [0,1]$ is the persistence parameter; $\gamma_\Pi \geq 0$ and $\gamma_y \geq 0$ indicate how strong is the response of the interest policy rate to deviations of Π_t^{MU} and y_t^{MU} from their steady states, respectively; and σ_m is the volatility of the monetary policy shock, $\varepsilon_{m,t} \backsim N(0,1)$.

The nominal interest rate is modified through open market operations financed by transfers, T_t and T_t^* for the home and foreign country, respectively.

3.10 Macroprudential authority

This section includes a macroprudential authority that sets policies to stabilize the financial system. Through counter-cyclical macroprudential policy instruments the amount of loans to be lent to the private financial sector is controlled and private debt volatility is reduced in order to guarantee a more stable cycle.

Therefore, following Quint and Rabanal (2014), I introduce a macroprudential tool that controls the ability to lend of the domestic financial intermediaries in the following way:

$$\frac{1}{\eta_t}\left(B_t + a_t\right) = b_t, \tag{53}$$

where η_t is a new variable that affects the credit market conditions.

The macroprudential regulation will affect financial variables countercyclically. Higher values of η_t reflect a tightening macroprudential policy, while lower values reflect an easing macroprudential policy. This macroprudential rule implies that, when the regulation is tightening, domestic financial intermediaries can only lend a fraction of the funds they get from households and from international financial intermediaries. In this case, this measure would be equivalent to a reserve requirement ratio or countercyclical capital buffers that make banks accumulate capital during good times. However, in line with Quint and Rabanal (2014), I allow the macroprudential instrument to behave symmetrically and go below one. So when macroprudential policy is easing, capital buffers are released to maintain the provision of credit to the real economy and domestic financial intermediaries can lend more than the amount of deposits and international funds they hold.

In line with Quint and Rabanal (2014), I also make η_t dependent on the deviation of credit market conditions, Ψ_t, from their steady state, Ψ, as follows:

$$\eta_t = \left(\frac{\Psi_t}{\Psi}\right)^{\gamma_\eta}, \tag{54}$$

where $\gamma_\eta > 0$ reflects how responsive η_t is to the indicator of credit market conditions considered. Notice that macroprudential policies do not affect the steady state since $\eta = 1$ whenever $\Psi_t = \Psi$.

De Blas and Malmierca (2020) includes an analysis of the two alternative macroprudential instruments that Quint and Rabanal (2014) propose. They first define Ψ_t as the deviation of the nominal private credit growth and second as the deviation of the private credit-to-GDP ratio.

The results obtained in de Blas and Malmierca (2020), for a closed economy, show that macroprudential policy always stabilizes private debt but GDP only when it targets nominal credit growth. Therefore, with the objective of analyzing macroprudential policy as a way of attaining macroeconomic and financial stability, in this paper I define Ψ_t as the nominal private credit growth. This is consistent with Basel III that states that monitoring excessive credit growth is one of the most important financial indicators that should be consider when implementing macroprudential policy. Therefore,

$$\Psi_t = \frac{\bar{b}_t}{\bar{b}_{t-1}} \Pi_t. \tag{55}$$

Thus, the macroprudential instrument becomes tightening when there is an increase in the nominal private credit growth and easing if the latter decreases.

I analyze the case of supranational macroprudential policy implying that the macroprudential tool is the same in both countries of the union. Malmierca (2021) shows that a supranational macroprudential policy, reacting with a specific intensity to aggregate variables, entails economic and financial instability in the foreign country. The reason is that the latter has to bear the costs of stabilizing the country where the shock is originated. The aim of the present paper is to undertake an optimal policy analysis, so a supranational macroprudential policy targeting union-wide aggregate variables, as modeled in many studies such as Rubio (2014) or Demej and Gambacorta (2017), seems inappropriate for the foreign country. Therefore, as opposed to the mentioned papers, the supranational macroprudential rule in this model does not target the financial indicator of each country with the same degree of responsiveness, i.e. I allow γ_η and γ_η^* to differ:

$$\eta_t^{MU} = n \left(\frac{\Psi_t}{\Psi}\right)^{\gamma_\eta} + (1-n) \left(\frac{\Psi_t^*}{\Psi^*}\right)^{\gamma_\eta^*}. \tag{56}$$

The introduction of macroprudential policy affects the credit conditions in the model. In particular, the lending-deposit spread becomes

$$\frac{R_{t+1}^{l}}{R_t}=\frac{s_t\eta_t}{\left[1-F\left(\varpi_{t+1},\sigma_{\omega,t}\right)\right]+\frac{(1-\mu)}{\varpi_{t+1}}\int_0^{\varpi_{t+1}}\omega dF\left(\omega,\sigma_{\omega,t}\right)}. \tag{57}$$

When the macroprudential policy is tightening, the lending-deposit spread increases. That is, a tightening macroprudential policy means less funds are available to lend, without any change in the policy rate, widening the gap between the lending and the deposit rates. The opposite holds when the macroprudential policy is easing.

