

# Unconventional monetary policy in a monetary union\*

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April 6, 2018

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## Abstract

I analyze the adoption of unconventional monetary policy measures in a monetary union. To this end, I lay out a two-country monetary union model with balance-sheet constrained financial intermediaries and central bank credit policy. The framework is used to compare the welfare implications of union-wide versus country-specific optimal simple unconventional monetary policy rules. It is shown that whenever the central bank reacts to indicators which are highly correlated between countries, a union-wide rule might be preferable over a country-specific rule – despite the presence of country-specific shocks. When considering structural asymmetries between countries, it is found that under some policies, a financially less stable country benefits much more from unconventional policy, implying, however, that incentives to reform financial structures might be eliminated.

**Keywords:** unconventional monetary policy, optimal simple rules, welfare, heterogeneous monetary union, financial frictions

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\*I would like to thank my supervisor Lutz Weinke for his guidance throughout this project. I am grateful for comments by participants of the 12th ifo Dresden Workshop and the Brownbag Seminar Macroeconomics at Humboldt-Universität zu Berlin. This work has further benefited from discussions with Jordi Galí, Giovanni Lombardo, Felix Strobel and Grzegorz Długoszek. I would also like to thank Johannes Pfeiffer for answering many of my questions in the Dynare Forum. All errors are mine.

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# 1 Introduction

It is widely known that joining a monetary union inevitably impairs the ability of monetary policy to address country-specific shocks. The common nominal interest rate adjusts proportionally to union-wide circumstances, which might cause either too much or too little stabilization in single countries. Furthermore, given that the nominal exchange rate between member countries is fixed, nominal devaluations – which have been occasionally used to prompt productivity in individual countries in the past – are ruled out.

This paper raises the question, whether it is desirable to use unconventional monetary policy to stabilize country-specific shocks in a monetary union. To this end, I lay out a two-country DSGE model with leverage-constrained financial intermediaries as modeled in [Gertler and Karadi \(2011\)](#) and [Gertler and Kiyotaki \(2011\)](#). The model features international trade in goods and assets, a common currency and a union-wide nominal interest rate. As in [Gertler and Karadi](#) and [Gertler and Kiyotaki](#), I assume that the common central bank can expand credit to banks (“liquidity facilities”) and firms (“corporate sector purchase programs”). Unconventional policy is conducted by following a feedback rule which responds to financial indicators such as the credit spread or credit growth. In particular, I compare the welfare implications of optimal simple rules<sup>1</sup> based upon country-specific indicators to the corresponding outcomes under rules that are based upon union-wide indicators. In the baseline version of my model, I assume that countries are symmetric. However, structural heterogeneity is an important factor when discussing the conduct of unconventional policies in a monetary union. When some countries of a monetary union rely more heavily on central bank credit than others, while costs and risks are born by the union as a whole, moral hazard considerations naturally arise. Therefore, I also consider a modified version of the model in which one country has a more sound financial system than the other.

A key finding of the analyses is that, under some circumstances, union-wide rules can provide higher welfare than their country-specific counterparts despite the presence of country-specific shocks. In particular, whenever the central bank reacts to indicators which are highly correlated between countries, a union-wide rule might be preferable over a country-specific rule. As in [Dedola et al. \(2013\)](#), this finding might be rationalized with the fact that I consider a second-best environment in which policymakers cannot fully eliminate financial frictions or their consequences. Unconventional monetary policy can reduce some of the additional volatility caused by financial frictions,<sup>2</sup> especially,

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<sup>1</sup>Optimal simple rules are feedback rules whose reaction coefficients are chosen such that the welfare of an individual household is maximized.

<sup>2</sup>The excess volatility caused by financial friction is a result of what is commonly referred to

in the economy hit by the shock. However, it can also fuel volatility by “overstabilizing” the country spared by the shock, especially when the unconventional instrument reacts to union-wide indicators. In general, a reduction in volatility is welfare-improving as it enhances consumption smoothing. On the other hand, in the second-best environment considered here, some degree of volatility interacts with the financial friction to stimulate precautionary behavior, such as precautionary saving and capital accumulation, which also has a positive effect on lifetime utility. In the given setup, the trade-offs between the differing effects of unconventional monetary policy on average volatility and, further, between the differing effects of volatility on union-wide welfare can be tilted towards the positive or the negative depending on how the rule is formulated, i.e., which indicators the central bank reacts to.

When considering asymmetric countries which differ with respect to the soundness of their financial system, I find that the introduction of certain unconventional monetary policy measures profits the financially less stable country much more. The latter implies, however, that incentives to reform financial markets<sup>3</sup> might be severely distorted by the introduction of unconventional monetary policy. These results hold even if the particular unconventional policy does not target country-specific needs.

The unconventional monetary policy measures analyzed in this paper represent instruments which are also part of the ECB’s toolbox. Liquidity facilities have been one of the most important instruments of the ECB. Since 2008, liquidity was provided to the banking system elastically and at increasingly long durations through main and longer-term refinancing operations (MROs and LTROs) (Praet, 2017). Before and at the beginning of the financial crisis, Germany was the main user of these instruments (see figure 3 in the appendix). However, when the most significant three-year LTROs were provided in 2011 and 2012, the composition of country usage changed completely. Since 2011, the periphery’s share in the usage of liquidity facilities has increased to more than 70% and has remained at this high level ever since (see figure 4 in the appendix). This implies that liquidity facilities were provided flexibly according to country-specific needs. The picture is quite different when considering the ECB’s asset purchase programs which started in 2016. Direct lending to non-financial firms is distributed between countries in a fixed manner, according to a capital key which reflects the market value of eligible corporate bonds (ECB, 2017). Therefore, as figure 5 in the appendix shows, mainly firms in the economically largest – and also less troubled – countries have access to central bank

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as “financial accelerator”, i.e., the real effects of shocks originating in the real or financial sector are amplified due to the presence of financial frictions.

<sup>3</sup>In particular, I consider regulatory reforms, e.g., the introduction of a countercyclical capital buffer, as a benchmark case.

credit.

Given the extensive usage of non-standard measures by central banks around the world in recent years, there has been a surge in empirical and theoretical literature trying to analyze the economic effects of different unconventional policy measures. Employing DSGE models featuring a banking sector with financial frictions, [Gertler and Karadi \(2011\)](#), [Gertler and Kiyotaki \(2011\)](#) and [Cúrdia and Woodford \(2011\)](#) have shown that there are substantial gains from expanding central bank credit during crisis. Yet, as the analyses are based on closed economies, they are not well-suited to give advice on how the institutions of a currency union should cope with a financial crisis. Papers which analyze unconventional monetary policy in a two-country setting are usually interested in game theoretical issues associated with two separate monetary authorities interested in their own welfare functions (see, e.g., [Dedola et al., 2013](#); [Nuguer, 2016](#)). For a monetary union, it is reasonable to assume that a common monetary policy maker adopts a union-wide welfare function, hence, game theoretical issues are not of crucial interest in this context. As long as business cycles between member countries are less than perfectly correlated, it is, however, of great interest to analyze union-wide versus country-specific implementation of unconventional monetary policies. To my knowledge, there is one paper by [Tischbirek \(2016\)](#) which addresses a very similar question, however, the author focuses on government debt purchases and employs a model without financial frictions but with a more elaborate government sector. Further, [Auray et al. \(2016\)](#) use a model very similar to mine to analyze unconventional monetary policies in the Eurozone. However, they do not distinguish between country-specific and union-wide measures but are rather interested in strategies aimed at different financial market sectors. [Schwanebeck \(2017\)](#) uses the same structurally asymmetric model (one country is a net borrower and the other is a net lender) as [Nuguer \(2016\)](#), to analyze the first-order implications of country-specific unconventional monetary policy rules in a monetary union. To the best of my knowledge, this paper is the first to analyze whether unconventional monetary policy can and should be used to stabilize country-specific shocks in a monetary union featuring – potentially heterogenous – financial frictions.

The paper is organized as follows. The next section develops the model. Section 3 provides the calibration. In section 4, I will explain the welfare measure used. In section 5, I present and discuss the results on optimal simple rules in the baseline setup and in the case where one country features a more sound financial system. The final section concludes and gives an outlook.

## 2 Model

I assume that the world consists of two countries with symmetric structures which belong to a monetary union, each inhabited by a continuum of agents of equal size. Each country features a financial intermediation sector which is modeled similar to the one in [Gertler and Karadi \(2011\)](#). The role of intermediaries is to transfer funds between households and intermediate goods producers who use the loans to finance investment into physical capital. Intermediaries face an endogenously determined constraint on their leverage ratio, motivated by a simple agency problem which drives a wedge between saving and borrowing rates.

The two countries feature integrated markets for final goods, capital assets and deposits. To allow for these multiple interlinkages, I have to abstract from complete international consumption risk sharing. Allowing the net foreign asset position to be adjusted via two margins - asset and bond trade - might imply two unit roots in a first-order approximation of the model (see, e.g., [Schmitt-Grohé and Uribe, 2003](#)). Hence, I introduce two stationarity inducing features, an endogenous discount factor and a debt elastic interest rate yield.

For simplicity only home country equations will be displayed. Foreign variables will be denoted with an asterisk.

### 2.1 Households

Within each household, there are two member types, workers and bankers. While the worker supplies work to intermediate goods firms and deposits to banks, the banker manages a financial intermediary and transfers retained earnings back to her household when the lifetime of the bank ends. Within the family, there is perfect consumption risk sharing, which allows to maintain the representative agent framework. As in [Gertler and Karadi \(2011\)](#), it is assumed that a fraction  $1 - f$  of household members are depositors, while a fraction  $f$  are bankers. Between periods there is a random turnover between the two groups: with probability  $\theta_B$  a banker will stay a banker and with probability  $1 - \theta_B$  she will become a depositor. The relative proportions are kept fixed. New bankers are provided with some start-up funds from their respective households.

The lifetime utility of a representative home worker, who draws utility from consumption  $C_t$  and disutility from labor  $L_t$ , is given by

$$E_t \sum_{k=0}^{\infty} \Theta_k \left( \ln(C_{t+k} - hC_{t+k-1}) - \chi \frac{L_{t+k}^{1+\phi}}{1+\phi} \right),$$

with  $\chi, \phi > 0$ . Variable  $\Theta_t$  is the endogenous discount factor of households chosen to ensure stationarity as explained above.

Households save by depositing funds at domestic and foreign intermediaries (see 2.2 for details). Total deposits held between  $t - 1$  and  $t$ , denoted by  $D_{t-1}$ , are equivalent to one-period riskless real bonds paying the gross real rate of return  $R_{t-1}$ . Furthermore, households provide labor to intermediate goods firms and receive the nominal wage  $W_t$ . Hence, the representative home household's budget constraint in real terms is given by

$$C_t + D_t + T_t = R_{t-1}D_{t-1} + \frac{W_t}{P_t}L_t + NP_t,$$

where  $NP_t$  denotes net profits from the ownership of firms (financial and non-financial) and  $T_t$  denotes lump-sum taxes.

Households have equal preferences for home and foreign final goods.<sup>4</sup> Hence,  $C_t$ , the CES composite of consumption, is given by

$$C_t = \left( 0.5^{\frac{1}{\iota}} C_{H,t}^{\frac{\iota-1}{\iota}} + 0.5^{\frac{1}{\iota}} C_{F,t}^{\frac{\iota-1}{\iota}} \right)^{\frac{\iota}{\iota-1}},$$

with  $\iota > 0$  and  $C_{H,t}$  and  $C_{F,t}$  denoting consumption of home and foreign final goods, respectively. The corresponding consumer price index takes the following form

$$P_t = \left( 0.5P_{H,t}^{1-\iota} + 0.5P_{F,t}^{1-\iota} \right)^{\frac{1}{1-\iota}},$$

where  $P_{H,t}$  denotes the price of the home good in the home country and  $P_{F,t}$  denotes the price of the foreign good in the home country.

Assuming local currency pricing, the law of one price holds, i.e.,  $P_{H,t} = P_{H,t}^*$  and  $P_{F,t} = P_{F,t}^*$ . As households preferences are identical in the two countries and no home bias is assumed, the consumption baskets are equal. Hence, Purchasing Power Parity holds and the real exchange rate is constant ( $P_t = P_t^*$ ). The terms of trade are defined as the ratio between the price of exports and the price of imports,  $ToT_t \equiv \frac{P_{H,t}}{P_{F,t}}$ .

The endogenous discount factor is determined as follows:

$$\begin{aligned} \Theta_{t+1} &= \Theta_t \beta(C_{A,t}), \\ \Theta_0 &= 1, \end{aligned}$$

where  $C_{A,t}$  is aggregate home consumption. Using aggregate consumption in the endogenous discount factor ensures that the household does not internal-

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<sup>4</sup>The main results of this paper are robust to changing this assumption, i.e., the results also hold when household consumption is biased towards home goods. However, the assumption of equal preferences simplifies the interpretation of results because real exchange fluctuations are absent.

ize the effect of its consumption decision on the discount factor, which simplifies calculations considerably. As in [Schmitt-Grohé and Uribe \(2003\)](#) and [Devreux and Yetman \(2010\)](#) the following functional form of the endogenous discount factor is assumed

$$\beta(C_{A,t}) = \omega_c(1 + C_{A,t})^{-\eta}.$$

Parameter  $\eta$ , the consumption elasticity of the discount factor, is chosen to be very small, to keep the effects of this purely technical feature on the results of the model negligibly small. Note that the discount factor decreases in  $C_{A,t}$ , i.e., whenever a country has relatively higher consumption in the present, it discounts future consumption more heavily and, hence, saves less. The latter implies lower consumption in the future and, therefore, the economy returns to the initial state.

Hence, the household's first-order conditions for the optimal choice of labor and consumption are given by

$$w_t = \chi \frac{L_t^\phi}{\lambda_t},$$

with  $w_t \equiv \frac{W_t}{P_t}$ , denoting the real wage, and

$$1 = \beta(C_{A,t})E_t\{\Lambda_{t,t+1}\}R_t,$$

with the household's real stochastic discount factor being defined as

$$\Lambda_{t,t+1} \equiv \frac{\lambda_{t+1}}{\lambda_t},$$

where  $\lambda_t$  denotes the marginal utility of consumption given by

$$\lambda_t = (C_t - hC_{t-1})^{-1} - \beta(C_{A,t})h(E_t C_{t+1} - hC_t)^{-1}.$$

## 2.2 International intermediaries

To simplify matters, it is assumed that households hold deposits with savings banks in the domestic country which – according to the needs in the financial system – channel the funds to home and foreign banks via international intermediaries. Total deposits of home households are given by  $D_t = D_{H,t} + D_{F,t}$ .

Allowing deposits to freely flow between countries, would induce a unit root. Therefore, it is assumed that home deposits can only be channeled to foreign banks by purchasing one-period bonds from international intermediaries. The latter charge a small interest rate premium on the union wide nominal interest

rate. The premium depends on the real net foreign bond position of the respective country. This assumption adds realism to the model and ensures stationarity (see, e.g., [Schmitt-Grohé and Uribe, 2003](#)). As in [Hjortsoe \(2016\)](#), I assume

$$i_t = i_t^{CB} \Phi(D_{F,t}), \quad (1)$$

where  $i_t^{CB}$  is the nominal interest rate set by the union-wide central bank and  $i_t$  is the country rate. It is assumed that the country-specific rate charged by international intermediaries is increasing in the deviation of the external household debt position (real debt is given by  $-D_{F,t}$ ) from its steady state, i.e.,  $\Phi(\cdot)' < 0$  and  $\Phi(0) = 0$ . As in [Hjortsoe \(2016\)](#), the following functional form is chosen for the debt-elastic interest rate premium

$$\Phi(D_{F,t}) = (1 - \omega_D D_{F,t}).$$

Profits of international intermediaries are distributed to households within the current account surplus country. Note that rates of return on home deposits and bonds (equivalent to foreign deposit holdings) are equalized due to arbitrage.

### 2.3 Banks

In the model economy, home financial intermediaries channel funds from households to home and foreign intermediate goods producers, fulfilling the double role of investment as well as commercial banks. In addition to obtaining funds from households, banks also raise funds internally by accumulating retained earnings. The balance sheet of home bank  $i$  is given by

$$B_{i,t} = D_{i,t}^B + N_{i,t},$$

where  $N_{i,t}$  denotes intermediary  $i$ 's net worth. Deposits at bank  $i$ , stemming from home and foreign households, are denoted by  $D_{i,t}^B = D_{iH,t} + D_{iH,t}^*$ . The asset portfolio of bank  $i$ ,  $B_{i,t}$ , consists of home as well as foreign assets which are combined according to the following CES aggregator<sup>5</sup>

$$B_{i,t} = \left( \mu_A^{\frac{1}{A}} (Q_t S_{iH,t})^{\frac{A-1}{A}} + (1 - \mu_A)^{\frac{1}{A}} (Q_t^* S_{iF,t})^{\frac{A-1}{A}} \right)^{\frac{A}{A-1}}. \quad (2)$$

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<sup>5</sup>Assuming that the portfolio composition is determined by a CES aggregator allows to solve the model without using an endogenous portfolio choice method. The latter are associated with certain drawbacks such as inaccuracies when analyzing structurally asymmetric countries and at higher orders of approximation (cf. [Rabitsch et al., 2015](#)). Therefore, the usage of the CES function to determine international portfolios has become more and more popular in recent years (see, e.g., [Auray et al., 2016](#); [Poutineau and Vermandel, 2015](#); [Brzoza-Brzezina et al., 2015](#); [Dräger and Proaño, 2016](#)).



Variable  $S_{iH,t}$  ( $S_{iF,t}$ ) denotes the state-contingent claims on future returns of a unit of capital used in intermediate goods production in the home (foreign) economy. The price of the claim is given by  $Q_t$  ( $Q_t^*$ ). Parameter  $\mu_A$  denotes home bias in portfolio holdings. Accordingly, the return on the portfolio,  $R_t^A$ , is determined by the following equation

$$\frac{1}{R_t^A} = \left( \mu_A \left( \frac{1}{R_{k,t}} \right)^{1-\iota_A} + (1-\mu_A) \left( \frac{1}{R_{k,t}^*} \right)^{1-\iota_A} \right)^{\frac{\iota_A}{\iota_A-1}},$$

where  $R_{k,t}$  ( $R_{k,t}^*$ ) denotes the state-contingent gross real rate of return of the home (foreign) capital asset. The banker chooses the optimal portfolio composition by maximizing expected portfolio returns subject to equation (2).<sup>6</sup>

Intermediary  $i$ 's net worth evolves according to the following equation

$$N_{i,t} = R_t^A B_{i,t-1} - R_{t-1} D_{i,t-1}^B.$$

Since the banker cannot invest in assets which yield a discounted return smaller than the cost of borrowing, the following inequality has to be satisfied

$$E_t\{\Theta_{t+1}\Lambda_{t,t+1}(R_{t+1}^A - R_t)\} \geq 0.$$

With perfect capital markets the above relation would hold with equality. In the presence of financial frictions, however, the premium must be positive. It covaries negatively with output as the intermediary's inability to obtain funds increases during bad states of the economy. As long as the banker earns some positive yield on each unit of money invested, she finds it worthwhile to operate and further accumulate earnings.

It is assumed that each period a fraction  $1-\theta_B$  of bankers exit the business with i.i.d. probability and pay out accumulated earnings to their respective households.<sup>7</sup> Therefore, a banker maximizes the terminal value of her net worth given by

$$V_t = \max E_t \sum_{k=0}^{\infty} (1-\theta_B)\theta_B^k \Theta_{t+k}\Lambda_{t,t+k+1} N_{i,t+k+1}.$$

To motivate the requirement to build up net worth, the following moral hazard problem is assumed: At the beginning of each period, before the shocks realize and any other transactions take place, the banker can choose to divert the

<sup>6</sup>The banker's CES portfolio choice problem and its solutions can be found in the online appendix.

<sup>7</sup>This arrangement precludes bankers from aggregating so much net worth that the incentive constraint becomes irrelevant for them.

fraction  $\lambda_B$  of available funds back to the household. The cost associated with this fraud is that the depositors recover the remaining fraction  $1 - \lambda_B$  and force the banker into bankruptcy. Therefore, for households to be willing to deposit funds with the bank, the following incentive constraint must hold

$$V_{i,t} \geq \lambda_B B_{i,t}.$$

To solve the banker's maximization problem define the objective of the bank recursively as

$$V_{i,t} = \max E_t \beta(C_{A,t}) \Lambda_{t,t+1} [(1 - \theta_B) N_{i,t+1} + \theta_B V_{i,t+1}],$$

and conjecture that the terminal value function is linear in assets and net worth

$$V_{i,t} = v_{i,t} B_{i,t} + \eta_{i,t} N_{i,t}.$$

The banker's problem consists in choosing the amount of total assets and deposits such that terminal net worth is maximized and the incentive constraint holds. It can be solved using the Lagrange method.

The solutions for the coefficients are given by

$$v_t = E_t \{ \Omega_{t+1} (R_{t+1}^A - R_t) \}, \text{ and}$$

$$\eta_t = E_t \{ \Omega_{t+1} \} R_t,$$

where

$$\Omega_{t+1} = \beta(C_{A,t}) \Lambda_{t,t+1} [(1 - \theta_B) + \theta_B (\eta_{t+1} + v_{t+1} \phi_{t+1})],$$

which can be interpreted as the stochastic discount factor of the banker. It differs from the household's stochastic discount factor due to the presence of financial frictions. Note that the subscript  $i$  was dropped as the coefficients exclusively depend on aggregate variables.

Assuming that the incentive constraint binds,<sup>8</sup> it can be expressed in terms of the coefficients of the value function

$$B_t = \frac{\eta_t}{\lambda_B - v_t} N_t = \phi_t N_t,$$

where  $\phi_t$  is the ratio of intermediated assets to net worth, which can be referred to as the leverage ratio. Note that it is determined endogenously in this model.

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<sup>8</sup>Parameters and steady state values are chosen such that the incentive constraint binds in the steady state. Holding the variance of shocks small enough guarantees that the incentive constraint also binds in a stochastic environment.

Finally, the law of motion for aggregate net worth can be derived as

$$\begin{aligned} N_t &= (N_{n,t} + N_{e,t}) \\ N_{e,t} &= \theta_B [(R_t^A - R_{t-1})\phi_{t-1} + R_{t-1}] N_{t-1} \epsilon_{N,t} \\ N_{n,t} &= \omega B_{t-1}, \end{aligned}$$

where  $N_{e,t}$  denotes existing bankers' net worth,  $N_{n,t}$  denotes new bankers' net worth and  $\omega$  is the fraction of the assets given to new bankers by their households. Variable  $\epsilon_{N,t}$  denotes an exogenous disturbance to the net worth of existing bankers.

## 2.4 Intermediate goods firms

Intermediate goods firms produce an intermediate good which is sold to final goods producers in the same country at the real price  $P_{m,t}$  for use in the production of the final good. The market for intermediate goods is assumed to be perfectly competitive.

The Cobb-Douglas production function of the representative intermediate goods firm is given by

$$Y_{m,t} = A_t (U_t \Psi_t K_{t-1})^\alpha L_t^{1-\alpha},$$

where  $Y_{m,t}$  denotes intermediary output,  $A_t$  exogenous technology and  $U_t$  the utilization rate of capital. Labor  $L_t$  is provided by households in the same country only. Capital  $K_{t-1}$  was bought from capital goods producers in the same country in the previous period at price  $Q_{t-1}$ . To finance capital purchases, the firm issues state-contingent securities to obtain funds from home and foreign intermediaries at the same price. Each period, after being productive, the firm has to pay back capital returns on the securities issued in the previous period. As in [Gertler and Karadi \(2011\)](#), I assume that there exists a shock to the quality of capital, denoted by  $\Psi_t$ , to provide a source for exogenous variations in the price of capital. It can be interpreted as the sudden realization that much of the capital installed is of lower quality than previously thought. As the capital stock is equal to the capital claims issued to banks, banks' balance sheets will be contracted in response to a negative capital quality shock. The law of motion for capital is given by

$$K_t = I_t + (1 - \delta(U_t)) \Psi_t K_{t-1},$$

where  $I_t$  is aggregate investment and  $\delta(U_t)$  denotes physical depreciation, where  $\delta'(U_t) > 0$  and  $\delta''(U_t) > 0$ .

The first-order conditions of the intermediate goods producer's profit maximization problem are, therefore, given by<sup>9</sup>

$$R_{k,t+1} = \frac{\alpha \frac{P_{m,t+1} Y_{m,t+1}}{K_t} + (Q_{t+1} - \delta(U_{t+1})) \Psi_{t+1}}{Q_t},$$

$$\frac{W_t}{P_t} = (1 - \alpha) \frac{P_{m,t} Y_{m,t}}{L_t},$$

and

$$\delta'(U_t) \Psi_t K_{t-1} = P_{m,t} \alpha \frac{Y_{m,t}}{U_t}.$$

The firm earns zero profits state-by-state, hence, it simply pays out the ex post return to capital  $R_{k,t}$  to the financial intermediary.

## 2.5 Capital goods firms

Competitive capital goods firms produce capital only for the domestic market using national final output as input facing investment adjustment costs (in consumption units). I follow the approach used by [Gertler and Karadi \(2011\)](#) and [Gertler and Kiyotaki \(2011\)](#) and assume that adjustment costs are on net investment so that the capital utilization decision is independent of the market price of capital. Their functional form is given by

$$f\left(\frac{I_{n,t} + I}{I_{n,t-1} + I}\right) = \frac{\eta_i}{2} \left(\frac{I_{n,t} + I}{I_{n,t-1} + I} - 1\right)^2,$$

with  $0 < \eta_i$ ,  $I$  denoting steady state investment and net investment being defined as  $I_{n,t} \equiv I_t - \delta(U_t) \Psi_t K_{t-1}$ . The capital goods producer chooses  $I_t$  to maximize lifetime profits given by

$$E_t \sum_{k=0}^{\infty} \Theta_k \Lambda_{t,t+k} \{Q_{t+k} I_{t+k} - [1 + f(\cdot)] I_{t+k}\}.$$

From the first order conditions, the real price of one unit of capital is obtained

$$Q_t = 1 - f(\cdot) + \frac{I_{n,t} + I}{I_{n,t-1} + I} f'(\cdot) - E_t \beta(C_{A,t}) \Lambda_{t,t+1} \left(\frac{I_{n,t+1} + I}{I_{n,t} + I}\right)^2 f'(\cdot).$$

Due to flow investment costs, capital goods firms can earn profits outside the steady state. These profits are distributed lump-sum to the households.

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<sup>9</sup>As in [Gertler and Karadi \(2011\)](#), I assume that the replacement price of depreciated capital is unity. Therefore, the value of the capital stock which is left over is given by  $(Q_{t+1} - \delta(U_{t+1})) \Psi_{t+1} K_t$ .

## 2.6 Final goods firms

Final output produced by home firms and purchased by consumers at home and abroad,  $Y_t$ , is assumed to be a CES composite of mass unity of differentiated final products

$$Y_t = \left[ \int_0^1 Y_t(f)^{\frac{\epsilon-1}{\epsilon}} df \right]^{\frac{\epsilon}{\epsilon-1}},$$

with  $0 < \epsilon$ .  $Y_t(f)$  denotes output by retailer  $f$ . The corresponding home producer price index is given by

$$P_{H,t} = \left[ \int_0^1 P_{H,t}(f)^{1-\epsilon} df \right]^{\frac{1}{1-\epsilon}}.$$

Given that consumers allocate consumption expenditures optimally between varieties, home final goods firm  $f$  faces the following demand by home and foreign consumers<sup>10</sup>

$$Y_t(f) = \left( \frac{P_{H,t}(f)}{P_{H,t}} \right)^{-\epsilon} Y_t,$$

i.e., its share in total home final goods production,  $Y_t$ , depends on its relative price.

It is assumed that each unit of final output is assembled costlessly from one unit of intermediate output. Real marginal cost is therefore given by the intermediate output price  $P_{m,t}$ . It is further assumed that firms face a positive probability,  $\theta$ , each period that they are not able to reset their price (Calvo-style pricing). If not able to reset its price, a firm can partly index its price to the lagged rate of inflation. Hence, the optimal price of a representative home firm,  $\tilde{P}_{H,t}$  is given by

$$\tilde{P}_{H,t} = \frac{\epsilon}{\epsilon-1} \frac{E_t \sum_{k=0}^{\infty} \theta^k \Theta_k \lambda_{t+k} \Pi_{H,t,t+k}^{\epsilon} \Pi_{H,t-1,t+k-1}^{-\epsilon \theta_{\pi}} Y_{t+k} P_{m,t+k}}{E_t \sum_{k=0}^{\infty} \theta^k \Theta_k \lambda_{t+k} \Pi_{H,t,t+k}^{\epsilon-1} \Pi_{H,t-1,t+k-1}^{(1-\epsilon)\theta_{\pi}} Y_{t+k} P_{H,t+k}} P_{H,t},$$

where  $\Pi_{H,t} \equiv \frac{P_{H,t}}{P_{H,t-1}}$  denotes home producer price inflation between  $t-1$  and  $t$ ,  $p_{H,t} \equiv \frac{P_{H,t}}{P_t}$  is the relative price of home goods and  $\theta_{\pi}$  denotes the degree of price indexation. The dynamics of the home price index are given by

$$P_{H,t} = \left( \theta \Pi_{H,t-1}^{\theta_{\pi}} P_{H,t-1}^{1-\epsilon} + (1-\theta) \tilde{P}_{H,t}^{1-\epsilon} \right)^{\frac{1}{1-\epsilon}}.$$

<sup>10</sup>Under the assumption of local currency pricing (which preserves the Law of one Price), a distinction between home and foreign demand is not necessary.

## 2.7 Market clearing

The capital market clearing conditions state that in each country, the current value of total installed capital has to be equal to the total value of state contingent claims on future returns of capital issued

$$\begin{aligned} Q_t K_t &= Q_t (S_{h,t} + S_{h,t}^*), \\ Q_t^* K_t^* &= Q_t^* (S_{f,t} + S_{f,t}^*). \end{aligned}$$

Bonds are in zero net supply, i.e.,

$$D_{F,t} = -D_{H,t}^*$$

where  $D_{H,t}^*$  denotes foreign households' deposits in home banks or, more specifically, foreign international bond holdings invested in home banks. Home and foreign goods market clearing conditions are given by

$$\begin{aligned} Y_t &= C_{H,t} + C_{H,t}^* + \frac{P_t}{P_{H,t}} [I_t + f\left(\frac{I_{n,t} + I}{I_{n,t-1} + I}\right) (I_{n,t} + I)], \\ Y_t^* &= C_{F,t} + C_{F,t}^* + \frac{P_t^*}{P_{F,t}} [I_t^* + f\left(\frac{I_{n,t}^* + I^*}{I_{n,t-1}^* + I^*}\right) (I_{n,t}^* + I^*)]. \end{aligned}$$

## 2.8 Monetary policy

### 2.8.1 Interest rate policy

Interest rate policy is specified by a standard Taylor rule. It is assumed that the common central bank reacts to variations in the union-wide output gap and the consumer price index (CPI). The union-wide output gap is determined as a weighted average of the country-specific output gaps. Given that Purchasing Power Parity holds, consumer price inflation is the same among both countries, i.e.,  $\Pi_t = \Pi_t^*$ , where  $\Pi_t = \frac{P_t}{P_{t-1}}$  denotes consumer price inflation between periods  $t-1$  and  $t$ . CPI targeting is chosen, because it represents a better description of actual Taylor rules used in central banks following inflation targeting strategies (Devereux et al., 2014, p. 937). The particular Taylor rule of the central bank is given by

$$i_t^{CB} = \left( \beta \Pi_t^{\gamma_\pi} \hat{y}_t^{0.5\gamma_y} \hat{y}_t^*{}^{0.5\gamma_y} \right)^{1-\rho_i} (i_{t-1}^{CB})^{\rho_i} \varepsilon_{M,t},$$

where  $\beta$  is the steady state discount factor and  $\hat{y}_t$  ( $\hat{y}_t^*$ ) denotes the domestic (foreign) output gap, defined as the difference between flexible price output and sticky price output. The output gap is approximated by the inverse of the markup gap.<sup>11</sup> The monetary disturbance is denoted by  $\varepsilon_{M,t}$ .

<sup>11</sup>In the given setup, the markup is given by  $\frac{p_{H,t}}{p_{m,t}}$ .

The Fisher equation establishes the link between the country-specific nominal and real interest rates, i.e.,

$$i_t = R_t E_t \Pi_{t+1},$$

where the link between the country-specific nominal rate,  $i_t$ , and the union-wide policy rate,  $i_t^{CB}$ , is given by equation (1).

Note that I do not assume that conventional monetary policy acts to accommodate unconventional policy. [Cahn et al. \(2014\)](#) model an accommodating interest rate policy and find that, in this case, the effects of unconventional policy are much larger.

### 2.8.2 Unconventional policies

In this paper, I analyze the impact of two kinds of unconventional monetary policy, in particular, liquidity facilities and private sector credit purchases. Both types of policies are modeled using simple rules.

#### *Liquidity facilities*

In the European union, since the end of 2008, liquidity facilities are conducted under the fixed rate full allotment tender procedure, i.e., the ECB sets the interest rate and elastically supplies any amount of liquidity financial institutions ask for. The model cannot directly replicate this policy feature as the central bank in the model chooses the quantity of funds by following a feedback rule. However, rule-based liquidity injections capture the endogeneity of the balance sheet expansion to some extent as they imply that the supply of central bank credit reacts elastically to prevailing market conditions ([Cahn et al., 2014](#)).

The central bank can lend funds, denoted by  $M_t$ , directly to banks at rate  $R_{m,t}$ . As proposed by [Gertler and Kiyotaki \(2011\)](#), it is assumed that the central bank has superior enforcement possibilities compared to households, hence, only the fraction  $\lambda_B(1 - \lambda_m)$  with  $0 < \lambda_m < 1$  of central bank assets can be diverted.<sup>12</sup> Given these assumptions, a home intermediary's balance sheet takes the following form

$$B_{i,t} = D_{i,t}^B + N_{i,t} + M_{i,t}.$$

The equation for the evolution of intermediary  $i$ 's net worth needs to be replaced by the following equation

$$N_{i,t} = R_t^A B_{i,t-1} - R_{t-1} D_{i,t-1}^B - R_{m,t-1} M_{i,t-1}.$$

---

<sup>12</sup>If the fraction of divertable assets would be the same for central bank funds as for household deposits, the extra credit would not expand the supply of liquidity in the banking market but simply supplant it.

The incentive constraint is now given by

$$V_{i,t} \geq \lambda_B(B_{i,t} - \lambda_m M_{i,t}).$$

Taking into account the modified balance sheet and incentive constraint, the net cost of an extra unit of liquidity facilities is given by

$$\eta_{m,t} = E_t \Omega_{t+1} (R_{m,t} - R_t).$$

From the first order conditions of the modified bank's problem, it can be further derived that

$$\eta_{m,t} = \lambda_m \nu_t,$$

which ties down  $R_{m,t}$ . The law of motion for existing banks' net worth changes to

$$N_{e,t} = \theta_B \left[ (R_t^A - R_{t-1}) \frac{\phi_{t-1}}{1 - \lambda_m \Phi_{m,t-1}} - (R_{t-1}^m - R_{t-1}) \frac{\phi_{t-1} \Phi_{m,t-1}}{1 - \lambda_m \Phi_{m,t-1}} + R_{t-1} \right] N_{t-1},$$

where  $\Phi_{m,t}$  denotes the fraction of home bank assets intermediated by the central bank, i.e.,

$$M_t = \Phi_{m,t} B_t.$$

As already discussed, I use a rule-based approach to model the provision of liquidity facilities. The fractions of intermediated assets in the home and foreign economy,  $\Phi_{m,t}$  and  $\Phi_{m,t}^*$ , respectively, are determined by simple rules. In particular, I distinguish between union-wide versus country-specific rules and credit spread versus credit growth rules. If a union-wide rule is chosen, the central bank adjusts  $\Phi_{m,t} = \Phi_{m,t}^*$  in reaction to union-wide averages, whereas, when a country-specific rule is chosen, it holds that  $\Phi_{m,t} \neq \Phi_{m,t}^*$ , whenever the economy is not in the deterministic steady state.<sup>13</sup> Note that an increase in the credit spread and a decrease in credit growth indicate a tightening of financial conditions caused by an adverse shock. Hence, the fractions of intermediated assets,  $\Phi_{m,t}$  and  $\Phi_{m,t}^*$ , are either directly proportional to the deviation of the external finance spread<sup>14</sup> from its steady state value (credit spread rule) or inversely proportional to credit growth (credit growth rule).

<sup>13</sup>I only consider uncorrelated country-specific shocks. If shocks were perfectly correlated between the two economies, it would also hold in the presence of shocks that  $\Phi_{m,t} = \Phi_{m,t}^*$ .

<sup>14</sup>Note that I use the same definition of the external finance premium as [Gertler and Karadi \(2011\)](#), i.e., the difference between financing costs of firms and the deposit rate. In their model, this spread coincides with the spread relevant for banks. With banking market integration, I could alternatively use  $\ln R_{A,t+1} - \ln R_t$ , reflecting more closely the conditions in the banking sector. Although I do not expect results to differ much, I plan to include such an analysis into the robustness checks.



Hence, the *union-wide rule* is either given by

$$\Phi_{m,t} = \kappa_m \left[ 0.5 \left( \ln \left( \frac{R_{k,t}}{R_t} \right) + \ln \left( \frac{R_{k,t}^*}{R_t^*} \right) \right) - \ln \left( \frac{R_k}{R} \right) \right]$$

or

$$\Phi_{m,t} = -\kappa_m \ln \left[ \frac{0.5(Q_t K_t + Q_t^* K_t^*)}{0.5(Q_{t-1} K_{t-1} + Q_{t-1}^* K_{t-1}^*)} \right].$$

The *country-specific rules* are either given by

$$\begin{aligned} \Phi_{m,t} &= \kappa_m \left[ \ln \left( \frac{R_{k,t}}{R_t} \right) - \ln \left( \frac{R_k}{R} \right) \right], \\ \Phi_{m,t}^* &= \kappa_m \left[ \ln \left( \frac{R_{k,t}^*}{R_t^*} \right) - \ln \left( \frac{R_k}{R} \right) \right], \end{aligned}$$

or

$$\begin{aligned} \Phi_{m,t} &= -\kappa_m \ln \left[ \frac{Q_t K_t}{Q_{t-1} K_{t-1}} \right], \\ \Phi_{m,t}^* &= -\kappa_m \ln \left[ \frac{Q_t^* K_t^*}{Q_{t-1}^* K_{t-1}^*} \right]. \end{aligned}$$

#### *Corporate sector credit policy*

The second type of unconventional monetary policy is the direct provision of non-financial private sector credit by the central bank (see also, e.g., [Gertler and Karadi, 2011](#); [Dedola et al., 2013](#)). I assume that the central bank intermediates fractions  $\Phi_{f,t}$  and  $\Phi_{f,t}^*$  of overall funding needs in the home and foreign economy, i.e.,

$$\begin{aligned} F_t &= \Phi_{f,t} Q_t K_t, \\ F_t^* &= \Phi_{f,t}^* Q_t^* K_t^*, \end{aligned}$$

where  $F_t$  and  $F_t^*$  denote overall private sector asset purchases by the central bank in the home and foreign economy, respectively. Hence, the capital market clearing conditions provided in section 2.7 have to be modified to

$$\begin{aligned} (1 - \Phi_{f,t}) Q_t K_t &= Q_t (S_{h,t} + S_{h,t}^*), \\ (1 - \Phi_{f,t}^*) Q_t^* K_t^* &= Q_t^* (S_{f,t} + S_{f,t}^*). \end{aligned}$$

As before, I distinguish between union-wide versus country-specific and credit spread versus credit growth rules. As before, it holds that whenever the central

bank choses a union-wide rule, the same fraction of privat sector assets is provided in each countries, i.e.,  $\Phi_{f,t} = \Phi_{f,t}^*$ .

Therefore, the *union-wide rule* is either given by

$$\Phi_{f,t} = \kappa_f \left[ 0.5 \left( \ln \left( \frac{R_{k,t}}{R_t} \right) + \ln \left( \frac{R_{k,t}^*}{R_t^*} \right) \right) - \ln \left( \frac{R_k}{R} \right) \right]$$

or by

$$\Phi_{f,t} = -\kappa_f \ln \left( \frac{0.5(Q_t K_t + Q_t^* K_t^*)}{0.5(Q_{t-1} K_{t-1} + Q_{t-1}^* K_{t-1}^*)} \right).$$

The *country-specific rules* are either given by

$$\begin{aligned} \Phi_{f,t} &= \kappa_f \left[ \ln \left( \frac{R_{k,t}}{R_t} \right) - \ln \left( \frac{R_k}{R} \right) \right], \\ \Phi_{f,t}^* &= \kappa_f \left[ \ln \left( \frac{R_{k,t}^*}{R_t^*} \right) - \ln \left( \frac{R_k}{R} \right) \right], \end{aligned}$$

or by

$$\begin{aligned} \Phi_{f,t} &= -\kappa_f \ln \left( \frac{Q_t K_t}{Q_{t-1} K_{t-1}} \right), \\ \Phi_{f,t}^* &= -\kappa_f \ln \left( \frac{Q_t^* K_t^*}{Q_{t-1}^* K_{t-1}^*} \right). \end{aligned}$$

#### *Public intermediation costs and government budget constraint*

It is assumed that central bank intermediation is costly. These costs could capture efficiency costs but also the risk of credit default whose actual occurrence is ruled out in this kind of model. I follow [Gertler et al. \(2012\)](#) and [Dedola et al. \(2013\)](#) in assuming quadratic intermediation costs. This kind of modelling reflects the more realistic scenario where costs are higher whenever the central bank has a long position in corporate assets or bank credit ([Gertler et al., 2012](#)),

$$\begin{aligned} \Gamma_{m,t} &= \tau_1(M_t + M_t^*) + \tau_2(M_t^2 + M_t^{*2}), \\ \Gamma_{f,t} &= \tau_1(F_t + F_t^*) + \tau_2(F_t^2 + F_t^{*2}). \end{aligned}$$

As there is no information on the cost of central bank credit policy, however, the modelling of these costs directly affects the welfare results, robustness checks

were conducted.<sup>15</sup> I assume that costs are equally split between the two countries.

Central bank credit to financial and non-financial firms is financed by the issuance of government debt which is a perfect substitute for household deposits. I assume that for each country the amount of government credit is equal to the issuance of government debt. Thereby, the aggregate resource constraints are not affected by unconventional monetary policy. Hence, the home government flow budget constraint takes the following form

$$0.5(\Gamma_{m,t} + \Gamma_{f,t}) + M_t + F_t = T_t + (R_{m,t-1} - R_{t-1})M_{t-1} + (R_{k,t} - R_{t-1})F_{t-1}.$$

## 2.9 Further equilibrium conditions

To close the model, aggregate resource constraints and the relationship between final and intermediate goods production are needed. The home aggregate resource constraint is derived from aggregation of home budget constraints, considering profits from the ownership of non-financial firms, profits of international intermediaries, the government flow budget constraint, retained earnings from exiting bankers and the transfer to new bankers

$$\begin{aligned} \frac{P_{H,t}}{P_t} Y_t + Q_{t-1}^* S_{F,t-1} R_{k,t}^* - Q_{t-1} S_{H,t-1}^* R_{k,t} + D_{F,t-1} \frac{i_{t-1}}{\Pi_t} + 0.5\pi_t^{int} \\ = C_t + D_{F,t} + [I_t + f\left(\frac{I_{n,t} + I}{I_{n,t-1} + I}\right)(I_{n,t} + I)] \\ + Q_t^* S_{E,t} - Q_t S_{H,t}^* + 0.5(\Gamma_{m,t} + \Gamma_{f,t}), \end{aligned}$$

where  $\pi_t^{int} = -\left(\frac{1}{\Phi(-D_{F,t})} - 1\right) \frac{D_{F,t}}{i_t^{CB}}$  denotes international intermediaries' profits.

Last but not least, the relationship between final goods production and intermediate goods production characterizes the equilibrium

$$Y_{m,t} = Y_t \Delta_{p,t},$$

with  $\Delta_{p,t}$  denoting the price dispersion which arises in a model with a two-stage production process with intermediate and final good producers and sticky prices à la Calvo. It can be written in terms of producer price inflation

$$\Delta_{p,t} = \theta \Delta_{p,t-1} \Pi_{H,t}^\epsilon \Pi_{H,t-1}^{-\epsilon \theta \pi} + (1 - \theta) \left( \frac{1 - \theta \Pi_{H,t}^{\epsilon-1} \Pi_{H,t-1}^{\theta \pi (1-\epsilon)}}{1 - \theta} \right)^{\frac{\epsilon}{\epsilon-1}}.$$

<sup>15</sup>Welfare tables for higher values of the cost parameters  $\tau_1$  and  $\tau_2$  can be found in the online appendix. The main results are not qualitatively affected by choosing higher costs.

### 3 Calibration

Table 1 reports the baseline calibration. The values for the habit formation parameter,  $h$ , the Frisch elasticity of labor supply,  $\phi^{-1}$ , the steady state depreciation rate,  $\delta(U)$ , the elasticity of marginal depreciation with respect to the utilization rate,  $\zeta$ , the inverse elasticity of net investment to the price of capital,  $\eta_i$  and the Calvo parameter,  $\theta$ , are based on estimates from [Primiceri et al. \(2006\)](#). The steady state savings propensity,  $\eta$ , was taken from [Devereux and Sutherland \(2009\)](#). The value for the other parameter in the endogenous discount factor,  $\omega_c$ , was chosen as to guarantee a steady state interest rate of 4%, i.e., a steady state value of  $\beta(C_A)$  of 0.99. The value chosen for the trade elasticity between home and foreign goods is in line with the values [de Walque et al. \(2006\)](#) estimated for the European Union. The parameters of the banking system,  $\lambda$ ,  $\theta_B$  and  $\omega$  are taken from [Gertler and Karadi \(2011\)](#). They choose these values to hit three targets: a steady state interest rate spread of 100 basis points, a steady state leverage ratio of four and an average lifetime of a bank of 10 years. Home bias in asset holdings,  $\mu_A$ , and the elasticity between home and foreign assets,  $\iota_A$ , where taken from [Poutineau and Vermandel \(2015\)](#) who estimated them based on Eurozone data. In the model, the value for  $\iota_A$  ensures that returns on capital assets are highly synchronized, which is a realistic feature of international capital markets. The coefficients from the Taylor rule were also taken from [Gertler and Karadi \(2011\)](#). Parameter  $\lambda_m$  was chosen to yield a divertibility of government assets of approximately 0.2 ( $= \lambda_B(1 - \lambda_M)$ ), which is, admittedly, an arbitrary value, however, robustness checks were conducted. The intermediation cost parameters are taken from [Gertler et al. \(2012\)](#) and were also tested for robustness. The calibration of the shock processes is largely taken from [Gertler and Karadi \(2011\)](#). The feedback coefficients of the unconventional monetary policy rules will be chosen optimally.

### 4 Welfare measure

Welfare is evaluated by first computing the conditional expected lifetime utility of the representative household under each financial market setting, as proposed by [Schmitt-Grohé and Uribe \(2004\)](#). The advantage of using conditional welfare is that it takes into account the transition to a particular, regime specific, stochastic steady state<sup>16</sup>. In the upcoming analyses, all regimes are associated with different stochastic steady states. Welfare is conditioned on the initial state

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<sup>16</sup>I define the stochastic steady state as the point in the state space where agents decide to stay in the absence of shocks, but taking into account the distribution of future shocks (cf. [Juillard and Kamenik, 2005](#)).

Parameter	Description	Value
<i>Households</i>		
$h$	habit formation parameter	0.815
$\chi$	utility weight of labor	2.054
$\phi$	inverse of Frisch elasticity of labor supply	0.276
$\eta$	elasticity of the discount factor w.r.t. consumption	0.01
$\omega_c$	parameter from endogenous discount factor	0.9961
<i>International intermediaries</i>		
$\omega_D$	parameter from debt-elastic interest rate premium	0.01
<i>Capital producing firms</i>		
$\eta_i$	inverse elasticity of net investment to the price of capital	1.728
<i>Intermediate goods firms</i>		
$\alpha$	capital share	0.33
$\delta(U)$	steady state depreciation rate	0.025
$\zeta$	elasticity of marginal depreciation w.r.t. utilization rate	7.2
$b$	parameter from variable capital utilization	0.0377
<i>Final goods firms</i>		
$\theta$	probability of not being able to change price	0.779
$\theta_\pi$	degree of price indexation	0.241
$\epsilon$	elasticity of substitution between varieties	4.167
$\iota$	elasticity of substitution between home and foreign goods	4
<i>Financial intermediaries</i>		
$\lambda_B$	fraction of divertable assets	0.3815
$\omega$	transfer to entering banks	0.002
$\theta_B$	quarterly survival rate of banks	0.972
$\iota_A$	elasticity of substitution between home and foreign assets	2.02
$\mu_A$	home bias in asset holdings	0.91
<i>Monetary policy</i>		
$\gamma_y$	feedback coefficient on the output gap	0.125
$\gamma_\pi$	feedback coefficient on inflation	1.5
$\rho_i$	interest rate smoothing coefficient	0.8
$\lambda_m$	parameter to determine divertibility of central bank funds	0.5
$\kappa_m$	feedback coefficient from liquidity facilities rule	-
$\kappa_f$	feedback coefficient from credit policy rule	-
$\tau_1$	intermediation cost parameter	0.000125
$\tau_2$	intermediation cost parameter	0.0012
<i>Exogenous processes</i>		
$\rho_\psi$	persistence of capital quality shock	0.66
$\rho_A$	persistence of technology shock	0.95
$\rho_N$	persistence of net worth shock	0.8
$\sigma_\psi, \sigma_N, \sigma_A, \sigma_M$	standard deviations of shocks	0.01

**Table 1:** Parameters

being the deterministic steady state, which is the same in all scenarios. Steady state welfare is given by

$$\bar{W} = \frac{U(\bar{C}, \bar{L})}{1 - \beta(\bar{C})} = \frac{\ln((1 - h)\bar{C}) - \chi \frac{\bar{L}^{1+\phi}}{1+\phi}}{1 - \omega_c(1 + \bar{C})^{-\eta_c}}.$$

The conditional expectation of lifetime utility as of time 0 of a particular regime is denoted as

$$W_0 = E_0 \sum_{k=0}^{\infty} \beta(C_{A,t+k}) \left( \ln(C_{t+k} - hC_{t+k-1}) - \chi \frac{L_{t+k}^{1+\phi}}{1+\phi} \right).$$

The benefit or loss of a particular policy regime is calculated as the permanent change in steady state consumption, necessary to make agents in the non-stochastic steady state as well off as those in the stochastic economy. I define the necessary permanent change in steady state consumption as  $g$ . A positive value of  $g$  means that agents in the stochastic setting are better off, whereas a negative value implies that agents in the non-stochastic setting have a higher welfare. The particular value for  $g$  is found by solving the following equation:

$$W_0 = \frac{\ln((1 + g)(1 - h)\bar{C}) - \chi \frac{\bar{L}^{1+\phi}}{1+\phi}}{1 - \omega_c(1 + (1 + g)\bar{C})^{-\eta_c}}.$$

Conditional welfare is calculated with Dynare. Following, e.g., [Gertler and Karadi \(2011\)](#), I write welfare recursively as

$$W_t = U(C_t, L_t) + \beta(C_{A,t}) E_t W_{t+1},$$

into the model block and take a second-order approximation of the whole model. From the output I take the uncertainty correction of variable  $W_t$  and add it to the deterministic steady state<sup>17</sup>.

For each type of policy – liquidity facilities and credit policy, credit spread and credit growth rule, union-wide and country-specific rule – I search for the optimal rule by searching numerically for the value of  $\kappa_m$  or  $\kappa_f$  which yields the highest conditional welfare. I restrict the values of the reaction coefficients to lay in the interval of [0,330]. [Gertler and Karadi \(2011\)](#) call a rule with  $\kappa_f = 100$  “aggressive policy”, hence, parameter values which lay even above 100 can be seen as very unrealistic. However, this paper is just a first step towards a deeper analysis of unconventional monetary policy in a monetary union and also a wide arrange of rules is analyzed, therefore, on purpose, the interval was chosen to be very wide as well.

<sup>17</sup>This procedure is described in the Dynare Forum under the topic *Welfare cost of business cycles*, see <https://forum.dynare.org/t/welfare-cost-of-business-cycles/3802>.

	$\kappa_f, \kappa_m$	$g$	rel. gain	riskshar.	$K$	$N$	$C$	$L$
no UMP	-	-3.16	-	0.69	5.606	1.516	0.702	0.331
<i>Rule 1 - credit spread rule</i>								
LF, cou.	53	-2.53	0.63	0.66	5.652	1.496	0.705	0.332
LF, un.	66	-2.52	0.64	0.63	5.655	1.491	0.705	0.332
CP, cou.	129	-1.65	1.50	0.66	5.668	1.314	0.706	0.332
CP, un.	188	-1.53	1.63	0.60	5.675	1.210	0.706	0.332
<i>Rule 2 - credit growth rule</i>								
LF, cou.	59	3.18	6.34	0.67	5.973	1.286	0.713	0.333
LF, un.	66	2.92	6.07	0.65	5.950	1.297	0.713	0.333
CP, cou.	119	4.81	7.97	0.72	6.070	1.206	0.717	0.334
CP, un.	122	4.38	7.54	0.63	6.044	1.221	0.717	0.334

no UMP: no unconventional monetary policy.  $\kappa_f$ : optimal feedback coefficient for liquidity facilities.  $\kappa_m$ : optimal feedback coefficient for credit policy. LF: liquidity facilities. CP: corporate credit policy.  $g$ : welfare gains in consumption equivalents in percent of steady state consumption. Relative gain: difference in  $g$  to case without unconventional policy. International risksharing is measured as  $\text{corr}(\lambda_t, \lambda_t^*)$ . Columns 5-8 display the stochastic steady state of the given variable.

**Table 2:** Optimal simple rules in a symmetric setup (all shocks)

## 5 Results

### 5.1 Optimal simple rules in a symmetric setup

Table 2 displays the results for the the different policy regimes. First, it should be noted, that all types of policies analyzed here can be welfare improving compared to the case of no unconventional policy (relative gain is always positive). However, this is not a general result but depends, most importantly, on the presence and calibration of specific shocks in the model, the calibration of  $\lambda_m$  and the assumptions regarding the intervention costs.

Furthermore, it can be seen that in all cases, credit policy yields higher welfare than the provision of liquidity facilities. The reason is that in the case of credit policy, the central bank directly provides credit to the corporate sector, while in the case of liquidity facilities, the funds provided by the central bank are channeled through the private financial intermediation sector which is subject to financial frictions.<sup>18</sup> This can also explain, why it is optimal to conduct

<sup>18</sup>Rewriting the banking sector's balance sheet in the presence of liquidity facilities as

$$B_t = \phi_t N_t + \lambda_m M_t,$$

it is straightforward to see that of each unit of central bank funds provided, only  $\lambda_m < 1$  are

credit policy much more aggressively than the provision of liquidity facilities ( $\kappa_f > \kappa_m$  for each rule).<sup>19</sup>

A further result is, that credit growth rules yield higher welfare than credit spread rules. As the positive  $g$  implies, when living in an environment in which the central bank conducts unconventional policies following credit spread rules, a household even prefers the stochastic over the deterministic environment. Assumably, the reason is that credit growth is more closely related to welfare relevant, i.e., real, variables than the credit spread. Moreover, the credit spread should be reflected in credit growth. Furthermore, credit growth might be a better indicator of country-specific needs, as the credit spread is also strongly driven by the degree of international financial integration and, thereby, by union-wide developments, which might also partly explain the next result.

The most interesting finding is that whenever the central bank uses a credit spread rule, welfare is higher when the central bank reacts to union-wide averages than when it reacts to country-specific indicators. The opposite holds when the central bank relies on a credit growth rule. In this case, country-specific rules are better suited to address country-specific disturbances. In the next section, I will provide some additional analyses in order to find an explanation for this result.

Table 2 also reports consumption risksharing between the two countries and the stochastic steady state values of capital ( $K$ ), bankers' net worth ( $N$ ), consumption ( $C$ ) and labor ( $L$ )<sup>20</sup>. It is interesting to see that the welfare results are not – or only marginally – driven by consumption risksharing. Although welfare is lowest in the case without unconventional monetary policy, international risksharing ranks second among all regimes. For each rule and policy, – quite plausibly – risksharing is higher when the policy maker reacts to country-specific indicators, however, as has been discussed before, welfare is not necessarily higher for country-specific policy. It should further be noted, that welfare is positively related to the stochastic steady state capital stock. On the other hand, in most cases, welfare is higher when banking net worth is lower. Taken together, these two findings reflect that unconventional policy is successful in reducing financial frictions which allows banks to hold less net worth, freeing

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turned into credit.

<sup>19</sup>If one is interested in a direct welfare comparison between these two types of measures, it might be recommendable to set intervention costs higher for corporate credit policy, given that corporate asset purchases presumably require a higher amount of monitoring activities by the central bank.

<sup>20</sup>The stochastic steady state is computed by simulating the model forward without shocks using the policy functions obtained from a second-order approximation of the model. This procedure is explained in the Dynare Forum under the topic *Where is the stochastic steady state in dynare?*, see <https://forum.dynare.org/t/where-is-the-stochastic-steady-state-in-dynare/2370>.



resources which can be shifted towards the buildup of a higher capital stock. Labor slightly increases with a higher capital stock, due to the assumption of a Cobb-Douglas production technology. As shown in column 7 (C), a higher capital stock allows higher consumption in the stochastic steady state which can partly explain welfare differences. However, the table also shows that – up to three digits – stochastic steady state consumption does not differ between the country-specific and the union-wide conduct of a particular unconventional policy rule. Differences in welfare between these regimes must therefore stem from differences in volatility not being reflected in the stochastic steady state.

## 5.2 Understanding the results

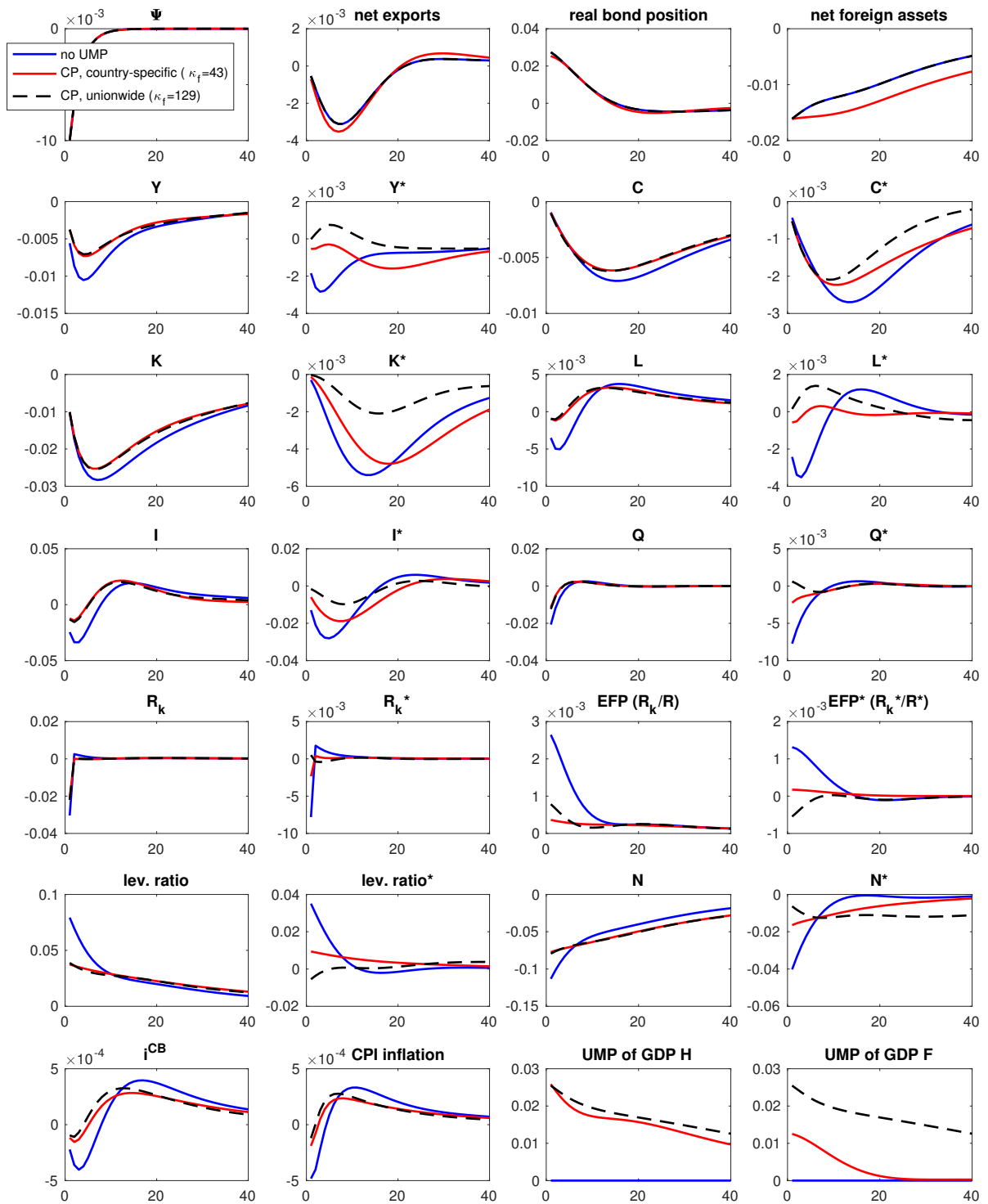
As it is well known, welfare results are – to a large extent – driven by the underlying sources of risk. Therefore, when trying to understand the results, it is advisable to look at the optimal simple rules in environments featuring only one shock at a time. Tables 7 to 10 in the appendix contain the respective coefficients and welfare results. It can be easily seen that the capital quality shock drives the main results. This shock is quite powerful and enters the model in different ways. First, capital quality shocks perfectly resemble technology shocks with respect to their direct impact on output by hitting the production function. Second, they have a direct effect on the capital accumulation process, which brings about additional persistency. Third, they directly hit banks' balance sheets, by changing the value of assets. Due to their large impact on the model, it is not surprising that they have an important effect on the welfare results.

When only technology shocks are present, households are mostly indifferent between country-specific and union-wide rules. Furthermore, in such a world, unconventional measures only have a small impact on welfare. These findings are not surprising, as unconventional monetary policy targets the financial sector, which, in the case of technology shocks, only causes “a modest amplification of the decline in output” (Gertler and Karadi, 2011, p. 26).

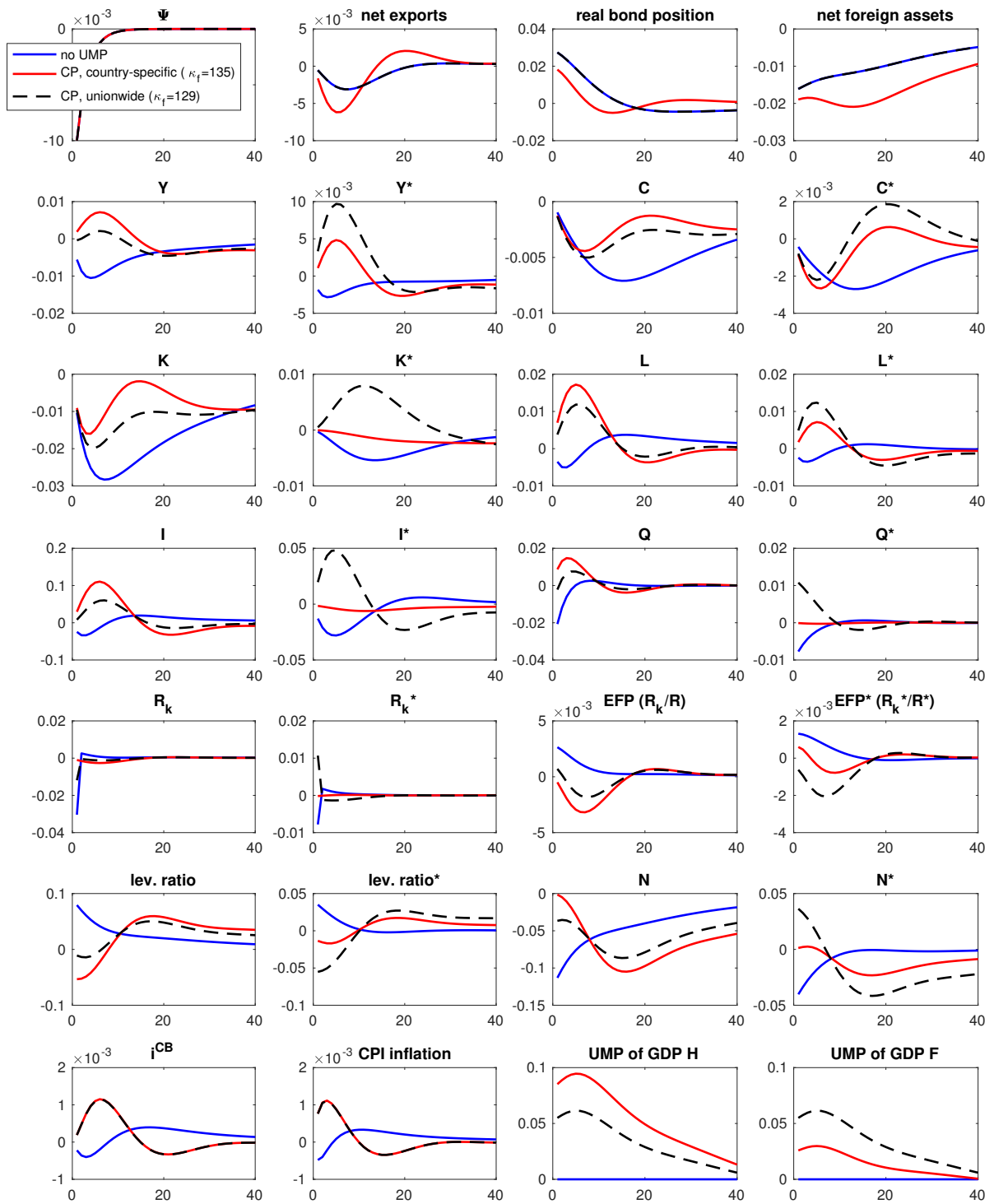
If households were to exist in a world with only net wealth shocks, i.e., purely financial shocks, they would unambiguously prefer rules based upon country-specific indicators. There are sizeable gains from unconventional monetary policy, even with small optimal coefficients. Credit spread rules score higher than credit growth rules, which implies that the credit spread might be a better indicator of the needs of the financial system than credit growth.

In a world with only monetary policy shocks, by construction, households are completely indifferent between country-specific and union-wide rules, as these shocks are not country-specific.

As capital quality shocks were found to drive the main result stated in the previous section, it seems natural to have a closer look at the economies' direct response to capital quality shocks. Figures 1 and 2 show the impulse responses to an adverse capital quality shock hitting the home economy in the presence of credit policy by the central bank. Figure 1 displays the responses for country-specific versus union-wide *credit spread rules*, whereas figure 2 displays the respective responses in case the central bank resorts to *credit growth rules*. As in Gertler and Karadi (2011), credit policy significantly moderates the contraction in the economy hit by the shock. By taking over some of the lending activities of the troubled banking sector, the rise in the credit spread and the drop in the asset price are dampened. This, in turn, dampens the decline in banks' lending activities. In the absence of central bank credit policy, the foreign economy also experiences a decline in output which is essentially driven by the deterioration of foreign banks' balance sheets which are exposed to home assets. As explained in Krenz (2016), given financial market integration, the home capital quality shock directly hits foreign banks' balance sheets by destroying part of the asset portfolio. Credit policy by the central bank can completely eliminate the adverse effect on foreign output (and other real and financial variables) by effectively combatting the balance sheet recession. Recall that in the all-shocks environment as well as in the environment only featuring capital quality shocks, union-wide policies yield higher welfare in the case of credit spread rules (figure 1), whereas country-specific policies yield higher welfare in the case of credit growth rules (figure 2). In order to understand the impulse responses, it is important to remember that when the central banks adheres to a union-wide rule it reacts to union-wide averages and intermediates the same share of funds in both countries. On the other hand, when it follows country-specific rules, the shares of funds provided in each country are chosen based on country-specific needs. The figures clearly show that the differences between country-specific and union-wide policies are much smaller for credit spread rules (figure 1) than for credit growth rules (figure 2). This holds even though, in the latter case, the optimal coefficients are much more alike. From this, it can be drawn that – at least in the case of capital quality shocks – credit spreads are much more correlated between countries than credit growth. Per construction, union-wide policy leads to “overstabilization” in the country which is not hit by a shock (F) in both figures. However, for credit growth rules (figure 2), overstabilization is much more pronounced. In figure 2, foreign capital, investment, net worth and capital prices are pushed into the opposite direction, when the monetary authority relies on union-wide as opposed to country-specific indicators. Last but not least, it can be seen that in both figures, union-wide policies do not affect net exports, real foreign bond positions and net foreign assets.



**Figure 1:** Impulse responses to an adverse capital quality shock under a *credit spread rule* (rule 1)



**Figure 2:** Impulse responses to an adverse capital quality shock under a *credit growth rule* (rule 2)

As the cross-country correlations of the indicators of the unconventional monetary policy rules seem to be an important driver of the findings of the impulse response analyses, it seems worthwhile to conduct robustness checks with respect to some of the determinants of the cross-country correlation

of the indicator variables. In particular, I will analyze the two extreme cases where banks do not provide credit to foreign firms and, on the other extreme, where banks hold a fully diversified portfolio ( $\mu_A = 0.5$ ). Tables 11 and 12 in the appendix show the optimal coefficients and welfare results for the different rules in the two extreme cases. Table 11 shows that with domestic credit provision, the result that credit policy following a credit spread rule yields higher welfare when reacting to union-wide indicators still holds. In the case of fully diversified banks (see table 12), however, it does not hold any more. Now, union-wide rules score higher, when the central bank resorts to credit growth as an indicator variable. Tables 3 and 4 support the view that this is again the result of underlying cross-country correlations: In the baseline model ( $\mu_A = 0.91$ ) and the model with domestic credit provision, the correlation between credit spreads is higher than the correlation between credit growth. In the model with fully diversified bank portfolios, the ranking is turned around. This result holds for an environment with all shocks, but is even more pronounced when only taking into account capital quality shocks.

corr	baseline $\mu_A = 0.91$	domestic credit	full diversification $\mu_A = 0.5$
$Y, Y^*$	0.661	0.588	0.730
$\lambda, \lambda^*$	0.689	0.608	0.722
$\frac{R_k}{R}, \frac{R_k^*}{R^*}$	0.831	0.552	0.880
$QK, Q^* K^*$	0.660	0.479	0.995

**Table 3:** Cross-country correlations (all shocks)

corr	baseline $\mu_A = 0.91$	domestic credit	full diversification $\mu_A = 0.5$
$Y, Y^*$	0.457	0.588	0.972
$\lambda, \lambda^*$	0.590	0.608	0.981
$\frac{R_k}{R}, \frac{R_k^*}{R^*}$	0.810	0.552	0.228
$QK, Q^* K^*$	0.384	0.479	0.987

**Table 4:** Cross-country correlations (only capital quality shocks)

Although it is difficult to entirely determine what exactly drives the findings presented in section 5.1, it can be concluded that if the central bank reacts to indicator variables which are highly correlated between countries, it might be

welfare-superior to resort to union-wide rules as opposed to country-specific rules. If indicators are highly correlated, union-wide rules provide similar stabilization in the economy hit by the shock while over-stabilization in the economy spared by the shock is smaller, rendering union-wide rules preferable over country-specific rules. As explained in the introduction, this can be rationalized with the fact that I consider a second-best environment. When financial frictions cannot be fully eliminated, the effects of unconventional monetary policy on welfare are two-fold. On one hand, reductions in volatility reduce the financial accelerator and please the consumption-smoothing motive of the consumer. On the other hand, reductions in volatility might prevent precautionary behaviour, such as precautionary saving and net worth accumulation, which – to some extent – is desirable in a world with financial frictions.<sup>21</sup> Therefore, depending on the cross-country correlation of the indicator variables, the overall welfare effects can either be higher for rules providing relatively less stabilization in the economy hit by the shock but relatively more stabilization in the other country (=union-wide rules) or for rules providing relatively more stabilization in the economy hit by the shock but relatively less in the other economy (=country-specific rules).

### 5.3 Optimal simple rules in an asymmetric setup

It is very often argued, that unconventional monetary policy can cause free-riding behavior and lower the incentives to reform financial structures. This is especially relevant in a financially heterogeneous monetary union where the risks and costs of unconventional monetary policy are shared among member countries. In this section, I consider the case where country  $H$  has a more sound financial system than country  $F$ . This is modeled by introducing a macroprudential instrument with similar effects as a countercyclical capital buffer in country  $H$ .<sup>22</sup>

Regarding the implementation of the capital requirement, I follow [Ghilardi and Peiris \(2016\)](#) and [Levine and Lima \(2015\)](#) by introducing a countercyclical subsidy on net worth,  $\tau_t^N$ , which adjusts in proportion to variations in the credit-

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<sup>21</sup>Note that the relationship between welfare and stochastic steady state net worth implied by, e.g., table 2 is not monotonous.

<sup>22</sup>The [Basel Committee on Banking Supervision \(2017\)](#) reports considerable cross-country differences in the implementation of the countercyclical capital buffer required by the Basel III framework.

to-GDP-ratio<sup>23</sup>

$$\ln(1 + \tau_t^N) = -\kappa_\tau \ln \left[ \frac{B_t/Y_t}{B/Y} \right],$$

where  $\kappa_\tau = 0.1$ .

In general, a subsidy on net worth increases the cost of borrowing from households,  $R_t$ , making it more attractive for banks to accumulate net worth instead of collecting deposits in order to finance loans. If implemented in a countercyclical fashion, the subsidy increases whenever the economy performs below average boosting lending activities while it precludes the economy from overheating during economic upswings.

Given the subsidy, intermediary  $i$ 's net worth evolves according to the following equation

$$N_{i,t} = R_t^A B_{i,t-1} - R_{t-1} D_{i,t-1}^B + \tau_{t-1}^N N_{i,t-1}.$$

Solving the banks' maximization problem in the presence of the subsidy, the marginal cost of deposits changes to

$$\eta_t = E_t \{ \Omega_{t+1} \} (R_t + \tau_t^N).$$

On an aggregate level, only the net worth of existing bankers is affected by the macroprudential subsidy, i.e.,

$$N_{e,t} = \theta_B \left[ (R_t^A - R_{t-1}) \phi_{t-1} + R_{t-1} + \tau_{t-1}^N \right] N_{t-1} \epsilon_{N,t}.$$

In this asymmetric setup, the optimal policy coefficients of the country-specific unconventional monetary policy rules will obviously differ between countries, i.e.,  $\kappa_m \neq \kappa_m^*$  and  $\kappa_f \neq \kappa_f^*$  in the country-specific rules. Since I assume that unconventional monetary policy is conducted by a single authority, reaction coefficients  $\kappa_m$  and  $\kappa_m^*$ , or  $\kappa_f$  and  $\kappa_f^*$ , respectively, are chosen to jointly maximize union-wide welfare. Given the optimal simple rule for each policy, I also calculate the welfare for each country separately.

Table 5 shows the welfare results for such a heterogenous monetary union. First of all, it should be noted that union-wide welfare is higher than in the baseline case, where both countries are symmetric and macroprudential regulations are absent (see table 2,  $g = -3.16$ ). That means, on average, both countries profit from higher stability of the banking system in country  $H$ . Without

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<sup>23</sup>Ghilardi and Peiris (2016) use foreign borrowing as an indicator variable and Levine and Lima (2015) employ a whole set of different indicator variables in the macroprudential rule. However, as it is generally agreed that macroprudential instruments should prevent excessive credit development (see, e.g., Lang and Welz, 2017), the credit-to-GDP-ratio seems to be a natural choice for an indicator variable in a macroprudential rule in the given model.

unconventional monetary policy and in the presence of unconventional policy following a credit spread rule, the country with a more regulated financial system ( $H$ ) is better off in welfare terms than the other country. However, once the common central bank adopts a credit growth rule for the conduct of unconventional policies, this result changes. Now, the less stable country profits more from the introduction of unconventional measures than the more stable country. An intuition for why country  $H$  profits more from credit spread rules while country  $F$ , the non-regulated economy, profits more from credit growth rules is the way the macroprudential rule in country  $H$  is specified. As  $\tau_t^N$ , the macroprudential policy instrument, reacts to a credit measure, its stabilization effects might partly overlap with those of unconventional policies reacting to credit growth. Last but not least, table 5 shows that the preferences regarding the formulation of the rules are different. While the financially less stable country ( $F$ ) prefers country-specific rules in all cases, the more stable country ( $H$ ) prefers union-wide rules in some cases.

	$H$ (fin. regulated)		$F$ (fin. non-regulated)		union av.
	opt. $\kappa_{f/m}$	$g$	opt. $\kappa_{f/m}$	$g$	$g$
no UMP	-	-2.73	0	-3.23	-2.98
<i>Rule 1 - credit spread rule</i>					
LF, cou.	73	-2.17	53	-2.45	-2.31
LF, un.	69	-2.22	69	-2.45	-2.34
CP, cou.	330	1.00	129	-1.15	-0.08
CP, un.	330	3.36	330	-1.13	1.10
<i>Rule 2 - credit growth rule</i>					
LF, cou.	53	0.97	63	3.23	2.10
LF, un.	66	1.04	66	2.67	1.85
CP, cou.	26	1.56	254	4.58	3.06
CP, un.	43	1.05	43	3.08	2.06

$g$ : welfare gains in consumption equivalents in percent of steady state consumption.

**Table 5:** Optimal simple rules and welfare gains with structurally heterogeneous countries

These results imply that unconventional monetary policy might aggravate free-riding behavior on the part of a country with a less stable financial sector. To evaluate whether the incentives to reform financial structures are affected by the introduction of unconventional monetary policy measures, country  $F$ 's welfare gains provided in table 5 have to be compared to its welfare gains in the counterfactual case in which it also adopts a macroprudential policy measure.



Note that in this case, the two countries of the union would be perfectly symmetric again. Table 6 shows the welfare gains from the different policy regimes in country  $F$  with and without a reform of the financial sector. As indicated by the positive values in the last column, country  $F$  profits from a reform of its own financial sector when unconventional monetary policy is absent and when the common monetary authority resorts to a credit spread rule. However, once the monetary authority decides to react to a credit growth measure, incentives to reform the financial structures in country  $F$  turn negative, i.e., country  $F$  would prefer not to reform its financial system. It should also be noticed that for each policy rule, the incentives to reform are lower when the common monetary authority follows a country-specific rule.

	no reform $g$ (F)	reform $g$ (F)	relative gain from reform
no UMP	-3.23	-2.78	0.45
<i>Rule 1 - credit spread rule</i>			
LF, cou.	-2.45	-2.09	0.36
LF, un.	-2.45	-2.13	0.32
CP, cou.	-1.15	1.53	2.67
CP, un.	-1.13	1.55	2.68
<i>Rule 2 - credit growth rule</i>			
LF, cou.	3.23	0.73	-2.50
LF, un.	2.67	0.65	-2.02
CP, cou.	4.58	0.83	-3.75
CP, un.	3.08	0.67	-2.41

$g$ : welfare gains in consumption equivalents in percent of steady state consumption. Relative gain: difference between  $g$  with and without reform.

**Table 6:** Incentives to reform financial structures in the foreign economy

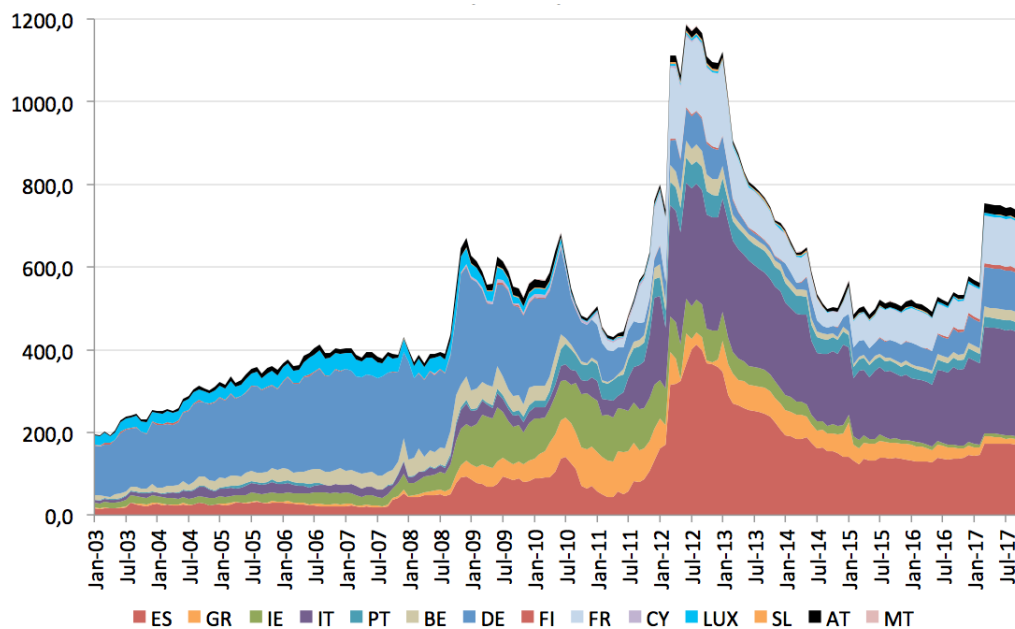
The results of this section underpin the concern that unconventional monetary policy in a structurally heterogeneous monetary union might distort incentives to reform financial structures in individual countries. However, the analysis should also be seen as a first, rather qualitative exercise, whose results cannot be generalized to the wide range of structural asymmetries found in, e.g., the European Union.

## 6 Conclusion

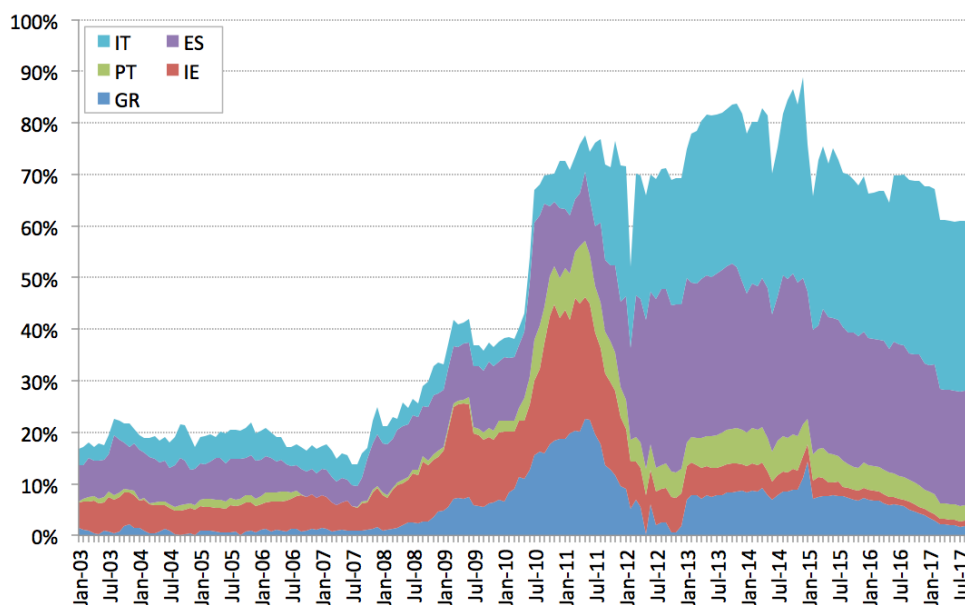
In recent years, the ECB has adopted a wide array of unconventional monetary policy measures. All of them were decided upon on a centralized level, i.e., responding to union-wide conditions. However, while some (several purchase programs) were made available to recipients in Eurozone countries in a fixed manner, according to their respective country's key, others (e.g., liquidity provision) were provided to recipients flexibly according to specific needs and regardless of nationality. Hence, while the former can be seen as measures addressing union-wide circumstances, the latter allow a tailor-made response to country-specific shocks. This paper analyzes the welfare implication of a small sample of unconventional monetary policy measures and, in particular, distinguishes between country-specific and union-wide approaches. Since the subject of cross-country heterogeneity is an important factor when discussing the risks and benefits of unconventional policies in a monetary union, I also consider the case of a structurally asymmetric monetary union.

The results obtained from these analyses provide some important policy implications for a monetary union. First, I show that from a theoretical point of view, it is not in general welfare improving to use unconventional instruments to address country-specific shocks. However, union-wide policy can only yield higher welfare than country-specific policy, when the central bank reacts upon indicators which are highly correlated between countries. If – for whatever reason – such indicators are not available (measurement problems, high divergence between countries etc.), union-wide policy can lead to welfare losses relative to country-specific policy. That this is a relevant problem in the European Union is, e.g., found by [Macchiarelli et al. \(2017\)](#) who report that “corporates in countries like Italy and Spain, where the banking system is more under pressure, might benefit less from the CSPP [Corporate Sector Purchase Program; note from the author]”. It is difficult to imagine how some of the unconventional monetary policy instruments, such as corporate sector asset purchases, can be provided in a more targeted (i.e., country-specific) way. However, they could, for example, be accompanied by programs which facilitate access to bond markets and support firms in troubled countries or market segments in meeting the eligibility criteria for bond purchase programs. Second, the analysis of a heterogeneous union showed that unconventional monetary policy – regardless of whether it is conducted in a union-wide or country-specific manner – might aggravate free-riding behaviour and lower the incentives to conduct regulatory reforms in single countries. This result supports the case for pushing forward the banking union in order to unify supervision and regulation across countries.

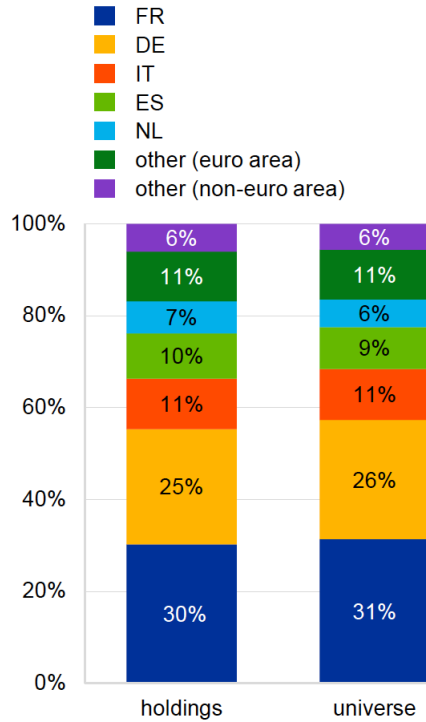
## Appendix



**Figure 3:** Country usage of the Eurosystem's main and longer-term refinancing operations, 01/2003-09/2017; [Bruegel \(2017\)](#)



**Figure 4:** Periphery's share in the usage of the Eurosystem's main and longer-term refinancing operations 01/2003 - 09/2017; [Bruegel \(2017\)](#)



**Figure 5:** Country classification of corporate sector purchase program (CSPP) holdings and CSPP-eligible bond universe; ECB (2017)

	$\kappa_f, \kappa_m$	$g$	rel. gain	riskshar.	$K$	$N$	$C$	$L$
no UMP	-	0.26	-	0.59	5.656	1.418	0.707	0.333
<i>Rule 1 - credit spread rule</i>								
LF, cou.	0	0.26	0	0.59	5.656	1.418	0.707	0.333
LF, un.	0	0.26	0	0.59	5.656	1.418	0.707	0.333
CP, cou.	43	0.28	0.01	0.59	5.655	1.406	0.707	0.333
CP, un.	129	0.33	0.06	0.50	5.657	1.373	0.707	0.333
<i>Rule 2 - credit growth rule</i>								
LF, cou.	40	1.20	0.94	0.53	5.726	1.374	0.709	0.333
LF, un.	40	0.96	0.70	0.51	5.702	1.386	0.708	0.333
CP, cou.	135	1.77	1.51	0.70	5.771	1.327	0.710	0.333
CP, un.	129	1.39	1.12	0.52	5.741	1.348	0.709	0.333

no UMP: no unconventional monetary policy.  $\kappa_f$ : optimal feedback coefficient for liquidity facilities.  $\kappa_m$ : optimal feedback coefficient for credit policy. LF: liquidity facilities. CP: corporate credit policy.  $g$ : welfare gains in consumption equivalents in percent of steady state consumption. Relative gain: difference in  $g$  to case without unconventional policy. International risksharing is measured as  $\text{corr}(\lambda_t, \lambda_t^*)$ . Columns 5-8 display the stochastic steady state of the given variable.

**Table 7:** Optimal simple rules in a symmetric setup (only capital quality shocks)

	$\kappa_f, \kappa_m$	$g$	rel. gain	riskshar.	$K$	$N$	$C$	$L$
no UMP	-	0.02	-	0.41	5.663	1.417	0.707	0.333
<i>Rule 1 - credit spread rule</i>								
LF, cou.	330	0.03	0.01	0.39	5.664	1.415	0.707	0.333
LF, un.	330	0.04	0.02	0.39	5.664	1.415	0.707	0.333
CP, cou.	330	0.04	0.02	0.40	5.663	1.410	0.707	0.333
CP, un.	330	0.04	0.02	0.39	5.663	1.408	0.707	0.333
<i>Rule 2 - credit growth rule</i>								
LF, cou.	23	0.06	0.04	0.39	5.666	1.415	0.707	0.333
LF, un.	26	0.06	0.04	0.38	5.665	1.415	0.707	0.333
CP, cou.	132	0.10	0.09	0.42	5.672	1.410	0.707	0.333
CP, un.	129	0.09	0.07	0.33	5.670	1.411	0.707	0.333

no UMP: no unconventional monetary policy.  $\kappa_f$ : optimal feedback coefficient for liquidity facilities.  $\kappa_m$ : optimal feedback coefficient for credit policy. LF: liquidity facilities. CP: corporate credit policy.  $g$ : welfare gains in consumption equivalents in percent of steady state consumption. Relative gain: difference in  $g$  to case without unconventional policy. International risksharing is measured as  $\text{corr}(\lambda_t, \lambda_t^*)$ . Columns 5-8 display the stochastic steady state of the given variable.

**Table 8:** Optimal simple rules in a symmetric setup (only technology shocks)

	$\kappa_f, \kappa_m$	$g$	rel. gain	riskshar.	$K$	$N$	$C$	$L$
no UMP	-	0.19	-	0.40	5.670	1.409	0.707	0.333
<i>Rule 1 - credit spread rule</i>								
LF, cou.	23	0.44	0.25	0.33	5.685	1.397	0.708	0.333
LF, un.	26	0.36	0.17	0.16	5.680	1.401	0.708	0.333
CP, cou.	13	0.46	0.28	0.28	5.684	1.397	0.708	0.333
CP, un.	16	0.37	0.19	0.14	5.680	1.400	0.708	0.333
<i>Rule 2 - credit growth rule</i>								
LF, cou.	16	0.39	0.21	0.32	5.680	1.401	0.708	0.333
LF, un.	16	0.33	0.15	0.28	5.677	1.403	0.708	0.333
CP, cou.	13	0.42	0.24	0.27	5.681	1.400	0.708	0.333
CP, un.	13	0.35	0.16	0.24	5.678	1.402	0.708	0.333

no UMP: no unconventional monetary policy.  $\kappa_f$ : optimal feedback coefficient for liquidity facilities.  $\kappa_m$ : optimal feedback coefficient for credit policy. LF: liquidity facilities. CP: corporate credit policy.  $g$ : welfare gains in consumption equivalents in percent of steady state consumption. Relative gain: difference in  $g$  to case without unconventional policy. International risksharing is measured as  $\text{corr}(\lambda_t, \lambda_t^*)$ . Columns 5-8 display the stochastic steady state of the given variable.

**Table 9:** Optimal simple rules in a symmetric setup (only net wealth shocks)

	$\kappa_f, \kappa_m$	$g$	rel. gain	riskshar.	$K$	$N$	$C$	$L$
no UMP	-	-3.61	-	1.00	5.603	1.518	0.703	0.331
<i>Rule 1 - credit spread rule</i>								
LF, cou.	92	-3.07	0.55	1.00	5.651	1.495	0.705	0.332
LF, un.	92	-3.07	0.55	1.00	5.651	1.495	0.705	0.332
CP, cou.	284	-2.04	1.57	1.00	5.670	1.160	0.706	0.332
CP, un.	284	-2.04	1.57	1.00	5.670	1.160	0.706	0.332
<i>Rule 2 - credit growth rule</i>								
LF, cou.	89	1.66	5.28	1.00	5.894	1.336	0.712	0.333
LF, un.	89	1.66	5.28	1.00	5.894	1.336	0.712	0.333
CP, cou.	139	2.63	6.24	1.00	5.947	1.290	0.715	0.334
CP, un.	139	2.63	6.24	1.00	5.947	1.290	0.715	0.334

no UMP: no unconventional monetary policy.  $\kappa_f$ : optimal feedback coefficient for liquidity facilities.  $\kappa_m$ : optimal feedback coefficient for credit policy. LF: liquidity facilities. CP: corporate credit policy.  $g$ : welfare gains in consumption equivalents in percent of steady state consumption. Relative gain: difference in  $g$  to case without unconventional policy. International risksharing is measured as  $\text{corr}(\lambda_t, \lambda_t^*)$ . Columns 5-8 display the stochastic steady state of the given variable.

**Table 10:** Optimal simple rules in a symmetric setup (only monetary policy shocks)

	$\kappa_f, \kappa_m$	$g$	rel. gain	riskshar.	$K$	$N$	$C$	$L$
no UMP	-	-3.45	-	0.61	5.600	1.530	0.702	0.331
<i>Rule 1 - credit spread rule</i>								
LF, cou.	53	-2.74	0.71	0.58	5.650	1.502	0.705	0.332
LF, un.	76	-2.75	0.70	0.54	5.657	1.486	0.705	0.332
CP, cou.	330	-1.73	1.72	0.56	5.726	1.234	0.707	0.333
CP, un.	267	-1.61	1.84	0.49	5.673	0.982	0.705	0.332
<i>Rule 2 - credit growth rule</i>								
LF, cou.	56	3.32	6.77	0.62	5.982	1.282	0.713	0.333
LF, un.	66	2.62	6.07	0.56	5.943	1.309	0.713	0.333
CP, cou.	122	5.22	8.67	0.63	6.124	1.176	0.719	0.334
CP, un.	125	4.10	7.55	0.54	6.040	1.231	0.717	0.334

no UMP: no unconventional monetary policy.  $\kappa_f$ : optimal feedback coefficient for liquidity facilities.  $\kappa_m$ : optimal feedback coefficient for credit policy. LF: liquidity facilities. CP: corporate credit policy.  $g$ : welfare gains in consumption equivalents in percent of steady state consumption. Relative gain: difference in  $g$  to case without unconventional policy. International risksharing is measured as  $\text{corr}(\lambda_t, \lambda_t^*)$ . Columns 5-8 display the stochastic steady state of the given variable.

**Table 11:** Optimal simple rules in a symmetric setup (domestic credit provision)

	$\kappa_f, \kappa_m$	$g$	rel. gain	riskshar.	$K$	$N$	$C$	$L$
no UMP	-	-3.20	-	0.72	5.599	1.521	0.702	0.331
<i>Rule 1 - credit spread rule</i>								
LF, cou.	53	-2.66	0.54	0.68	5.650	1.504	0.704	0.332
LF, un.	66	-2.58	0.63	0.67	5.645	1.502	0.704	0.332
CP, cou.	178	-1.41	1.79	0.63	5.676	1.245	0.706	0.332
CP, un.	172	-1.62	1.58	0.64	5.664	1.281	0.705	0.332
<i>Rule 2 - credit growth rule</i>								
LF, cou.	53	2.75	5.96	0.66	5.926	1.303	0.711	0.333
LF, un.	66	2.89	6.09	0.68	5.942	1.301	0.712	0.333
CP, cou.	125	4.35	7.55	0.66	6.039	1.224	0.716	0.334
CP, un.	125	4.38	7.58	0.67	6.038	1.224	0.716	0.334

no UMP: no unconventional monetary policy.  $\kappa_f$ : optimal feedback coefficient for liquidity facilities.  $\kappa_m$ : optimal feedback coefficient for credit policy. LF: liquidity facilities. CP: corporate credit policy.  $g$ : welfare gains in consumption equivalents in percent of steady state consumption. Relative gain: difference in  $g$  to case without unconventional policy. International risksharing is measured as  $\text{corr}(\lambda_t, \lambda_t^*)$ . Columns 5-8 display the stochastic steady state of the given variable.

**Table 12:** Optimal simple rules in a symmetric setup (fully diversified portfolio,  $\mu_A = 0.5$ )

## References

- Auray, S., Eyquem, A., and Ma, X. (2016). Banks, sovereign risk and unconventional monetary policies. Working Paper 2014-10, Centre de Recherche en Economie et Statistique. 3, 7
- Basel Committee on Banking Supervision (2017). Range of practices in implementing the countercyclical capital buffer policy. Technical report, Bank for International Settlements. 29
- Bruegel, editor (2017). *Eurosystem liquidity*. Bruegel datasets. Available from: <http://bruegel.org/publications/datasets/eurosystem-liquidity/>. 34
- Brzoza-Brzezina, M., Kolasa, M., and Makarski, K. (2015). Monetary and macroprudential policy with foreign currency loans. Working Paper Series 1783, European Central Bank. 7
- Cahn, C., Matheron, J., and Sahuc, J.-G. (2014). Assessing the macroeconomic effects of LTROs. Working paper 528, Banque de France. 14

- Cúrdia, V. and Woodford, M. (2011). The central-bank balance sheet as an instrument of monetary policy. *Journal of Monetary Economics*, 58:54–79. [3](#)
- de Walque, G., Smets, F., and Wouters, R. (2006). An estimated two-country DSGE model for the Euro area and the US economy. Working paper presented at the 7th EABCN Workshop (Zurich, August 2006), Swiss National Bank. [19](#)
- Dedola, L., Karadi, P., and Lombardo, G. (2013). Global implications of national unconventional policies. *Journal of Monetary Economics*, 60:66–85. [1](#), [3](#), [16](#), [17](#)
- Devereux, M. B., