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Cross-Border Banking and Business Cycles in Asymmetric Currency Unions

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Abstract

Against the background of the recent housing boom and bust in countries such as Spain and Ireland, we investigate in this paper the macroeconomic consequences of cross-border banking in monetary unions such as the euro area. For this purpose, we incorporate in an otherwise standard two-region monetary union DSGE model a banking sector module along the lines of Gerali et al. (2010), accounting for borrowing constraints of entrepreneurs and an internal constraint on the bank's leverage ratio. We illustrate in particular how different lending standards within the monetary union can translate into destabilizing spill-over effects between the regions, which can in turn result in a higher macroeconomic volatility. This mechanism is modelled by letting the loan-to-value (LTV) ratio that banks demand of entrepreneurs depend on either regional productivity shocks or on the productivity shock from one dominating region. Thereby, we demonstrate a channel through which the financial sector may have exacerbated the emergence of macroeconomic imbalances within the euro area. Additionally, we show the effects of a monetary policy rule augmented by the loan rate spread as in Cúrdia and Woodford (2010) in a two-country monetary union context.

Keywords: Cross-border banking, euro area, monetary unions, DSGE

JEL classification: F41, F34, E52.

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1 Introduction

One of the central features of the European monetary unification process has been the steady integration of financial markets across the European Monetary Union (EMU) over the last three decades, which was embedded in an unprecedented financial globalization process (Lane and Milesi-Ferretti, 2007, European Commission, 2008, ECB, 2010). According to the textbook theory, more integrated financial markets improve portfolio diversification and facilitate the channeling of funds towards the more productive projects, thereby promoting better risk sharing and faster economic convergence across regions (Barro et al., 1995). However, the traditional view on financial globalization has been significantly relativized since the 2007 global financial crisis (see e.g. Kose et al., 2009 for a critical review). An alternative view stresses the importance of a potential link between financial integration and the emergence of financial bubbles and, thus, macroeconomic instability due to overly optimistic growth expectations and excessive cross-border private and public borrowing (Blanchard and Milesi-Ferretti, 2010 and Jaumotte and Sodsriwiboon, 2010).

The increased financial integration among euro area countries, driven by the elimination of currency risk, a fall in real interest rates in Southern European economies and the general economic integration, led to a surge in cross-border financial flows as shown in Figure 1. Given the well-known predominance of the banking sector in the European financial landscape, the expansion in cross-border financial activities took place primarily in the form of bank-related capital flows (BIS, 2010; Kleimeier et al., 2013). While initially economic convergence processes within EMU seemed to be related to the increase in financial integration, cross-border banking was also a driving factor for the credit booms and housing bubbles in some European countries such as Spain and Ireland, and thereby contributed to the build-up of intra-Eurozone current account imbalances (see e.g. Allen et al., 2011 and BIS, 2011).

Against this background, we investigate in this paper the role of cross-border bank credit flows in a two-region monetary union by incorporating a banking sector in an otherwise standard two-country DSGE framework. As the main contribution of the paper, we evaluate the macroeconomic consequences of cross-border banking under different lending standards. This is modelled by letting the loan-to-value (LTV) ratio that banks demand of firms as a measure of their creditworthiness depend on either regional productivity shocks, or on the productivity shock from one dominating region. The latter scenario, which we term rule-of-thumb banking, may capture the effect of interest rate convergence within EMU shown in Figure 1, where the elimination of currency risk effectively led financial markets to apply the low risk standards of the largest European economies throughout the whole monetary union. Our model thus allows to evaluate the role of the financial sector for the transmission and amplification of shocks throughout the monetary union. Following Gerali et al. (2010) and Gambacorta and Signoretti (2014), the banking sector is assumed to consist of an international wholesale branch, which underlies an exogenous constraint on the target leverage ratio, and regional retail

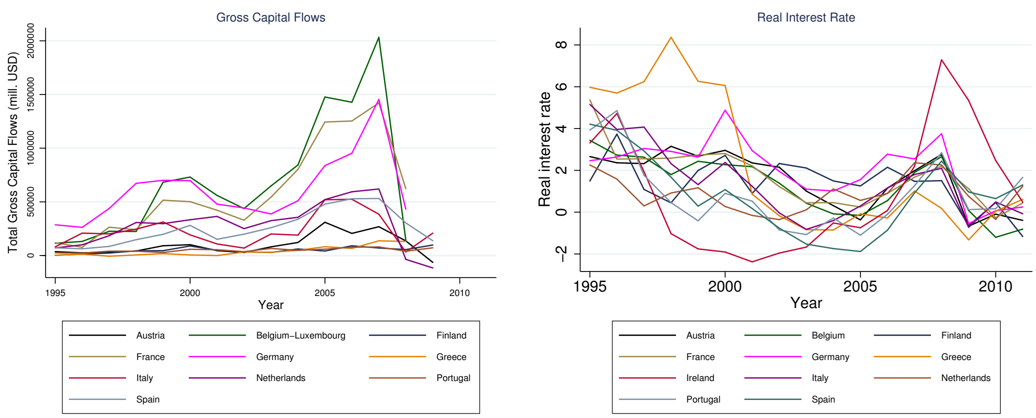

Figure 1: Total Gross Capital Flows and Real Interest Rates across EMU. Source: IMF Balance of Payments Statistics Yearbooks as assembled in Broner et al. (2013) and AMECO database.

branches providing credit to entrepreneurs and collecting deposits from households. As in Iacoviello (2005), entrepreneurs are subject to a financial constraint where credit is awarded relative to their net worth, weighted with banks' desired LTV ratio as a measure for firms' creditworthiness.

Calibrating the model to the euro area, we first analyze the effect of a common monetary policy shock. Second, the nature of cross-border banking and trading flows in a monetary union with different LTV-based credit standards is evaluated. In the baseline scenario, bank's desired LTV ratio of firms is assumed to be constant and equal across regions. The baseline scenario may thus be regarded as capturing the case with symmetric information regarding firms' net worth in both regions. In the second scenario, the parameter follows an AR(1) process driven by regional-specific technology shocks. Thereby, a positive technology shock not only affects firms' net worth directly, but also serves as a signal for banks' assessment of firms' creditworthiness. Hence, in this scenario banks are assumed to suffer from asymmetric information which they attempt to recover using the technology shock as a signal. The effect of the shock on bank lending is amplified, and via the trade links between the regions, the whole monetary union is affected. In the third scenario, we assume that there exists one dominating region providing the signal for credit worthiness. This scenario may be regarded as capturing convergence in short-run interest rates across EMU countries with the introduction of the common currency. Notably, macroeconomic volatility is highest in the third scenario.

In a nutshell, our simulation results highlight the role of cross-border lending not only as an amplifying mechanism within a monetary union, but also as a potential source of macroeconomic instability in the presence of asymmetric information. More precisely, while cross-border lending amplifies the effects of exogenous shocks in all three considered scenarios, in the latter one – where there is a dominant region which implicitly determines the lending standards for the whole monetary union – cross-border lending also leads to the occurrence of business fluctuations driven purely by laxer credit conditions, and not by macroeconomic fundamentals. Hence, the financial sector may work to exacerbate the emergence of macroeconomic imbalances in a monetary union if banks assign lending standards from one dominating region to the whole monetary union. Analyzing possibilities for monetary policy against this scenario, we find that a standard inflation targeting monetary policy rule augmented by an intermediate loan spread target may be beneficial for reducing the volatility of macroeconomic variables, an argument along the lines of the proposals by Cúrdia and Woodford (2010) and, more recently, Gambacorta and Signoretti (2014).

In modern DSGE models, the financial sector has only more recently received more attention. While models accounting for a financial accelerator as in Bernanke et al. (1999) or Iacoviello (2005) are now relatively common, most models do not feature a detailed banking sector. Recently, Gerali et al. (2010) set up a DSGE model with an imperfectly competitive banking sector subject to an internal leverage constraint and entrepreneurs facing a borrowing constraint. Estimating the model on euro area data, the authors report that shocks originating in the banking sector explain the largest share of the contraction of economic activity in 2008, while macroeconomic shocks play only a limited role. A similar result is obtained in Kollmann et al. (2011) in an estimated two-country model for the US and the euro area. In a simplified version of this model, Gambacorta and Signoretti (2014) analyse whether monetary policy should also target asset prices or credit in the presence of borrowing constraints on firms' side and a banking sector with a credit supply constraint. They show that leaning-against-the-wind policies by the central bank in reaction to supply side shocks allow for a better trade-off between output and inflation stabilization. Hence, the authors reinforce the results obtained by Cúrdia and Woodford (2010) in a much simpler model with exogenously introduced interest rate spreads. We extend the analysis in Gerali et al. (2010) and Gambacorta and Signoretti (2014) by evaluating the effect of borrowing and credit supply constraints in a two-region model of a monetary union, allowing us to focus on spill-over effects of banking related shocks between the regions.

Moreover, our paper is related to the three-country New Keynesian model analyzed in in 't Veld et al. (2014), which also focuses on the emergence of international capital flows in a monetary union like the euro area. Specifically, in 't Veld et al. (2014) identify the following determinants for the recent boom-bust cycle in Spain: a) falling risk premia on Spanish housing and non-residential capital, b) a loosening of collateral constraints for Spanish households and firms, and c) a fall in the interest rate spread between Spain and the rest of the euro area. Their approach differs from ours in that we model cross-border lending in an explicit manner through the specification of an international bank with loan retail branches at the national level, and analyze the effects of changes in banks' assessment of firms' credit-worthiness across the monetary union.

Finally, our approach is more broadly related to other two-region DSGE models of a monetary union, such as Benigno (2004), Gali and Monacelli (2008), Beetsma and Jensen (2005), Duarte and Wolman

(2008), Ferrero (2009) and Engler et al. (2013). While the former three papers evaluate optimal monetary and fiscal policy rules in a monetary union, the latter three papers focus more specifically on problems related with fiscal policy in a monetary union, such as possibilities to improve inflation differentials with fiscal policy, or to use fiscal devaluation to counteract macroeconomic imbalances.

The remainder of this paper is organized as follows: In section 2 we set up a two-region DSGE model of a monetary union with a cross-border banking sector consisting of an international wholesale branch and country-specific retail branches as in Gerali et al. (2010) and Gambacorta and Signoretti (2014). In section 3 we discuss the properties of the resulting theoretical framework, and analyze the dynamic adjustments of the model's main variables to unexpected monetary policy and cost-push shocks, as well as the consequences of alternative specifications of the lending standards by the banking sector. In section 4 we investigate the design of monetary policy in such an environment. Finally, we draw some concluding remarks in section 5.

2 The Model

We consider a two-region monetary union populated by a continuum of agents on the interval $[0, 1]$, a segment $[0, n]$ residing in a region labeled H(ome), and the other segment living in the other region labeled F(oreign). We assume that Home is the risky region (the South, for the sake of illustration), and Foreign is the safe-haven region (the North, for the sake of illustration). There is no labor mobility between the regions. Both regions are assumed to produce tradable consumption goods, which are considered to be imperfect substitutes due to a standard home bias argument.[1] Since we model a monetary union, the nominal exchange rate between the regions is constant and may be normalised to one.

2.1 Households

Households in both regions are infinitely-lived and have identical preferences and endowments within each region. Further, as in Iacoviello (2005) households are assumed to be more patient than entrepreneurs, that is, that they have a lower discount factor ($\beta < \beta_E$). As a result, households purchase a certain amount of new deposit contracts and entrepreneurs borrow a positive amount of loans in equilibrium. In other words, in equilibrium positive financial flows exist with households being net lenders and entrepreneurs being net borrowers. In order to render the model stationary, we follow Schmitt-Grohé and Uribe (2003) and assume that households face a small quadratic portfolio adjustment cost θ^D when their deposits differ from the steady-state level $\overline{D}$.

[1] Capital letters denote indices, small letters denote single units.

In a standard manner, the utility maximization problem of households in Home (analogous expressions apply for the Foreign households) is given by

$$\max E_t \left[\sum_{s=t}^{\infty} \beta^s \left(\ln C_s^H - \frac{\left(N_s^H\right)^{\eta+1}}{\eta+1} \right) \right] \tag{1}$$

subject to the real budget constraint

$$C_t^H + D_t^H = \left(\frac{W_t^H}{P_t^H} \right) N_t^H + \frac{(1+r_{t-1}^d) D_{t-1}^H}{\pi_t^H} + \frac{\theta_D}{2} \left(D_t^H - \overline{D} \right)^2 + \Pi_t^H, \tag{2}$$

where C_t^H represents the households' aggregate consumption bundle (to be defined below), N_t^H the households' labour supply, D_t^H the interest-earning deposits, $\pi_t^H \equiv P_t^H / P_{t-1}^H$ the gross CPI inflation rate, W_t/P_t^H the real wage and Π_t^H the real profits from retailers in H, which are paid in a lump-sum manner to households. Households thus maximize the expected present discounted value of intertemporal utility, which we assume to be separable in consumption and leisure. Households in both Home and Foreign save in the form of bank deposits, earning a uniform deposit rate r_t^d which for the sake of simplicity is assumed to be equal to the short-term interest rate controlled by the monetary authority of the currency union.

From the FOCs of this intertemporal optimization problem we obtain a consumption Euler equation and the standard labor supply equation:

$$\frac{C_{t+1}^H}{C_t^H} = E_t \left(\frac{\beta(1+r_t^d)}{\pi_{t+1}^H \left[1 - \theta_D (D_t^H - \overline{D}) \right]} \right) \tag{3}$$

and

$$\left(N_t^H\right)^{\eta} = \frac{W_t^H}{C_t^H P_t^H} \tag{4}$$

As the households in Foreign are assumed to have symmetric intertemporal preferences, we get analogous expressions for the Foreign households:

$$\frac{C_{t+1}^F}{C_t^F} = E_t \left(\frac{\beta(1+r_t^d)}{\pi_{t+1}^F \left[1 - \theta_D (D_t^F - \overline{D}) \right]} \right) \tag{5}$$

and

$$\left(N_t^F\right)^{\eta} = \frac{W_t^F}{C_t^F P_t^F} \tag{6}$$

Following Duarte and Wolman (2008) and Ferrero (2009), the aggregate consumption bundle in Home (analogous expressions hold for Foreign) contains country-specific goods bundles from both regions and is defined as

$$C_t^H = \left[\left(1-\omega^H\right)^{\frac{1}{\sigma}} \left(C_t^h\right)^{\frac{\sigma-1}{\sigma}} + \left(\omega^H\right)^{\frac{1}{\sigma}} \left(C_t^f\right)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \tag{7}$$

where C_t^h and C_t^f represent bundles of retail consumption goods i produced in Home and Foreign, respectively, σ denotes the elasticity of substitution between these two consumption bundles and the parameter ω^H represents the steady-state import share of households in H. Given our assumption of home bias in consumption, it holds that $\omega^H < (1-n)$.[2]

Next, we determine the optimal allocation of total consumption expenditures of the representative household across the regional good bundles C_t^h and C_t^f. This is derived from the point of view of a household in H here, where analogous relations apply for households in F. Assuming that the law of one price (LOP) holds, the price for identical bundles of goods will be the same in both regions. For instance, $P_t^h = S_t P_t^{h*}$, where P_t^{h*} is the price of goods produced in H in terms of foreign currency and S_t is the nominal exchange rate. Since we model a monetary union, the nominal exchange rate is fixed at one and LOP implies $P_t^h = P_t^{h*}$ and $P_t^f = P_t^{f*}$.

Households in region H first allocate consumption across individual retail goods, and then optimally choose how to allocation consumption across bundles produced in region H and F. We assume that country-specific bundles of retail goods i, produced in H and in F, are packed into consumption bundles C_t^h and C_t^f with the usual CES functions, adjusted for region size, where n is the size of region H, $(1-n)$ the corresponding size of region F and ε denotes the elasticity of substitution between differentiated goods:[3]

$$C_t^h = \left[n^{-\frac{1}{\varepsilon}} \int_0^n \left(C_t^h(i) \right)^{\frac{\varepsilon-1}{\varepsilon}} di \right]^{\frac{\varepsilon}{\varepsilon-1}} \tag{8}$$

$$C_t^f = \left[(1-n)^{-\frac{1}{\varepsilon}} \int_n^1 \left(C_t^f(i) \right)^{\frac{\varepsilon-1}{\varepsilon}} di \right]^{\frac{\varepsilon}{\varepsilon-1}} \tag{9}$$

This gives the usual demand functions for individual goods:

$$C_t^h(i) = \frac{1}{n} \left(\frac{P_t^h(i)}{P_t^h} \right)^{-\varepsilon} C_t^h \tag{10}$$

$$C_t^f(i) = \frac{1}{1-n} \left(\frac{P_t^f(i)}{P_t^f} \right)^{-\varepsilon} C_t^f \tag{11}$$

where the retail price indices are defined as

$$P_t^h \equiv \left[\frac{1}{n} \int_0^n \left(P_t^h(i) \right)^{1-\varepsilon} di \right]^{\frac{1}{1-\varepsilon}} \quad \text{and} \quad P_t^f \equiv \left[\frac{1}{1-n} \int_n^1 \left(P_t^f(i) \right)^{1-\varepsilon} di \right]^{\frac{1}{1-\varepsilon}}.$$

[2]Note that the assumption of a symmetric steady state with equal per-capita output in the two regions implies that the amount of home bias in both regions is related to the relative region size: $\omega^F = \frac{n}{1-n}\omega^H$.

[3]When using consumers' demand functions to derive total demand for retailers' individual goods, we model the elasticity of substitution as a country-specific exogenous shock process. Thereby, a cost-push shock on retailers' mark-up may be introduced. To keep the model simple, we omit this assumption here and simply treat the elasticity of substitution as a parameter.

Consequently, the cost minimization problem for the allocation of consumption across the region-specific bundles of retail consumption goods produced in H and F gives the following demand functions:

$$C_t^h = \left(1-\omega^H\right)\left(\frac{P_t^h}{P_t^H}\right)^{-\sigma} C_t^H \tag{12}$$

$$C_t^f = \left(\omega^H\right)\left(\frac{P_t^f}{P_t^H}\right)^{-\sigma} C_t^H \tag{13}$$

where $P_t^H \equiv \left[\left(1-\omega^H\right)\left(P_t^h\right)^{1-\sigma} + \omega^H\left(P_t^f\right)^{1-\sigma}\right]^{\frac{1}{1-\sigma}}$ denotes the CPI price index for region H. Given the assumed home bias in consumption, the households' aggregate consumption bundles in Home and Foreign and the corresponding price indices are not necessarily symmetric. In order to get rid of relative prices, we can express everything in terms of trade. Terms of trade T_t are defined as follows: $T_t \equiv P_t^f/P_t^h$. By expanding the expression for the CPI price indices in H and F, we thus derive:

$$\frac{P_t^h}{P_t^H} = \left[\left(1-\omega^H\right) + \omega^H T_t^{1-\sigma}\right]^{\frac{1}{\sigma-1}} \tag{14}$$

$$\frac{P_t^f}{P_t^H} = \left[\left(1-\omega^H\right) T_t^{\sigma-1} + \omega^H\right]^{\frac{1}{\sigma-1}} \tag{15}$$

Similarly, we get for relative prices in region F, assuming that the law of one price holds:

$$\frac{P_t^f}{P_t^F} = \left[\left(1-\omega^F\right) + \omega^F T_t^{\sigma-1}\right]^{\frac{1}{\sigma-1}} \tag{16}$$

$$\frac{P_t^h}{P_t^F} = \left[\left(1-\omega^F\right) T_t^{1-\sigma} + \omega^F\right]^{\frac{1}{\sigma-1}} \tag{17}$$

Finally, in a monetary union with fixed nominal exchange rate the real exchange rate RER_t is given by the relation of foreign to home CPI price indices:

$$RER_t = \frac{P_t^F}{P_t^H} = T_t\left(\frac{(1-\omega^F) + \omega^F T_t^{\sigma-1}}{(1-\omega^H) + \omega^H T^{1-\sigma}}\right)^{\frac{1}{1-\sigma}} \tag{18}$$

2.2 Firms

We assume that production takes place in two stages. In the first stage, firms in region H and firms in region F produce the intermediate good $Y_t^{h,int}$ and $Y_t^{f,int}$ in fully competitive markets and under credit constraints as in Iacoviello (2005). In line with Bernanke et al. (1999), we then assume that intermediate goods are sold to retailers, who take their price as given and differentiate them at no cost. Due to the differentiation of products, retailers are assumed to operate under monopolistic competition and face a quadratic cost for the adjustment of prices as in Rotemberg (1982). All profits from retail activities are rebated lump-sum to households in the respective region.

2.2.1 Entrepreneurs

Entrepreneurs in regions H and F produce intermediate goods $Y_t^{h,int}$ and $Y_t^{f,int}$ under perfect competition. Intermediate goods are used in the production of a final consumption good and are assumed to be non-tradable. Entrepreneurs aim at maximizing their consumption and use capital goods and labor for the production of intermediate goods. We assume that entrepreneurs consume only goods from their own region. At the end of each period, entrepreneurs buy new capital goods from capital producers, so that capital is only realized in the next period. Investment into new capital goods is assumed to be financed with loans from banks.[4] Following Iacoviello (2005), we assume that entrepreneurs are credit-constrained and thus can only borrow up to a fraction of their collateral, i.e. their capital assets. The resulting dynamics are similar to a financial accelerator effect as in Bernanke et al. (1999). Note that our assumption of a lower discount factor for firms ensures that the borrowing constraint will always bind in the neighbourhood of the steady-state.

Entrepreneurs in H thus maximize consumption C_t^{EH} subject to their budget and their borrowing constraints and to a Cobb-Douglas constant-returns-to-scale production function:

$$\max E_0 \sum_{t=0}^{\infty} \beta_E^t \ln C_t^{EH} \tag{19}$$

s.t.

$$C_t^{EH} + \frac{(1+r_{t-1}^{bH})}{\pi_t^H} B_{t-1}^{EH} + \left(\frac{W_t^H}{P_t^H}\right) N_t^{dH} + q_t^{KH} K_t^H \leq \frac{Y_t^{h,int}}{\mu_t} + B_t^{EH} + q_t^{kH}(1-\delta^k) K_{t-1}^{EH} \tag{20}$$

$$B_t^{EH} \leq \frac{m^E q_{t+1}^{kH}(1-\delta^k) K_t^{EH} \pi_{t+1}^H}{1+r_t^{bH}} \tag{21}$$

$$Y_t^{h,int} = A_t^H \left(K_{t-1}^{EH}\right)^{\xi} \left(N_t^{dH}\right)^{(1-\xi)} \tag{22}$$

where C_t^{EH} is entrepreneurs' consumption in H, B_t^{EH} is the amount borrowed from banks at the loan rate $(1+r_t^{bH})$, N_t^{dH} is the amount of labor demanded by entrepreneurs, $\mu_t \equiv P_{h,t}/P_t^{h,int}$ denotes the mark-up of retail over intermediate goods prices (we assume that the mark-up is the same in both regions), K_t^{EH} is capital obtained at the price q_t^{kH} and depreciated with rate δ^k. Entrepreneurs' discount factor β_E is assumed to be lower than households' β, so that entrepreneurs are always net borrowers.

The borrowing constraint in (21) states that loans cannot exceed a fraction m^E of the real depreciated value of capital assets in relation to the interest obligations. The parameter m^E may be interpreted as the loan-to-value (LTV) ratio that banks demand of entrepreneurs and, thus, gives a measure of banks' assessment regarding firms' credit-worthiness. We assume that m^E may vary across

[4] This seems to be a reasonable assumption for a model of the EMU, since bank credit is the predominant source of external finance for European firms, see for instance Allen et al. (2011).

regions in the monetary union, reflecting different macroeconomic conditions and different assessments of firms' credit-worthiness by banks. While the baseline simulation assumes symmetric borrowing constraints in both regions, in section 3.4 we assume that the borrowing constraint parameter is either affected by the region's own technology shock, or banks may perceive one region's technology shock as dominant and apply restrictions to borrowing constraints in both regions.

Finally, the Cobb-Douglas production function gives output as a function of capital and labour inputs, where A_t^H is an exogenous technology process which may differ across countries. We define A_t^H as an exogenous AR(1) process with persistence parameter ρ_a and *i.i.d.* shock process ε_t^{AH}. Defining the real return of capital as $R_t^{kH} \equiv \frac{\xi A_t^H \left(K_{t-1}^{EH}\right)^{\xi-1} \left(N_t^{dH}\right)^{(1-\xi)}}{\mu_t}$ we then get the following optimality conditions:

$$\frac{1}{C_t^{EH}} - s_t^B = \frac{\beta_E(1+r_t^{bH})}{\pi_{t+1}^H} C_{t+1}^{EH} \tag{23}$$

$$\frac{q_t^{kH}}{C_t^{EH}} = \frac{\beta_E}{C_{t+1}^{EH}} \left[R_{t+1}^{kH} + q_{t+1}^{kH}(1-\delta^k)\right] + \frac{s_t^B m^E q_{t+1}^{kH}(1-\delta^k)\pi_{t+1}^H}{1+r_t^{bH}} \tag{24}$$

$$\frac{W_t^H}{P_t^H} = \frac{(1-\xi)Y_t^{h,int}}{N_t^{dH}\mu_t} \tag{25}$$

Equation (23) gives entrepreneurs' Euler equation, where s_t^B denotes the Lagrange multiplier on the borrowing constraint and thus gives the marginal value of one unit of borrowing. The relation in (24) gives the optimal relation between entrepreneurs' consumption and real returns from capital, given the borrowing constraint. Finally, equation (25) shows that in the optimum, real wages equal the marginal product of labor. Analogous optimality conditions hold for entrepreneurs in region F.

2.2.2 Capital producers

As in Gerali et al. (2010) and Gambacorta and Signoretti (2014), we assume that each period, capital production is undertaken by perfectly competitive capital producers, which are owned by entrepreneurs. These firms buy last period's depreciated capital stock from entrepreneurs as well as an investment I_t in the form of new final goods from retailers and use both to produce the new capital stock. In line with previous authors, we assume that old capital stock can be transformed one-for-one into new capital stock, while investment from final goods underlies a quadratic adjustment cost for the transformation into capital goods. At the end of the period, the resulting new capital stock is sold back to entrepreneurs. Since capital goods production takes place within each region, we only describe the problem for capital goods producers in H, but analogous relations hold also in F:

Defining $\Delta\overline{x}_t^H \equiv K_t^{EH} - (1-\delta^k)K_{t-1}^{EH}$, capital goods producers then solve the following problem:

$$\max_{\Delta\overline{x}_t^H, I_t^H} E_0 \sum_{t=0}^{\infty} \Lambda_{k,t}^{EH} \left[q_t^{kH} \Delta\overline{x}_t^H - I_t^H\right] \tag{26}$$

s.t.

$$\Delta \overline{x}_t^H = \left[1 - \frac{\kappa^I}{2}\left(\frac{I_t^H}{I_{t-1}^H} - 1\right)^2\right] I_t^H, \tag{27}$$

where $\Lambda_{k,t}^{EH} \equiv \beta_E^k U'(C_{t+k}^{EH}) = \beta_E^k \lambda_{t+k}^{EH}$, with $k = 0, 1, ...$, is the stochastic discount factor from entrepreneurs, who are assumed to own capital producing firms, and λ_t^{EH} is the Lagrange multiplier on entrepreneur's budget constraint. The capital adjustment cost is denoted by κ^I, which we assume to be equal across regions. The FOCs then yield an expression determining the price of real capital, q_t^{kH}:

$$1 = q_t^{kH}\left(1 - \frac{\kappa^I}{2}\left(\frac{I_t^H}{I_{t-1}^H} - 1\right)^2 - \kappa^I\left(\frac{I_t^H}{I_{t-1}^H} - 1\right)\frac{I_t^H}{I_{t-1}^H}\right) + \beta_E E_t\left(\frac{\lambda_{t+1}^{EH}}{\lambda_t^{EH}} q_{t+1}^{kH} \kappa^I \left(\frac{I_{t+1}^H}{I_t^H} - 1\right)\left(\frac{I_{t+1}^H}{I_t^H}\right)^2\right) \tag{28}$$

2.2.3 Retailers

Retailers in countries H and F buy intermediate goods $Y_t^{h,int}$ or $Y_t^{f,int}$ from entrepreneurs in a competitive market, taking their price $P_t^{h,int}$ or $P_t^{f,int}$ as given. These intermediate goods are then differentiated into final consumption goods at no cost, so that retailers operate under monopolistic competition. Additionally, they are assumed to face quadratic costs for the adjustment of prices as in Rotemberg (1982). In our two-region model, retailers are symmetric, but face demand from consumers in both regions as well as from domestic entrepreneurs.

Aggregating over households and entrepreneurs, world demand for individual retail goods for retailers in H is then derived from the demand equations of households and from entrepreneurs, measured in units per domestic firm. Note that we model the elasticity of substitution for individual goods produced in H as a country-specific exogenous process ε_t^H. This gives the demand for individual good $Y_t^h(i)$, faced by a retailer in H (again, analogous relations apply for retailers in F):

$$Y_t^{h,total}(i) = \left(\frac{P_t^h(i)}{P_t^h}\right)^{-\varepsilon_t^H}\left[(1-\lambda)\left[\left(1-\omega^H\right)\left(\frac{P_t^h}{P_t^H}\right)^{-\sigma} C_t^H + \omega^F \frac{1-n}{n}\left(\frac{P_t^h}{P_t^F}\right)^{-\sigma} C_t^F\right] + \lambda C_t^{EH}\right]$$

$$Y_t^{h,total}(i) = \left(\frac{P_t^h(i)}{P_t^h}\right)^{-\varepsilon_t^H}\left[(1-\lambda)\left[\left(1-\omega^H\right)\left[\left(1-\omega^H\right) + \omega^H T_t^{1-\sigma}\right]^{\frac{\sigma}{1-\sigma}} C_t^H + \omega^F \frac{1-n}{n}\left[\left(1-\omega^F\right) T_t^{1-\sigma} + \omega^F\right]^{\frac{\sigma}{1-\sigma}} C_t^F\right] + \lambda C_t^{EH}\right]$$

$$Y_t^{h,total}(i) = \left(\frac{P_t^h(i)}{P_t^h}\right)^{-\varepsilon_t^H} C_t^{WH} \tag{29}$$

where C_t^{WH} denotes aggregate world demand for retail goods from region H and F, respectively, and λ is the share of entrepreneurs in the economy. Individual retailers in H set the price $P_t^h(i)$ for the individual final good $Y_t^h(i)$, and thus face the following maximization problem:

$$\max_{P_t^h(i)} E_t \sum_{t=0}^{\infty} \Lambda_{k,t}^{HH}\left[\frac{P_t^h(i)}{P_t^h} Y_t^{h,total}(i) - \frac{P_t^{h,int}}{P_t^h} Y_t^{h,total}(i) - \frac{\kappa_p}{2}\left(\frac{P_t^h(i)}{P_{t-1}^h(i)} - 1\right)^2 C_t^{WH}\right], \tag{30}$$

where $\Lambda_{k,t}^{HH} \equiv \beta^k U'(C_{t+k}^H) = \beta^k \lambda_{t+k}^{HH}$, with $k = 0, 1, ...$, is the stochastic discount factor from households' utility maximization in H, $\pi_t^h = P_t^h / P_{t-1}^h$ defines retail price inflation and κ_p denotes the adjustment cost for changing prices. The maximization problem is subject to total demand for the final good as derived above:

$$Y_t^{h,total}(i) = \left(\frac{P_t^h(i)}{P_t^h} \right)^{-\varepsilon_t^H} C_t^{WH} \tag{31}$$

Imposing a symmetric equilibrium, this yields the following optimality condition:

$$1 - \varepsilon_t^H + \frac{\varepsilon_t^H}{\mu_t} - \kappa_p \pi_t^h \left(\pi_t^h - 1 \right) + \beta \kappa_p E_t \left[\frac{\lambda_{t+1}^{HH}}{\lambda_t^{HH}} \frac{C_{t+1}^{WH}}{C_t^{WH}} \pi_{t+1}^h \left(\pi_{t+1}^h - 1 \right) \right] = 0 \tag{32}$$

Finally, the exogenous process for the elasticity of substitution is related to retailers' mark-up mk_t^H in region H via the relation $mk_t^H = \varepsilon_t^H / (\varepsilon_t^H - 1)$. We model retailers' region-specific mark-up as an AR(1) process with persistence ρ_{mk} and an *i.i.d.* cost-push shock ε_t^{YH}.

2.3 The Banking Sector

For our model of cross-border banking within a monetary union, we build on the work of Gerali et al. (2010) and Gambacorta and Signoretti (2014). The two papers present DSGE models with both a collateral channel from entrepreneurs' credit constraint à la Iacoviello (2005) and a credit-supply channel stemming from a target for banks' leverage ratio, which may limit the supply of credit available from banks. We follow this approach and adjust the set-up of banks in the model to allow for cross-border credit flows.

Specifically, we assume that there exists a representative bank in the monetary union, which consists of an international wholesale branch and national retail branches in each region of the monetary union. The wholesale branch is responsible for collecting deposits from households throughout the monetary union and distributes the resulting funds to the retail branches at the internal loan rates R^{bH} and R^{bF}. The retail branches then provide credit to entrepreneurs in their country of residence. Note that in this set-up, banks cannot endogenously create new credit. The wholesale branch is additionally responsible for adhering to the exogenous constraint on the bank's leverage ratio, which is modelled in the form of a quadratic cost of deviating from the target value ν. The value of ν could for instance be interpreted as reflecting regulatory legislation regarding banks' equity holdings. The credit-supply channel thus introduces an additional feedback loop between real and financial conditions in the sense that the loan rates, as well as the spread between the loan rates and the risk-free policy rate, depends on banks' leverage, their profit and, hence, on macroeconomic conditions. Finally, retail branches in H, F are assumed to operate under monopolistically competitive conditions, and thus charge a constant mark-up $\overline{\mu}^b$ on the internal loan rate R^{bH}, i.e. R^{bF}.

Aggregate deposits in the monetary union and aggregate lending to entrepreneurs in both regions are defined as follows:

$$D_t \equiv nD_t^H + (1-n)D_t^F \tag{33}$$

$$B_t \equiv \left[n^{\frac{1}{\gamma}}\left(B_t^H\right)^{\frac{\gamma-1}{\gamma}} + (1-n)^{\frac{1}{\gamma}}\left(B_t^F\right)^{\frac{\gamma-1}{\gamma}}\right]^{\frac{\gamma}{\gamma-1}} \tag{34}$$

where B_t^H and B_t^H denote the credit supply given to retail branches in region H and F, respectively, and γ denotes the bank's elasticity of substitution between lending to both regions. We thus assume that loans to the two regions are imperfect substitutes from the point of view of the bank, which may be motivated with the notion of a historically more sound economic performance in one region (here the North), as well as with differences in the credit screening capabilities in both regions. Note that we assume no home bias in lending, because the wholesale bank is assumed to be international. In our set-up, the wholesale branch thus aims at maximizing profits subject to a quadratic cost for deviating from their target leverage ratio ν and to their budget constraint:

$$\max nR_t^{bH}B_t^H + (1-n)R_t^{bF}B_t^F - r_t^d D_t - \frac{\theta}{2}\left(\frac{K_t^b}{B_t} - \nu\right)^2 K_t^b \tag{35}$$

s.t.

$$B_t = D_t + K_t^b \tag{36}$$

$$B_t = \left[n^{\frac{1}{\gamma}}\left(B_t^H\right)^{\frac{\gamma-1}{\gamma}} + (1-n)^{\frac{1}{\gamma}}\left(B_t^F\right)^{\frac{\gamma-1}{\gamma}}\right]^{\frac{\gamma}{\gamma-1}}, \tag{37}$$

where K_t^b is the banks' own capital and the parameter θ gives the proportion of K_t^b to which the cost of deviating from target applies. The bank's leverage ratio and its budget constraint are determined with respect to aggregate lending B_t. Solving the maximization problem gives the internal loan rates for credit supply to retail branches in regions H and F:

$$R_t^{bH} = n^{\frac{1-\gamma}{\gamma}} r_t^d \left(\frac{B_t}{B_t^H}\right)^{\frac{1}{\gamma}} - n^{\frac{1-\gamma}{\gamma}}\theta\left(\frac{K_t^b}{B_t} - \nu\right)\frac{\left(K_t^b\right)^2}{B_t^{\frac{2\gamma+1}{\gamma}}\left(B_t^H\right)^{\frac{1}{\gamma}}} \tag{38}$$

$$R_t^{bF} = (1-n)^{\frac{1-\gamma}{\gamma}} r_t^d \left(\frac{B_t}{B_t^F}\right)^{\frac{1}{\gamma}} - (1-n)^{\frac{1-\gamma}{\gamma}}\theta\left(\frac{K_t^b}{B_t} - \nu\right)\frac{\left(K_t^b\right)^2}{B_t^{\frac{2\gamma+1}{\gamma}}\left(B_t^F\right)^{\frac{1}{\gamma}}} \tag{39}$$

Hence, extending the closed economy set-up in Gambacorta and Signoretti (2014) to the open economy case, it turns out that both the effect of the risk-free deposit rate and of the leverage constraint on the loan rate are weighted with the relative share of loan supply to the respective region, adjusted for region size. This means that loan rates in a given region will be more sensitive to deviations from the bank's leverage target and to changes in the policy rate if the wholesale branch distributes a larger share of its overall credit supply to this region.

As in Gambacorta and Signoretti (2014), the retail banks are then assumed to be able to differentiate the wholesale loans at no costs and pass them under monopolistic competition on to entrepreneurs, charging a constant mark-up $\overline{\mu}^b$, which we assume to be equal across regions in the monetary union:[5]

$$r_t^{bH} = R_t^{bH} + \overline{\mu}^b \quad (40)$$

$$r_t^{bF} = R_t^{bF} + \overline{\mu}^b \quad (41)$$

Finally, we define aggregate banks' profits J_t^b as the sum of wholesale and retail profits and assume that banks re-invest their profits into new bank capital, where a fraction δ^b is used each period to pay for banking activities:

$$J_t^b = n r_t^{bH} B_t^H + (1-n) r_t^{bF} B_t^F - r_t^d D_t - \frac{\theta}{2}\left(\frac{K_t^b}{B^t} - \nu\right)^2 K_t^b \quad (42)$$

$$K_t^b = (1-\delta^b) K_{t-1}^b + J_{t-1}^b \quad (43)$$

2.4 Monetary Policy

The central bank in the model controls the nominal risk-free interest rate r_t^d and adjusts to inflation as in Bernanke et al. (1998). Since we model a currency union, the central bank targets inflation in both regions, where the weight is given by their relative size. This results in the following Taylor-type rule:

$$(1 + r_t^d) = (1 + r_{t-1}^d)^{\rho} (1 + \bar{r}^d)^{1-\rho} \left(\left[n\left(\pi_t^H\right) + (1-n)\left(\pi_t^F\right)\right]^{\phi_\pi}\right)^{1-\rho} \varepsilon_t^{rd} \quad (44)$$

where ρ measures the amount of interest rate smoothing, $\bar{r}^d$ the nominal steady state interest rate, ϕ_π gives the strength of inflation targeting and ε_t^{rd} is an *i.i.d.* monetary policy shock.

[5] This assumption implies that throughout the monetary union, the market structure among retail banks is similar. Since we assume that the representative bank acts internationally in both countries of the monetary union, this assumption seems reasonable.

2.5 Equilibrium

Equilibrium in our model is defined by the resource constraints and market clearing conditions in all markets. These are given as follows for the goods market, the labor market and the banking sector, where Y^k denotes aggregate output in region k:

$$
\begin{aligned}
Y_t^H &= C_t^{WH} + q_t^{kH}\left(K_t^{EH} - (1-\delta)K_{t-1}^{EH}\right) + \frac{1}{n}\delta^b K_{t-1}^b && (45)\\
Y_t^F &= C_t^{WF} + q_t^{kF}\left(K_t^{EF} - (1-\delta)K_{t-1}^{EF}\right) + \frac{1}{1-n}\delta^b K_{t-1}^b && (46)\\
nY_t^H + (1-n)Y_t^F &= n\left[C_t^H + C_t^{EH} + q_t^{kH}\left(K_t^{EH} - (1-\delta)K_{t-1}^{EH}\right)\right] && (47)\\
&\quad +(1-n)\left[C_t^F + C_t^{EF} + q_t^{kF}\left(K_t^{EF} - (1-\delta)K_{t-1}^{EF}\right)\right]\\
N_t^H &= N_t^{dH} && (48)\\
N_t^F &= N_t^{dF} && (49)\\
B_t^{EH} &= B_t^H && (50)\\
B_t^{EF} &= B_t^F && (51)\\
B_t &= D_t + K_t^b && (52)
\end{aligned}
$$

Finally, the model is log-linearized around the steady state and solved numerically using Dynare 4.4.3, see Adjemian et al. (2011).

3 Simulations

3.1 Calibration

For the following simulations we follow Gambacorta and Signoretti (2014) and set our model parameters mainly as in Gerali et al. (2010), who calibrated their model so as to match key aspects of the euro area real and financial sectors. Additionally, some parameters relating to the open-economy aspect of the model are calibrated as in the two-region model of the euro area of Engler et al. (2013). Table 1 reports all parameter values.[6]

Accordingly, households' discount factor β_P is set at 0.996, which implies a steady-state policy rate of about 2 % (annualized). Entrepreneurs' discount factor β_E is set at 0.975, as in Iacoviello (2005). The inverse of the Frisch elasticity η is set at 1 as in (Galí, 2008). The share of capital in the aggregate production function α is set at 0.20, and the depreciation rate of physical capital (δ^k) at 0.05 as in Gerali et al. (2010). The elasticity of substitution across regional goods bundles σ is set at 2 as in Engler et al. (2013). Further, we set the adjustment cost for changing prices κ_p at the

[6] We also considered estimating the current framework with disaggregated euro area data, but decided against it because a proper estimation of the cross-border banking effects at work here would be a task beyond the scope of this paper, due to their overlap with the global financial liberalization since the 2000s. We leave this for further research.

Table 1: Calibration parameters

Parameter	Description	Value
β_P	Patient household discount factor	0.996
β_E	Entrepreneurs discount factor	0.975
σ	Elasticity of substitution between Home and Foreign goods bundles	2
θ^D	Parameter for households' portfolio adjustment cost	0.001
$\overline{D}$	Steady-state level of deposits	1
ω^H	Steady-state import share in Home	0.33
ω^F	Steady-state import share in Foreign	0.17
n	Home's relative size	0.34
η	Inverse of the Frisch elasticity	1
α	Capital share in the production function	0.20
δ^k	Depreciation rate of physical capital	0.050
κ^I	Investment adjustment cost parameter	5
m^E	Entrepreneurs LTV ratio	0.35
κ_p	Adjustment cost for changing prices	28.65
γ	Bank's elasticity of substitution between lending to both regions	2
θ	Bank capital adjustment cost	11
ν	Target capital-to-asset ratio	0.09
δ^b	Cost for managing the bank's capital position	0.049
ϕ_π	Inflation gap Taylor rule parameter	1.5
ρ	Monetary policy inertia	0.77
ρ_{mk}	Persistence of retailers' cost-push shocks	0.5
ρ_a	Persistence of technology shocks	0.95
σ^2_{mp}	Variance of monetary policy shock	0.1
σ^2_{mk}	Variance of cost-push shock	1
σ^2_a	Variance of technology shock	1

value estimated by Gerali et al. (2010) for the euro area, namely 28.65. Concerning the investment adjustment cost parameter κ^I, we set it at 5 as in Gambacorta and Signoretti (2014) in their analysis of their model's response to technology shocks.[7]

The required LTV ratio for entrepreneurs set by the retail bank branches, m^E, is set at 0.35 in the baseline case, which is similar to the average ratio of long-term loans to the value of shares and

[7] Gambacorta and Signoretti (2014) set κ^I at 0.5 when analyzing cost-push shocks, but argue that when both technology and cost-push shocks hit their model at the same time, their overall results are not affected by the choice of a particular value of κ^I, see Gambacorta and Signoretti (2014, p.155-56).

other equities for nonfinancial corporations in the euro area, see also Gerali et al. (2010) as well as Gambacorta and Signoretti (2014). The target leverage ratio ν and the cost for managing the bank capital position δ^b are set at 9% and 0.049, respectively, following again Gerali et al. (2010). Due to the lack of a more direct measure, we set the bank capital adjustment cost θ at 11, the value estimated by Gerali et al. (2010). Finally, the bank's elasticity of substitution between loans to Home and Foreign, γ, is set equal to the elasticity of substitution between Home and Foreign goods bundles, σ, at 2. The degree of monetary policy inertia is set at 0.77, and ϕ_π is set at 1.5, as it is standard in the literature.

Finally, we set the relative size of the Home and Foreign economies at 0.34 and 0.66, respectively, to reflect the asymmetric economic size of the regions within the euro area, assuming for the sake of illustration that Home represents the Southern euro area countries such as Spain, Italy, Portugal or Greece, and Foreign the Northern euro area countries, in particular Germany (see also Engler et al., 2013).

3.2 Monetary policy shock

In order to illustrate the different mechanism at work in the present framework, in the following we discuss the dynamic adjustments of the model's endogenous variables to an unexpected contractionary shock on the policy rate of the monetary union's central bank.

As summarized in Figure 2, the unexpected increase in the policy rate of the monetary union's central bank affects both economies through a variety of channels. First, a contractionary shock to the policy rate r_t leads to an increase in the internal rate of interest between the wholesale and the region-specific retail bank branches, and thus by extension also to an increase in the loan interest rates R^{bH} and R^{bF} offered to the entrepreneurs by the retail bank branches in the Southern and Northern regions, respectively. This pass-through effect from r_t to R^{bH} and R^{bF} is larger than one, as the rise in the spread between the loan rate in both regions and the policy interest rate clearly illustrates. At this point it is noteworthy that despite the fact that the initial shock in the policy rate affects both regions in an identical fashion, the reaction of loan interest rates, the loan spreads and by extension the aggregate amount of awarded loans is, though qualitatively similar, quantitatively different in both regions, with a larger effect on the spread in the Southern region. This rather unexpected result arises from the different economic sizes assumed for both economic regions and the resulting different relative shares of aggregate lending allocated to each region.[8]

The deterioration in the credit financing-conditions for firms leads to a decrease in the demand for credit and thus in the amount of loans granted in equilibrium. This results in a reduction in the level

[8]Theoretically, if both countries were completely identical in their economic structure and had the same relative economic size, i.e. $n = 0.5$, then the reactions would also be identical and no shift in relative prices would occur. This is indeed corroborated by our model when n is set at 0.5.

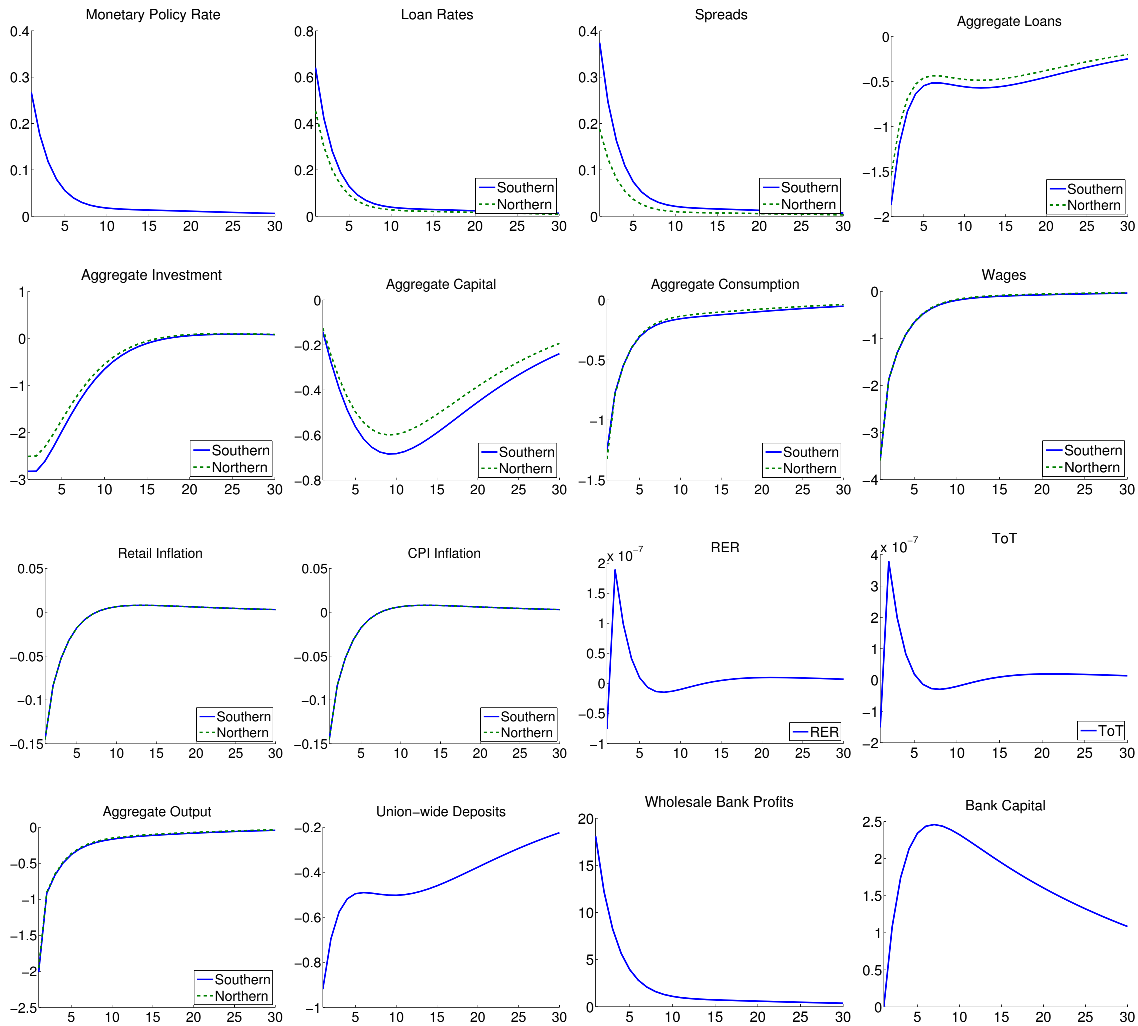

Figure 2: Dynamic adjustments after a union-wide monetary policy shock. All rates are shown as absolute deviations from steady state, expressed in percentage points. All other variables are percentage deviations from their respective steady state levels.

of aggregate investment and by extension in the capital accumulation in both economies, as illustrated in Figure 2.

The increase in the policy rate leads of course also to a reduction in aggregate (both households' and entrepreneurs') consumption – by their respective consumption Euler equations – which, jointly with the reduction in aggregate investment, leads to an overall decrease in current aggregate output, employment and wages. Note that the effect of the monetary policy shock on aggregate output is very similar across both regions despite larger differences in the effect on investment. This is because aggregate consumption in our model is a relatively larger part of output compared to investment. The reduction in households' wage income causes a net reduction in their bank deposits despite the increased opportunity costs related with the increase in the deposit rate (which is assumed to be equal to the policy rate).

Finally, as expected the increase in the policy rate causes a fall in both retail and CPI inflation in the two regions. Since the LOP assumption holds, inflation in both regions reacts symmetrically to the shock, even though the level of inflation may differ.

Turning our attention back to the banking sector, the dynamic reactions of the wholesale bank's profits J_t^B and capital K_t^b illustrated in Figure 2 show clearly that while the reduction in the quantities of both deposits and loans affects the international wholesale banking sector negatively, the net effect of a policy rate increase is positive due to the larger increase in the internal and loan interest rates, leading to an increase in the bank's profits and capital.

3.3 Cost-Push Shock

Next, we briefly discuss the dynamics resulting from an unexpected cost-push shock of one standard deviation in the Northern region. Figure 3 summarizes the dynamics of the main variables of the model.

As can be clearly observed, an unexpected asymmetric cost-push shock in the Northern region leads to an immediate rise in both retail and CPI inflation in both regions, as well as to a relative (though very small in absolute terms) improvement in the competitiveness position of the Northern economy. Note that since the LOP applies in our model, prices in both regions adjust symmetrically to the cost-push shock in the Northern region, even though the level of CPI inflation may differ due to the asymmetric region sizes. The standard countercyclical reaction of the monetary union's central bank implies a rise in the policy rate sufficient to yield an increase in the real interest rate. Again, this effect is amplified via the banking sector, as the increase in loan rate spreads in both regions clearly illustrates. Note that the larger increase in the Southern regions' loan spread is again due to the different region sizes.

However, in the case of a cost-push shock occurring only in one region, here the North, only the Northern region's economy is adversely affected by the shock. This may be observed by the drop in retail profits due to a fall in aggregate demand for retail goods produced in the Northern region (the initial positive effect is because prices increase on impact, while demand is slower to adjust), leading to a fall in agregate consumption, wages, investment and output. By contrast, retail profits in the Southern region increase, yielding a boom in the region. Therefore, even though loan spreads increase more in the Southern region, entrepreneurs from the South are awarded relatively more loans.

Finally, as in the case of a monetary policy shock, the banking sector profits relatively more from the increase in loan spreads than from the drop in loans and deposits, so that overall banking profits and capital increase.

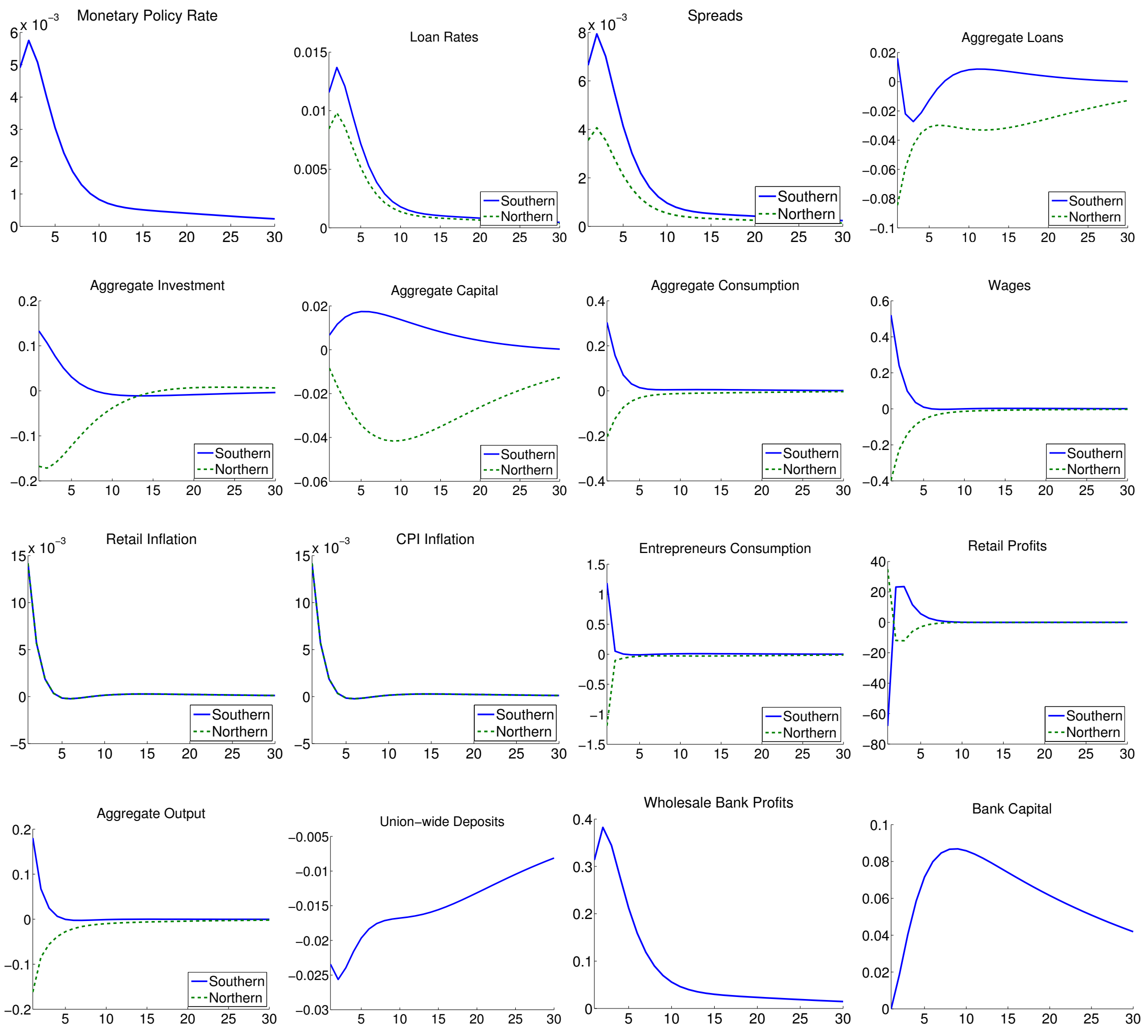

Figure 3: Dynamic adjustments after a cost-push shock in the Northern region. All rates are shown as absolute deviations from steady state, expressed in percentage points. All other variables are percentage deviations from their respective steady state levels.

3.4 Cross-Border Lending, Rule-of-Thumb Banking and Business Fluctuations

Here we investigate the implications of cross-border banking for macroeconomic activity. Indeed, as previously discussed (see also CIEPR, 2012), the recent experience of the housing boom-and-bust cycles in Spain and Ireland – which were financed to a large extent by cross-border capital flows from Germany – seems to suggest that cross-border lending may not have been subject to the same screening standards for credit worthiness as internal lending, and that this practice may have thus contributed decisively to the recent macroeconomic instability of those countries.

In order to model this phenomenon in the most parsimonious manner, we assume in the following that the LTV borrowing constraint for entrepreneurs, captured by the parameter m^E, is not constant as assumed in the previous sections, but that it follows a time-varying process driven by firms' region-specific total factor productivity (TFP):

$$m_t^{E,k} = (1 + \mu A_{t-1}^k)\, m^E, \quad k = \{H, F\} \tag{53}$$

where $\mu \leq 1$ is a proportionality factor, assumed here to equal 0.65. While this is of course a convenient modeling shortcut, the rationale behind this specification is straightforward: In the real world, banks usually employ a screening mechanism to assess the profitability of the investment projects to be financed, and thus the creditworthiness of the loan applicants. To reflect this, we assume that investment profitability is given solely by TFP. Under the assumption that TFP shocks are observable also by the banking sector, it is natural to assume that a positive TFP shock leads to a relaxation of the borrowing constraint imposed on the entrepreneurs by the banks. Obviously, the determination of $m_t^{E,k}$ would be region-specific in the normal case, with the retail bank branches in Home and Foreign determining m_t^{EH} and m_t^{EF} according to the observation of A_{t-1}^H and A_{t-1}^F, respectively. We refer to this normal case as scenario 1 in the following.

Alternatively, we consider an additional scenario where the lending standards in both countries are determined uniformly solely on the observation of TFP in the Northern region, i.e.

$$m_t^{E,k} = (1 + \mu A_{t-1}^F) m^E, \quad k = \{H, F\}. \tag{54}$$

This alternative specification of $m_t^{E,k}$ solely as a function of A_{t-1}^F is meant to represent the rule-of-thumb determination of lending standard in cross-border banking within the euro area discussed for instance by Allen et al. (2011) and CIEPR (2012). In particular, this specification reflects the implicit risk pooling associated with the establishment of monetary unions, and observable in the excessively low sovereign risk premia of EMU countries and resulting interest rate convergence during the 2000s, see e.g. De Grauwe and Ji (2012) and Proaño et al. (2014). We term this scenario rule-of-thumb banking or scenario 2.

Figure 4 illustrates the dynamic adjustment of selected variables of our model under a constant LTV borrowing constraint (baseline scenario), varying region-specific lending standards (scenario 1), and rule-of-thumb lending standards (scenario 2). In all cases we assume a positive one-standard deviation shock in TFP in the Northern region, A_t^F, leaving all other variables (and especially TFP in the Southern region) unchanged, as the first two graphs in the first column of Figure 4 show.

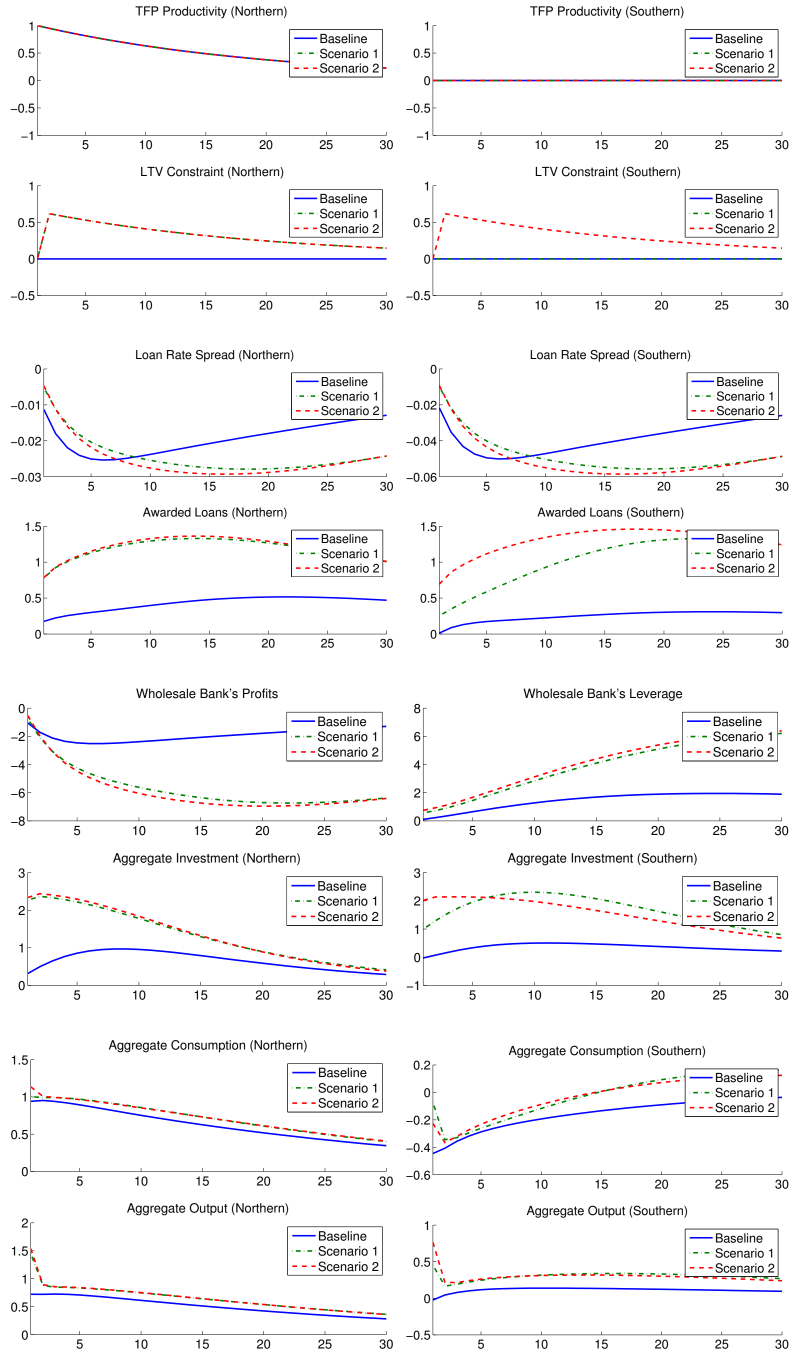

Figure 4: Dynamic adjustments to a positive TFP shock in the Northern region under constant (baseline), region-specific (scenario 1) and rule-of-thumb (scenario 2) lending standards. All rates are shown as absolute deviations from steady state, expressed in percentage points. All other variables are percentage deviations from their respective steady state levels.

As further shown in Figure 4, a positive shock to TFP in the North leads to an expansion in aggregate income, consumption and investment in that region, the latter being partly financed by an expansion of lending to the entrepreneurs by the banking sector over time. Note that this credit expansion takes place also in the baseline case where $m^{E,k}$ = const., but is of course larger in magnitude in the two alternative scenarios, where $m^{E,k}$ is a direct function of TFP in the Northern region. Due to the higher aggregate income in the North, there is also a higher demand for goods produced there which requires an expansion of the capital stock and thus in the production capabilities of the region. This effect takes place in all three scenarios, but is of course largest in scenario 2, where the LTV borrowing constraint (assumed to be a function of the observed TFP in the Northern region) is relaxed not only in the Northern economy (where indeed an increase in TFP took place), but also in the Southern region. As the graphs in the last row in Figure 4 show, aggregate economic activity in both regions is significantly larger – particularly in the first periods after the shock – in scenarios 1 and 2 relative to the baseline scenario.

Analyzing the different effects on dynamic adjustments in the Southern economy in the different scenarios allows to distinguish between spill-over effects via the trade linkages and the additional effect of rule-of-thumb banking assumed in scenario 2. These emerge specifically with respect to loans awarded to entrepreneurs and, thus, investment. As the South is awarded the same relaxation in borrowing conditions than the North in scenario 2, both loans and investment increase more rapidly. Finally, both aggregate consumption and output increase by more with time-varying LTV ratios, although there are only marginal differences between scenario 1 and 2. Overall, the comparison between scenarios 1 and 2 shows that with rule-of-thumb banking additional business cycle dynamics occur in the Southern region, which are solely related to relaxations in credit availability, and not backed by macroeconomic fundamentals.

Loan rate spreads decrease in both regions following the increase in loans awarded after the Northern TFP shock, whereas the effect is relatively larger in the Southern region. In both regions, the effect becomes stronger over time as the bank adjusts the borrowing constraint to changes in productivity. Since credit expands at the same time, we observe again that – as in the previously discussed cases of a monetary policy or cost-push shock – price effects (in this case changes in loan rate spreads) dominate over quantity effects (i.e. loans awarded), resulting here in a negative effect of the TFP shock on the international wholesale bank's profits. Further, as it can be clearly observed in Figure 4, the reduction in the bank's profits increases ceteris paribus the wholesale bank's leverage, as a higher quantity of awarded loans goes hand in hand with lower profits and, by extension, lower bank capital, see eq. (43). This result is particularly noteworthy as it implies that cross-border rule-of-thumb banking leads to a higher leverage in the financial system, and thus to a more fragile macrofinancial situation.

In order to assess the effects of this alternative specification of the LTV borrowing constraint for the business cycle dynamics of the model, we report the theoretical first and second moments of the (logarithms of the) main variables of the model in Table 2.

Table 2: Theoretical First and Second Moments (of the logarithms of the variables)

	Mean			Variance		
Variable	Baseline	Scenario 1	Scenario 2	Baseline	Scenario 1	Scenario 2
C_t^H	0.999	1.007	1.007	4.913	5.520	5.552
C_t^F	1.004	1.013	1.013	4.301	4.957	4.991
WI_t^H	-0.375	-0.364	-0.364	8.005	12.235	12.239
WI_t^F	-0.372	-0.361	-0.361	7.855	11.987	12.037
D_t	0.174	0.664	0.664	3.706	15.078	15.167
I_t^H	-2.027	-1.959	-1.959	7.598	20.432	20.233
I_t^F	-2.010	-1.937	-1.937	6.812	15.705	15.782
K_t^H	0.969	1.037	1.037	4.160	11.761	11.635
K_t^F	0.986	1.059	1.059	3.744	8.440	8.469
B_t^H	-0.147	0.943	0.943	4.856	13.001	13.072
B_t^F	-0.127	0.966	0.966	4.232	9.829	9.877
B_t	0.531	1.623	1.623	4.315	10.938	11.127
K_t^b	-2.171	-1.177	-1.177	15.370	59.777	59.917
K_t^b/B_t	2.702	2.799	2.799	19.202	68.921	69.140
J_t^b	-4.992	-3.997	-3.997	28.348	81.419	81.617
r_t^d	0.003	0.001	0.001	0.416	0.463	0.465
$spread_t^H$	0.011	0.008	0.008	0.572	0.648	0.650
$spread_t^F$	0.008	0.007	0.007	0.285	0.324	0.325
Y_t^H	1.048	1.059	1.059	3.862	5.925	5.901
Y_t^F	1.051	1.063	1.063	3.939	5.717	5.743
π_t^H	-0.000	-0.002	-0.002	0.234	0.301	0.303
π_t^F	-0.000	-0.002	-0.002	0.234	0.301	0.303
RER_t	-0.000	-0.000	-0.000	0.000	0.000	0.000
T_t	-0.000	-0.000	-0.000	0.000	0.000	0.000

As can be observed there, there is no significant variation in the theoretical means of the reported variables across the three scenarios just analyzed, notable exceptions being the means of aggregate investment I_t^H and I_t^F, the amount of loans awarded to the entrepreneurial sector B_t^H and B_t^F (and by extension, B_t^b), as well as the aggregate amount of households deposits D_t, which feature a significant increase due to a varying LTV constraint, either as determined by eq. (53) or by eq. (54). In other words, a varying LTV constraint linked to the development of TFP in the entrepreneurial sector leads to a larger amount of awarded loans and aggregate investment in both economies, and thus in the monetary union.

This rather small level effect of the endogenization of the LTV ratio through eq. (53) and eq. (54) at the macroeconomic level is, however, relativized when taking a look at the second moments of the model's main variables. Indeed, as reported in the last three columns of Table 2, the volatility of nearly all variables (the only exceptions being the real exchange rate RER_t and the terms-of trade

T_t) is significantly larger in the two scenarios 1 and 2 in comparison to the baseline scenario, being marginally larger in the second scenario in the great majority of cases.

Summing up, the numerical results discussed in this section suggest that cross-border lending activities, especially with time-varying and potentially cycle-enhancing borrowing constraints, can contribute to the magnification of macroeconomic fluctuations. This may eventually lead to sudden busts as was the case in Spain and Ireland. Further, they highlight the need of a strict regulation of the financial system and the lending standards, in particular given the perfect mobility of capital within monetary unions such as the euro area.

Nonetheless, it could be possible that monetary policy could support such regulatory efforts by the appropriate design of a monetary policy rule. Indeed, recent theoretical studies within the DSGE modeling paradigm have shown that the incorporation of the banking sector – and the explicit modeling of interest spreads – has important consequences for the design of monetary policy, see for instance Gambacorta and Signoretti (2014). In the next section we thus address this question.

4 Is there a role for monetary policy in stabilizing the effects of cross-border banking?

Despite the highly stylized formulation of the banking sector in our model of a monetary union, the simulation exercises of the previous sections clearly illustrate how cross-border lending can act as an amplifying factor in the business cycle fluctuations within monetary unions, especially when lending standards are not adequately determined at the regional level. In this context, the obvious question is: What are the consequences of cross-border lending for the conduction of monetary policy? Or, in a more plain wording: Can monetary policy alleviate some of the destabilizing effects of cross-border banking?

Since we model a banking sector (both wholesale and retail branches) with monopolistic power as in Gerali et al. (2010) and Gambacorta and Signoretti (2014) in the present theoretical framework, monetary policy has only imperfect control of the effective loan interest rates at the regional level. However, in contrast to these studies which analyzed only closed economies, in the present paper we explore the open-economy, union-wide implications of such a modeling approach for the banking sector in the presence of trade links and cross-border banking. In other words, our framework allows us to investigate how monetary policy should be conducted in the presence of an imperfect interest rate pass-through to the monetary union sphere.

In order to address this imperfect pass-through problem, recent studies introducing a banking sector into the DSGE model such as Cúrdia and Woodford (2010), Gertler and Karadi (2011), Goodfriend and McCallum (2007) and Gambacorta and Signoretti (2014) have proposed incorporating the spread between the loan and the policy rate in an otherwise standard monetary policy rule.

In our framework, this implies including the loan rate spreads in *both* regions H and F, namely r_t^{bH} and r_t^{bF} – weighted by the respective relative regional sizes – in eq. (44), delivering

$$(1+r_t^d) = (1+r_{t-1}^d)^{\rho}(1+\bar{r}^d)^{1-\rho}\left(\left[n\pi_t^H + (1-n)\pi_t^F\right]^{\phi_\pi}\right)^{1-\rho}\left(\left[n\, r_t^{bH} + (1-n)\, r_t^{bF} - r_t^d\right]^{\phi_s}\right)^{1-\rho}\varepsilon_t^{rd} \tag{55}$$

as $n\left(r_t^{bH} - r_t^d\right) + (1-n)\left(r_t^{bF} - r_t^d\right) = n\, r_t^{bH} + (1-n)\, r_t^{bF} - r_t^d$, where ϕ_s represents the reaction parameter of the policy rate to increases in the weighted average of the loan rate spreads in the two monetary union regions.

In Figure 5 we show the variances of the key model variables as functions of different values of the monetary policy parameters ϕ_π and ϕ_s under the scenario 2 specification of the LTV borrowing constraint discussed in the previous section. The purpose of this exercise is of course to analyze the effects of implementing an unconventional monetary policy rule as discussed in the recent literature.

Figure 5 contains a variety of important results. To begin with, it is interesting to note that the variances of all reported variables are nonlinear functions in ϕ_π and ϕ_s, as the irregular shape of the surfaces indicate. Nonetheless, a common feature of all variances is that they decrease in ϕ_π for all considered values of ϕ_s. This underlines the common notion that inflation targeting is key for the stabilization not only of inflation, but for the other key macroeconomic variables as well.

In contrast, the relationship between macroeconomic volatility and ϕ_s is less straightforward. On the one hand, concerning aggregate output in the Southern and Northern regions, the graphs in Figure 5 show that the incorporation of the unconventional term $\phi_s(\,\cdot\,)$ in the monetary policy rule, i.e. the switch from $\phi_s = 0$ to $\phi_s = 0.05$, leads to an increase of the output variance in the two economies. However, for $\phi_\pi \in [1.5\,,\,1.65]$, a further increase of ϕ_s leads to a small decrease in Y_t^H's variance, but not in Y_t^F's. As the graphs concerning aggregate consumption and investment illustrate, this effect results primarily from the reaction of consumption volatility to these parameter changes. By contrast, it is particularly noteworthy that higher values of ϕ_s lead to a lower volatility of aggregate investment in both Southern and Northern regions for rather low values of ϕ_π and ϕ_s, i.e., when monetary policy targets inflation with the strength commonly assumed ($\phi_\pi = 1.5$) and reacts only with about $\phi_s = 0.2$ to changes in loan rate spreads. Note that this effect is more pronounced regarding investment in the Southern region.

Further, the dependence of the loans' variance with respect to ϕ_s is also worth being highlighted, as it demonstrates in a clear manner that this type of unconventional monetary policy works to contribute to macroeconomic stabilization through the reduction in the amount of (eventually destabilizing) cross-border lending. Similar to the effect on aggregate investment, we observe in Figure 5 that a medium reaction to interest rate spreads with $\phi_s \in [0.2\,,\,0.4]$ is necessary to reduce the volatility of loans if the central bank targets inflation with $\phi_\pi = 1.5$. Finally, at the usual inflation targeting parameter our results show that a mild reaction to interest rate spreads will also stabilize

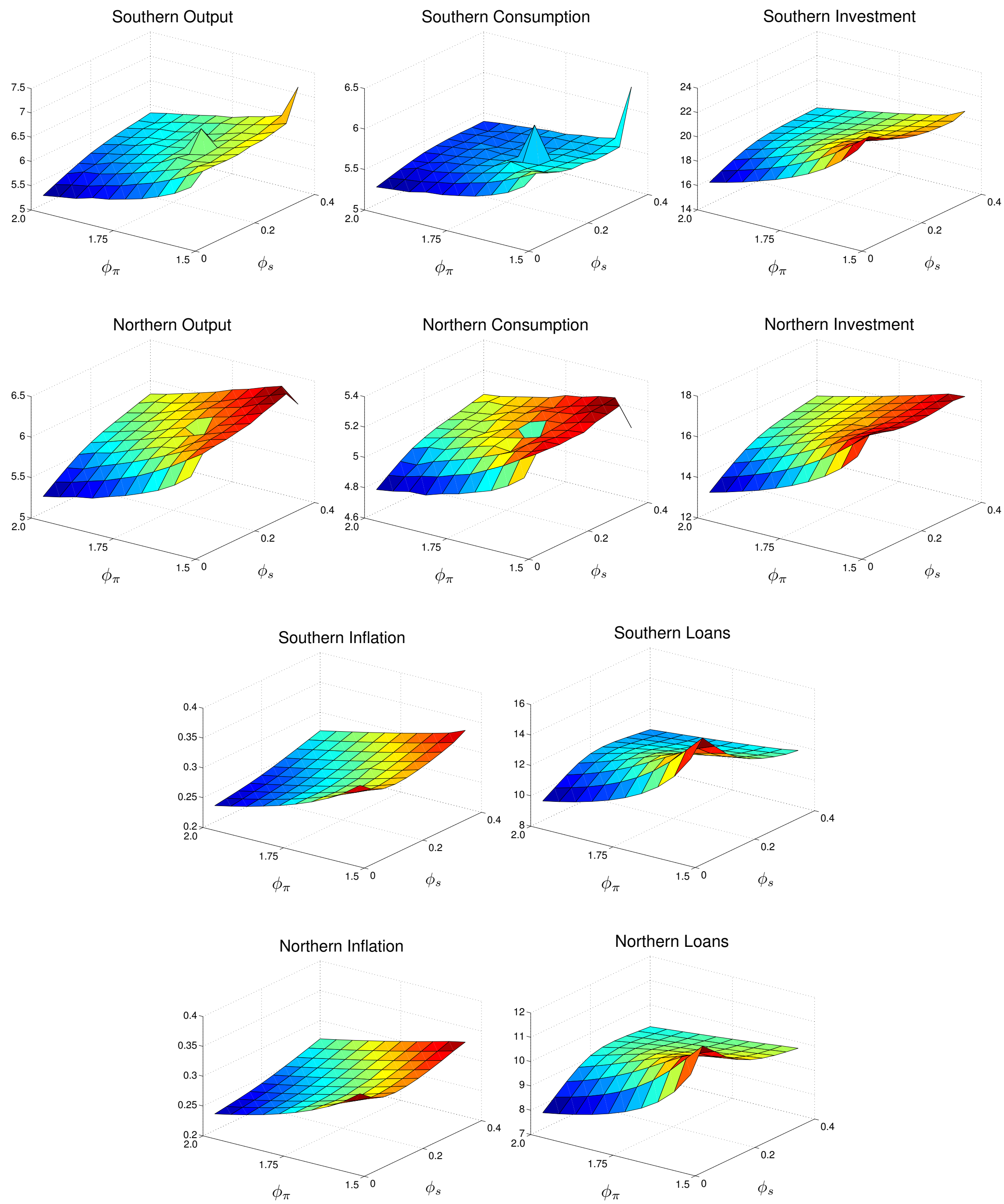

Figure 5: Theoretical Variances of Key Model Variables for $\phi_\pi \in [1.5, 2.0]$ and $\phi_s \in [0, 0.4]$

inflation further. Overall, our results thus corroborate the findings in Cúrdia and Woodford (2010) and Gambacorta and Signoretti (2014) also in an open-economy monetary union setting.

5 Concluding Remarks

What are the macroeconomic consequences of cross-border banking and a rule-of-thumb determination of lending standards? In this paper, we try to shed some light onto this and other questions by setting up a two-region DSGE model of a monetary union featuring a banking sector along the lines of Gerali et al. (2010) and Gambacorta and Signoretti (2014), allowing us to differentiate the effects of cross-border lending from the standard trade links of two interacting economies in a monetary union.

Against the background of the recent credit-fuelled housing booms and busts experienced in some euro area countries such as Spain and Ireland, we investigate the macroeconomic consequences of asymmetric rule-of-thumb lending standards applied in a cross-border manner. Specifically, we compare a scenario where the LTV ratio that banks demand of entrepreneurs depends on regional productivity shocks to a scenario where desired LTV ratios are driven by productivity shocks from one dominating region, thereby relaxing borrowing constraints for all firms after a positive technology shock in that region. The latter scenario is motivated by the observation of converging real interest rates after the start of the European monetary union, with a corresponding increase in cross-border capital flows as financial markets applied the low risk standards of the Northern region throughout the whole monetary union. Our simulation results suggest that such type of cross-border lending practices amplifies the effects of a region-specific technology shock in both regions of the monetary union, leading to business fluctuations in the other country generated by the relaxation of lending standards, and not by corresponding changes in macroeconomic fundamentals. Furthermore, such developments lead to a significant increase in the volatility of all main macro variables in both regions of the monetary union. We thus show that under certain conditions the financial sector may exacerbate macroeconomic imbalances originating via the trade channel within the monetary union.

Given the significant effects that such a larger aggregate volatility implies both in macroeconomic and social terms, our results suggest that macroeconomic policy (both fiscal and monetary) concerned with stabilizing the regions within a monetary union should pay attention to the nature of cross-border lending within the union, especially if banks do not assign region-specific lending standards. Further, our simulation results indicate that a central bank adjusting to changes in loan spread rates with a relatively small coefficient may enhance macroeconomic stability in the face of rule-of-thumb cross-border banking. This effect, however, may not replace a tighter regulation and standardization of lending practices across the monetary union intended to reduce destabilizing capital in- and outflows between the regions within monetary unions such as the euro area.

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