The one period interest rate of the loan is set on the contract that the domestic financial intermediary agrees with the entrepreneur. The previous expression shows that R_{t+1}^{l} also depends on the level of η_t for the current period, so the macroprudential policy affects the contractual agreement. In particular, when the macroprudential rule is too restrictive the R_{t+1}^{l} set in the contract is higher than when macroprudential policy is relaxed. This ensures that when macroprudential policy is introduced, domestic financial intermediaries can still obtain zero profits, paying the same R_t to households and international financial intermediaries. Macroprudential policy only affects the rate on loans, R_{t+1}^{l}. Therefore, despite macroprudential policy, lending funds in the form of deposits or through an international bond to financial intermediaries is still worth it for households and international intermediaries. Entrepreneurs, however, face a higher cost on their debt if they need to borrow when macroprudential policy is tightening, and vice versa. As a consequence, private credit is affected not only from the supply side but also from the demand side, which is the goal of macroprudential policy.

4 AGGREGATION AND EQUILIBRIUM

Aggregate output in the model is given by

$$y_t = c_{H,t} + \frac{1-n}{n} c^*_{H,t} + i_t + g_t + \mu G\left(\varpi_t, \sigma_{\omega,t-1}\right)\left(r_t + q_t\left(1-\delta\right)\right) k_{t-1}, \tag{58}$$

from the demand side. And the aggregate supply is

$$y_t = \frac{1}{\upsilon_t} e^{z_t} k^{\alpha}_{t-1} l^{1-\alpha}_t, \tag{59}$$

being υ_t the inefficiency created by price dispersion that evolves as:

$$\upsilon_t = \theta \left(\frac{\Pi^{\chi}_{H,t-1}}{\Pi_{H,t}}\right)^{-\varepsilon} \upsilon_{t-1} + (1-\theta)\left(\bar{\Pi}_{H,t}\right)^{-\varepsilon}. \tag{60}$$

The home country's net foreign asset position is

$$n\bar{B}_t = nR_{t-1}\frac{\bar{B}_{t-1}}{\Pi_t} + n\frac{p_{F,t}}{p_t} c_{F,t} - (1-n)\frac{p_{H,t}}{p_t} c^*_{H,t}. \tag{61}$$

The equilibrium in this model, considering that there is a home country and a foreign country, can be defined as the sequence of quantities $\{c_t,\ c_{H,t},\ c_{F,t},\ l_t,\ a_t,\ k_t,\ i_t,\ b_t,\ B_t,\ c^*_t,\ c^*_{H,t},\ c^*_{F,t},\ l^*_t,\ a^*_t,\ k^*_t,\ i^*_t,\ b^*_t,\ B^*_t\}^{\infty}_{t=0}$; fiscal policy $\{g_t,\ tax_t,\ d_t,\ g^*_t,\ tax^*_t,\ d^*_t\}^{\infty}_{t=0}$; prices $\{p_t,\ p_{H,t},\ p_{F,t},\ r_t,\ w_t,\ q_t,\ p^*_t,\ r^*_t,\ w^*_t,\ q^*_t\}^{\infty}_{t=0}$, and interest rates $\{R^d_t,\ R_t,\ R^k_t,\ R^l_t,\ R^{d*}_t,\ R^*_t,\ R^{k*}_t,\ R^{l*}_t\}^{\infty}_{t=0}$, given exogenous variables $\{z_t,\ \sigma_{\omega,t},\ \widetilde{s}_t,\ \phi_t,\ z^*_t,\ \sigma^*_{\omega,t},\ \widetilde{s}^*_t,\ \phi^*_t,\ \kappa_t\}^{\infty}_{t=0}$, such that:

- optimization problems are satisfied for all agents of both countries in the model; and

- all markets clear, that is, in the case of the home country

$$y_t = c_{H,t} + \frac{1-n}{n} c^*_{H,t} + i_t + g_t + \mu G\left(\varpi_t, \sigma_{\omega,t-1}\right)\left(r_t + q_t\left(1-\delta\right)\right) k_{t-1},$$

$$y_t = \frac{1}{\upsilon_t} e^{z_t} k_{t-1}^{\alpha} l_t^{1-\alpha},$$

$$l_t^s = l_t^d,$$

$$nB_t = -\left(1-n\right) B_t^*$$

$$\begin{cases} a_t + B_t = b_t & \text{if macroprudential policy is not included,} \\ \frac{1}{\eta_t}\left(a_t + B_t\right) = b_t & \text{if macroprudential policy is included.} \end{cases}$$

- plus the laws of motion

$$k_t = (1-\delta)k_{t-1} + \left(1 - S\left[\frac{i_t}{i_{t-1}}\right]\right) i_t,$$

$$\frac{d_t}{p_t} = g_t + R_{t-1}^d \frac{d_{t-1}}{p_t} - tax_t, \text{and}$$

$$n\bar{B}_t = nR_{t-1}\frac{\bar{B}_{t-1}}{\Pi_t} + n\frac{p_{F,t}}{p_t}c_{F,t} - \left(1-n\right)\frac{p_{H,t}}{p_t}c_{H,t}^*.$$

For the foreign country the market clearing is replicated in the same way but using the foreign variables of the model.

5 CALIBRATION OF THE PARAMETERS AND STEADY STATE

Table 4 shows the parametrization I use in the model. I calibrate most of the parameters based on Gomes and Seoane (2018), Fernández-Villaverde (2012), Fernández-Villaverde (2010b) or Bernanke et al. (1999). All parameters and steady states are the same for both countries except for home country imports and foreign country imports, $\frac{c_F}{y}$ and $\frac{c_H^*}{y^*}$ respectively, and the steady states that result from these values. Parameters d_g and d_g^*, from the fiscal policy rules and γ_η and γ_η^*, from the macroprudential rules, depend on the optimized value that minimizes a specific loss function.

Open economy. I assume that both countries are of equal size, $n = 0.5$. Then I set the fraction of imported goods from the foreign country to the home country over GDP to 0.1 and the fraction of imported goods from the home country to the foreign country over foreign GDP to 0.11. Therefore, the home country is a net exporter and the foreign country a net importer in steady state what, taking into account the net foreign asset position, implies that international debt is different from 0. The substitutability between domestic and foreign goods is set to $\zeta = 1.5$ and the terms of trade, t, are 1 in steady state, what means that the price of the home country produce goods is the same to the price of the foreign country produced goods. The debt elasticity of the country premium is different to zero to induce stationarity (Schmitt-Grohe and Uribe, 2002), concretely $\Omega = 0.0043$.

Preferences. I set the discount factor to $\beta = 0.999$, being the same for both countries, and $\Pi_H = \Pi_F = \Pi = \Pi^* = 1.005$, implying an average annual real interest rate equal to 0.4%. Habits on consumption are $h = 0.5$, and the Frisch elasticity of labor is $1/\vartheta = 2$. Labor in steady state is $l = \frac{1}{3}$.

Technology. The capital share, α, is set equal to 0.33; capital depreciation rate, δ, equals 8.9% at an annual rate; and capital adjustment costs are such that $S^{"}[1] = 14.477$. The Calvo pricing parameter for the periphery of the union, represented by the home country, θ, is 0.72 what means on average 5.5 quarters of duration of prices; the Calvo pricing parameter for the core of the union, represented by the foreign country, θ^*, is 0.62 what means on average 6.5 quarters of duration of prices; the degree of indexation to past inflation, χ, equals 0.6; and the elasticity of substitution across goods, $\varepsilon = 8.577$, implies a markup of around 13% in the goods sector.

Financial variables. I consider monitoring costs, μ, are 15% of the entrepreneur's output;

the loan-to-capital ratio is equal to $\frac{\bar{b}}{k}=\frac{1}{3}$; the average spread on loans, s, is 0.25%; the survival rate of entrepreneurs is $\gamma^e=0.975$; and the annual probability of default is 3%.

Fiscal policy. The steady state values for the tax rates are $\tau_l=0.24$ and $\tau_r=0.42$; government spending-to-GDP ratio equals 20%, and the debt-to-GDP ratio is 60%. Given these values τ_c is determined from the government's budget constraint. Finally, the benchmark value of d_g is equal to -0.01, in line with Malmierca (2021).

Monetary policy. In the analysis below, monetary policy is conducted at the union level. I assume that the response of intervention rate to changes in inflation is $\gamma_{\Pi}(1-\gamma_R)=1.5$ what implies that the monetary union authorities have the objective of inflation stabilization, so monetary policy is active.

Macroprudential policy. The baseline macroprudential policy scenario is the no macroprudential policy regime that implies that γ_η and γ_η^* equal 0. When macroprudential policy is introduced in the model γ_η and γ_η^* take the optimized values that minimize the corresponding loss function.

Shock processes. I consider quite permanent shock processes, therefore, I set autorregressive coefficients equal to 0.95, and standard deviations are taken from the empirical evidence and past literature, as summarized in Table 4.

6 OPTIMAL POLICY ANALYSIS

In this section I evaluate the optimal macroprudential and fiscal policy scenarios that maximize the welfare gains for the national economies and the monetary union as a whole.

The analysis is carried out for different policy coordination and non-coordination scenarios. In the former, macroprudential and fiscal authorities share the objective of maximizing the same welfare (either national or union-wide). In the non-coordination case, the macroprudential authority pursues the union's welfare maximization, while fiscal authorities focus on their own national objectives.

Thus, the paper also provides a comparison of the optimal policies when macroprudential authorities are national versus the supranational macroprudential authority case.

Finally, to obtain more robust results, the analysis is replicated for different shocks, all of them originating in the home country and responsible for an economic crisis.

The results of the welfare-based comparison are presented in the last three columns of each table of the analysis, for the home country, the foreign country and the union as a whole, respectively.

I follow Schmitt-Grohé and Uribe (2004) and solve the model using a second order approximation of the equilibrium equations. Then, welfare is computed as the conditional expectation of lifetime utility as of time zero assuming that at time zero all variables in the economy equal their non-stochastic steady state values. This ensures that the economy starts from the same initial point under all policy regimes (the non-stochastic steady state is the same across all policy regimes considered). This conditional welfare criterion allows not to neglect the welfare effects during the transition from the non-stochastic to the stochastic steady state (different policy regimes are associated with different stochastic steady states).

Welfare results are presented in terms of percentage changes in steady state consumption, indicating the fraction of consumption that a household would be willing to give up to be indifferent between each computed optimal policy scenario and the baseline situation.[2] Therefore, a positive value of the welfare cost measure represents a decrease in welfare in the optimal scenario with respect to the baseline one. A negative value of the welfare cost measure represents a welfare gain with respect to the baseline scenario. Welfare costs for the home country are denoted by $\mathcal{W}$ and for the foreign country by $\mathcal{W}^*$. The aggregate welfare costs for the union as a whole are computed as the weighted sum

[2]This methodology is also used in Schmitt-Grohé and Uribe (2004), Quint and Rabanal (2014) or Rubio and Carrasco-Gallego (2016), among others.

of the welfare costs in the two countries:

$$\mathcal{W}^{MU} = n\mathcal{W} + (1-n)\,\mathcal{W}^{*}. \tag{62}$$

The baseline regime is where the economy is supposed to be before the optimal policies are set. It consists, in line with Leeper (1991), of a very passive fiscal policy that stabilizes the national public debt through a government spending rule that decreases (increases) by 1% for every unit of increase (decrease) in public leverage ($d_g = d_g^* = -0.01$). To eliminate the distortions that a macroprudential policy might entail, the benchmark scenario also consists of a zero macroprudential response ($\gamma_\eta = \gamma_\eta^* = 0$). Then, to ensure that the optimal values of the policy parameters, are reasonable and consistent with the existing literature, I impose a lower and an upper limit. Accordingly, γ_η and γ_η^*, must range between 0 and 5.00 and d_g and d_g^*, are restricted to a range between -0.01 and -0.0004. A higher value than -0.0004 would imply that fiscal policy is active and, given that monetary policy is active, this would not result in a determinate equilibrium, according to Leeper (1991) and Leith and Wren-Lewis (2006).

I first analyze a non-coordination situation where a supranational macroprudential authority maximizes the union-wide welfare while national fiscal authorities maximize their own national welfare. Then I undertake the analysis of two different coordination scenarios, one where both policies maximize welfare of the whole monetary union and another one where they maximize national welfare. At the same time, I consider two alternative ways of implementing each of this three scenarios: either macroprudential policy moves first or fiscal policy is the one firstly implemented. Consequently, the results are computed for a total of six cases.

The six scenarios are analyzed conditional on three different shocks. First, I evaluate the optimal policy after a financial shock consisting of a 1% increase in credit risk. Second, I consider a supply shock, concretely a technology shock. Finally, optimal policy is analyzed in the event of a demand shock, consisting of a shock to consumer preferences.

To perform the maximization analysis I follow a standard procedure in the welfare maximization literature, also used in Schmitt-Grohé and Uribe (2004). To determine the value of γ_η and γ_η^* that maximizes welfare I search over a grid from 0 to 5 with a step of 0.5, that is, considering 11 values for each macroprudential parameter. To pin down the optimal value of d_g and d_g^* that generates the maximized welfare I carry out a grid search in the interval [-0.01, -0.0004] with a step of 0.0012, that is, I consider 9 values for each fiscal policy parameter.

As explained above, in Tables 1, 2 and 3 the "Non-coordination" scenario is when a supranational macroprudential authority maximizes union-wide welfare while national fiscal authorities maximize national welfare. In the "Coordination at union level" scenario a supranational macroprudential authority and national fiscal authorities maximize union-wide welfare. The "Coordination at country level" scenario occurs when national macroprudential and fiscal authorities maximize national welfare. The rows headed by "MaP authority first" represent the cases where the Macroprudential authority moves first and the fiscal authority takes the optimal macroprudential policy as given. The rows headed by "Fiscal authority first" represent the cases where the fiscal authority moves first and the macroprudential authority takes the optimal fiscal policy as given.

6.1 Welfare maximization under a credit risk shock

In the event of a positive credit risk shock in the home country, the probability of default of home country entrepreneurs increases and the financial conditions to the home country private sector are toughened. The interest in analyzing this type of shock is due to its similarity with the case of the Great Recession, which sharply reduced private leverage, private investment and, consequently, GDP. These effects are represented in this model, implying a fall in the collection of taxes and a rise of home country public debt. This is how the private-public channel arises in the home country. Under financial shocks, the findings in de Blas and Malmierca (2020) prove that the cancellation of the channel leads to stabilization of the main economic variables. Countercyclical national macroprudential measures in the home country offset the channel (see Malmierca, 2021) because they directly target the home country's financial system, where the shock is originated.

Table 1 contains the optimal values of the policy parameters and welfare costs when the home economy is hit by a financial shock.

Table 1: Welfare maximization. Optimal values of the policy parameters and welfare costs in consumption equivalents. Home country credit risk shock.

	γ_η	γ_η^*	d_g	d_g^*	$\mathcal{W}$	$\mathcal{W}^*$	$\mathcal{W}^{MU}$
Non-coordination							
MaP authority first	1	0	-0.0004	-0.0064	-0.034%	0.002%	-0.016%
Fiscal authority first	5	5	-0.0004	-0.0004	-0.008%	0.007%	-0.001%
Coordination at union level							
MaP authority first	1	0	-0.0004	-0.01	-0.034%	0.002%	-0.016%
Fiscal authority first	5	5	-0.0004	-0.0004	-0.008%	0.007%	-0.001%
Coordination at country level							
MaP authority first	0.5	0.5	-0.0004	-0.0004	-0.036%	-0.003%	-0.019%
Fiscal authority first	5	0.5	-0.0004	-0.0004	-0.022%	-0.005%	-0.014%

On the one hand, optimal fiscal policy adopts a non-passive behavior; fiscal policy parameters, d_g and d_g^*, usually rank in the most active value among those considered in the analysis (-0.0004). The reason is that in the event of this shock, an almost active fiscal policy implies a lower decrease in government spending and, therefore, a higher level of GDP. There are only two cases in which d_g^* remains relatively passive in the foreign country (-0.0064 and -0.01) and, in both situations, a supranational macroprudential authority moves first, encouraging foreign GDP.

On the other hand, the results show that the optimal value of the macroprudential parameters is low under a passive fiscal policy framework (this happens when macroprudential policy is defined first. However, in general, optimal macroprudential policy becomes aggressive when fiscal policy is less passive. This is implied in the high values of γ_η and γ_η^* when optimal fiscal policy is set first and adopts a more active nature. Thus, there is a clear interaction between fiscal and macroprudential policy, as the latter reacts aggressively to stabilize the financial sector, compensating for of an almost active fiscal policy the inability to stabilize public debt.

After the financial shock, the greatest benefits, in terms of both national and union-wide welfare, are achieved when macroprudential policy is undertaken at the country level. These are the scenarios where both fiscal and macroprudential national authorities have the objective of maximizing its national welfare. The main reason is that, as stated in Quint and Rabanal (2014), under a credit risk shock that destabilizes the financial sector, the welfare improvement arises as a consequence of the financial system stabilization. Quint and Rabanal (2014) explain that macroprudential policy leaning against the wind of credit cycles improves welfare under risk shocks. A national macroprudential policy establishes the concrete measures that each economy requires to stabilize its national financial system while a supranational macroprudential policy is common to all members of the union regardless the needs of each country. Consistently, after financial shocks, welfare in the home country, foreign country and the monetary union improves the most when macroprudential policy is national.

When a tightening national macroprudential policy is set by the foreign country, the foreign financial system is directly stabilized. Foreign GDP continues growing but at a more stable rate and therefore foreign labor does not need to increase as much as in the baseline case. Thus, the net effect in foreign welfare of national macroprudential policy is positive. However, due to the nature of the shock, optimal policies bring greater welfare improvements for the home than for the foreign country. Actually, under a supranational macroprudential authority, the optimal scenarios imply foreign welfare costs consequence of the common macroprudential policy, that reacts, to stabilize the more damaged home country's financial system, instead of addressing the foreign economy needs.

Another factor determining the results is the order in which optimal policies are set. If fiscal authorities move first, implying an aggressive optimal macroprudential response, there are lower welfare improvements. The reason is that macroprudential policy after a positive credit risk shock restores GDP and inflation, what raises the intervention rate. This increase in the interest rate directly reduces private consumption and, consequently, welfare. Thus, the more aggressive macroprudential policy the lower the welfare improvement.

6.2 Welfare maximization under a technology shock

This subsection analyzes the welfare implications of the optimal policies after a technology (supply) shock in the home country. The results can be found in Table 2. I analyze this kind of shock since its effects can be identified with the economic damages of the COVID-19 crisis since they were due, in the first place, to a shock that strongly reduced aggregate supply.

When a negative technology shock hits the home country, its aggregate supply and, therefore, GDP go down. Then, consequence of a fall in tax collection, home country public debt increases and government expenditures decrease to stabilize the government balance. As aggregate supply decreases, the level of prices rises thus the intervention rate goes up. The rate on loans also deteriorating financial conditions to entrepreneurs. But, under a technology shock, the home country private debt is barely destabilized, even if the amount of home country loans decreases after the shock, consequence of the fall in the economic activity.

Table 2: Welfare maximization. Optimal values of the policy parameters and welfare costs in consumption equivalents. Home country technology shock.

	γ_η	γ_η^*	d_g	d_g^*	$\mathcal{W}$	$\mathcal{W}^*$	$\mathcal{W}^{MU}$
Non-coordination							
MaP authority first	1	2	-0.0004	-0.01	-0.005%	-0.029%	-0.017%
Fiscal authority first	2	0	-0.0004	-0.01	-0.002%	-0.039%	-0.021%
Coordination at union level							
MaP authority first	1	2	-0.0004	-0.01	-0.005%	-0.029%	-0.017%
Fiscal authority first	2	0	-0.0004	-0.01	-0.002%	-0.039%	-0.021%
Coordination at country level							
MaP authority first	0	5	-0.0004	-0.01	-0.005%	-0.023%	-0.014%
Fiscal authority first	0	5	-0.0004	-0.01	-0.006%	-0.023%	-0.014%

Regarding this shock, the optimal values of the home country fiscal parameters always imply the least passive response possible, given the limits imposed in this analysis, thus $d_g = -0.0004$. This almost active fiscal policy causes lower government spending reductions than in the baseline regime, what accelerates the recovery of GDP and improves home country welfare. However, optimal fiscal policy in the foreign country remains as passive as in the baseline scenario ($d_g^* = -0.01$). Thus, the sharp decrease in foreign government debt allows for a significant foreign public spending rise to boost foreign GDP and foreign welfare gains.

If macroprudential policy is set at the union level, on the one hand, the macroprudential response to home country credit conditions, γ_η, is greater than that to foreign credit conditions, γ_η^*, to compensate for the lower stabilizing effects of the home active fiscal policy when fiscal policy is set first. But, on the other hand, when the macroprudential authority acts first, considering that fiscal policy is passive, the supranational macroprudential authority implements a policy that reacts more to changes in the foreign country financial variables (more destabilized by this shock than home private debt). This stabilization of the foreign financial system enhances the union's welfare.

When macroprudential policy is national, after this supply shock, the optimal macroprudential response is 0 in the home country. The reason is that a home country macroprudential policy would restrict the amount of loans to the private sector in the event of this shock, slowing investment and GDP. Therefore, in line with Quint and Rabanal (2014), I observe that macroprudential policy at the national level would reduce home country welfare under technology shocks due to an increase in the counter-cyclicality of the lending-deposit spread. By contrast, an aggressive foreign national macroprudential policy, $\gamma_\eta^* = 5$, eases the financial conditions and reduces the fall in foreign private investment and output, increasing foreign welfare (-0.023%). Thus, as opposed to the credit risk shock situation, optimal policies bring greater welfare benefits in the foreign country than in the home country.

More concretely, the best scenario for foreign and union-wide welfare takes place when supranational macroprudential policy only reacts only to home country variables ($\gamma_\eta^* = 0$). The best scenario, in terms of home country welfare, takes place when there is no home macroprudential policy implementation ($\gamma_\eta = 0$).

6.3 Welfare maximization under a preference shock

Finally, I consider the case of a preference (or demand) shock in the home country. As a consequence of the health crisis, a negative demand shock followed the supply shock in the EMU countries in 2020. For this reason, it has become important to evaluate the kind of policy mix that would improve welfare under a demand crisis. This shock reduces consumption due to a change in consumer's preferences. Then output goes down on impact and, with it, public revenues, so public leverage increases. The initial fall in aggregate demand reduces inflation and the intervention rate. This decrease is transmitted to other interest rates, such as the rate on loans. Thus private debt increases in the home country. The effect of the financial system is transmitted to the real economy through a rise in home country private investment.

The optimal value of the policy parameters and their welfare implications after a home country shock to consumer's preferences are listed in Table 3.

A preference shock in the home country always implies that the optimal fiscal policy is an almost active one, as the optimal value of the fiscal parameters is -0.0004. This allows to stabilize through fiscal policy the highly destabilized business cycle.

The home country macroprudential policy, that targets national nominal credit growth, tightens the financial conditions to the private sector. Thus, it reduces the amount of loans to be lent by home financial intermediaries. This generates a fall in private investment and GDP in the home country, damaging the households' welfare. My results coincide with the statement of Quint and Rabanal (2014) that a macroprudential policy which magnifies the counter-cyclical behavior of the lending-deposit spread reduces welfare. This explains why the optimal supranational macroprudential policy, requires a zero macroprudential response to home country credit market conditions and why optimal

Table 3: Welfare maximization. Optimal values of the policy parameters and welfare costs in consumption equivalents. Home country preference shock.

	γ_η	γ_η^*	d_g	d_g^*	$\mathcal{W}$	$\mathcal{W}^*$	$\mathcal{W}^{MU}$
Non-coordination							
MaP authority first	0	5	-0.0004	-0.0004	-0.020%	-0.012%	-0.016%
Fiscal authority first	0	3	-0.0004	-0.0004	-0.021%	-0.012%	-0.016%
Coordination at union level							
MaP authority first	0	5	-0.0004	-0.0004	-0.020%	-0.012%	-0.016%
Fiscal authority first	0	3	-0.0004	-0.0004	-0.021%	-0.012%	-0.016%
Coordination at country level							
MaP authority first	0.5	5	-0.0004	-0.0004	-0.012%	-0.014%	-0.013%
Fiscal authority first	0.5	1	-0.0004	-0.0004	-0.008%	-0.010%	-0.009%

national macroprudential policy, is quite moderate in the home country.

Conversely, foreign macroprudential policy stabilizes the foreign financial sector, increases private investment and GDP and, therefore, improves welfare. Hence, in terms of foreign welfare, the optimal macroprudential policy always reacts to foreign financial variables. Actually, the optimal supranational macroprudential policy consists of an aggressive response to foreign financial variables, $\gamma_\eta^* = 5$ and $\gamma_\eta^* = 3$. Moreover, the best scenarios in terms of home country and union welfare take place when macroprudential policy reacts aggressively to changes in foreign financial variables.

7 CONCLUSION

This paper provides a normative analysis to evaluate the welfare implications of the policy mix when macroprudential and fiscal authorities interact. To that aim this work assesses the effects of three different kind of shocks that would lead to economic crisis similar to the ones experienced by the EMU as a consequence of the Great Recession (financial shock) and as a consequence of the COVID-19 crisis (supply shock and demand shock). This will allow policy-makers to decide on the optimal macroprudential and fiscal policy coordination strategy depending on the type of shock responsible for the economic recession.

The first relevant conclusion is that the optimal values of the policy parameters depend more on the kind of macroprudential policy implementation (national or supranational) than on the macroprudential-fiscal interplay, under the three shocks considered.

Secondly, under financial, when the macroprudential authorities move first, there are greater welfare gains. Instead, when a supply shock drives the business cycle, welfare gains are maximized if macroprudential authorities wait for the optimal fiscal policy to be first implemented. After a demand shock the results are inconclusive in this area.

In line with Quint and Rabanal (2014), the findings also imply that, no matter the shock considered, the best scenario for the home country welfare does not always coincide with the best scenario for the foreign or union's welfare. Concretely, regarding fiscal policy, an active fiscal rule is usually preferred to maximize welfare. Only the country not responsible for the shock chooses, for certain welfare maximization scenarios, a more passive fiscal measure.

This analysis shows that, under financial shocks, macroprudential policies are always welfare improving both for the country where the shock is originated and for the monetary union as a whole. In the country hit by a technology shock the welfare maximization strategy under a national macroprudential authority implies a zero response of the latter.

By contrast, the country where a demand shock is originated, experiences the highest welfare gains under a supranational macroprudential policy that does not react to its financial conditions. Hence, the advisability of implementing macroprudential policy is beyond argument under financial shocks but not under supply or demand shocks.

Regarding the macroprudential-fiscal coordination strategy to be chosen, the national coordination scenario entails the highest welfare improvements under credit risk shocks. The scenario where authorities are coordinated to stabilize union aggregate variables is the best option regarding welfare in the case of a technology or a preference shock. Thus, when deciding on whether implementing national or supranational macroprudential measures, on whether coordinating macroprudential and fiscal policies and on whether one or the other authority moves first, policymakers should consider the kind of shock that hits the economy.

Some interesting issues, to be addressed in future work, derive from this paper. First of all, this analysis takes monetary policy as given. In further research, an area to cover is the analysis of alternative macroprudential instruments, suach as one targeting the credit-to-GDP ratio, or alternative optimal fiscal rules, such as different tax rules. These would allow to assess what designs of macroprudential and fiscal policies are more optimal. It could also be interesting to perform the analysis for a model in which banks are not just mere intermediaries (see Gerali et al., 2010). This would allow to broad the analysis of the interaction between fiscal and macroprudential policies, for instance, by considering that banks are exposed on unsustainable sovereign debt (Farhi and Tirole, 2018). Finally, in this paper, I impose the assumption that both countries have equal size, but this premise is far from reality. A sensitivity on this point would be very promising.

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Appendix

Contract between financial intermediary and entrepreneur

The model includes a productivity shock ω_{t+1} that is lognormally distributed with a cumulative distribution function represented by $F(\omega, \sigma_{\omega,t})$, being $\mu_{\omega,t}$ the average and $\sigma_{\omega,t}$ the standard deviation of the distribution where $E_t\omega_{t+1} = 1$. From the properties of the lognormal distribution:

$$E_t\omega_{t+1} = e^{\mu_{\omega,t}+\frac{1}{2}\sigma^2_{\omega,t}} \Rightarrow e^{\mu_{\omega,t}+\frac{1}{2}\sigma^2_{\omega,t}} = 1 \Rightarrow \mu_{\omega,t} + \frac{1}{2}\sigma^2_{\omega,t} = 0 \Rightarrow \mu_{\omega,t} = -\frac{1}{2}\sigma^2_{\omega,t}.$$

In the computations to obtain the loglinearized version of the model I use the following equations that are also derived from the properties of the lognormal distribution:

$$\Gamma(\varpi_{t+1}, \sigma_{\omega,t}) = \varpi_{t+1}(1 - F(\varpi_{t+1}, \sigma_{\omega,t})) + G(\varpi_{t+1}, \sigma_{\omega,t}),$$

$$\Gamma_\omega(\varpi_{t+1}, \sigma_{\omega,t}) = 1 - F(\varpi_{t+1}, \sigma_{\omega,t}),$$

$$G(\varpi_{t+1}, \sigma_{\omega,t}) = 1 - \phi\left(\frac{\frac{1}{2}\sigma^2_{\omega,t} - \log\varpi_{t+1}}{\sigma_{\omega,t}}\right),$$

and

$$G_\omega(\varpi_{t+1}, \sigma_{\omega,t}) = \varpi_{t+1}F_\omega(\varpi_{t+1}, \sigma_{\omega,t}).$$

Tables

Table 4: Calibration of the non-optimized parameters and steady states

Parameter	Description	Value	Source
β	Discount factor	0.999	Fernández-Villaverde (2010b)
h	Consumption habits	0.5	Fernández-Villaverde (2010b)
n	Size of the periphery	0.5	Faia (2001)
$\frac{c_F}{y}$	Imports from the core-to-GDP	0.1	Own calibration to obtain a ratio $\frac{\bar{B}}{y} = 1.88$
$\frac{c_H^*}{y^*}$	Exports to the core-to-GDP	0.11	Own calibration to obtain a ratio $\frac{\bar{B}}{y} = 1.88$
ζ	Substitutability between domestic and foreign goods	1.5	Faia (2001)
Ω	Debt elasticity of the country premium	0.0043	Quint and Rabanal (2014)
t	Steady state value for the terms of trade	1	Faia (2001)
ϑ	Frisch elasticity of labor	0.5	Fernández-Villaverde (2010b)
α	Capital share of the intermediate production function	0.33	Fernández-Villaverde (2012)
δ	Capital depreciation rate	0.023	Fernández-Villaverde (2012)

Parameter	Description	Value	Source
θ	Calvo pricing parameter in the periphery	0.72	Quint and Rabanal (2014)
θ	Calvo pricing parameter in the core	0.62	Quint and Rabanal (2014)
ε	Elasticity of substitution across goods	8.577	Fernández-Villaverde (2012)
χ	Degree of indexation	0.6	Fernández-Villaverde (2010b)
$pdef$	Annual probability of default	0.03	Bernanke et al. (1999)
μ	Bankruptcy costs	0.15	Fernández-Villaverde (2012)
$s = s^*$	Average spread	1.0025	Fernández-Villaverde (2012)
$\bar{\gamma}^e = \bar{\gamma}^{e*}$	Entrepreneurs exit coefficient	3.67	Fernández-Villaverde (2010b)
$\tau_l = \tau_l^*$	Steady state of labor income tax rate	0.24	Fernández-Villaverde (2010b)
$\tau_r = \tau_r^*$	Steady state of capital income tax rate	0.42	Own calibration to obtain a ratio $\frac{\bar{B}}{y}$ of 1.88
$\Pi = \Pi^* = \Pi_H = \Pi_F$	Target gross inflation	1.005	Fernández-Villaverde (2010b)
$l = l^*$	Time devoted to work	1/3	Fernández-Villaverde (2010b)

Parameter	Description	Value	Source
$q = q^*$	Tobin's q. Price of capital	1	Fernández-Villaverde (2010b)
R^d	Steady state of interest rate on periphery public debt	$\frac{\Pi}{\beta}$	Fernández-Villaverde (2010b)
R	Steady state of interest rate on periphery deposits	$\frac{R^d-1}{1-\tau_R}+1$	Fernández-Villaverde (2010b)
R^{d*}	Steady state of interest rate on core public debt	$\frac{\Pi^*}{\beta}$	Fernández-Villaverde (2010b)
R^*	Steady state of interest rate on core deposits	$\frac{R^{d*}-1}{1-\tau_R^*}+1$	Fernández-Villaverde (2010b)
$\frac{\bar{b}}{k} = \frac{\bar{b}^*}{k^*}$	Loan-to-capital ratio	1/3	Fernández-Villaverde (2010b)
$\frac{g}{y} = \frac{g^*}{y^*}$	Government expenditure-to-GDP ratio	0.2	Gomes and Seoane (2018)
$\frac{d}{y} = \frac{d^*}{y^*}$	Public debt-to-GDP ratio	0.6	Gomes and Seoane (2018)
$S"[1]$	Capital adjustment costs	14.477	Fernández-Villaverde (2012)
ρ_ϕ	Persistence of preference shock	0.95	Fernández-Villaverde (2012)
σ_ϕ	Volatility of preference shock	0.032	Gomes and Seoane (2018)
ρ_s	Persistence of spread shock	0.95	Fernández-Villaverde (2012)
σ_s	Volatility of spread shock	0.3058	Own estimation

Parameter	**Description**	**Value**	**Source**
γ_g	Persistence parameter of government spending shock	0.95	Fernández-Villaverde (2012)
σ_g	Volatility of government spending shock	0.007	Gomes and Seoane (2018)
ρ_z	Persistence of technology shock	0.95	Fernández-Villaverde (2012)
σ_z	Volatility of technology shock	0.025	Gomes and Seoane (2018)
ρ_σ	Persistence of credit risk shock	0.95	Fernández-Villaverde (2012)
η_σ	Volatility of credit risk shock	0.074	Christiano, Motto and Rostagno (2010)
γ_R	Persistence of monetary policy shock	0.95	Fernández-Villaverde (2012)
σ_m	Volatility of monetary policy shock	0.003	Gomes and Seoane (2018)
$\gamma_\Pi (1-\gamma_R)$	Response of intervention rate to changes in inflation	1.5	Fernández-Villaverde (2012)
$\eta = \eta^*$	Steady state value of macroprudential instrument	1	Quint and Rabanal (2014)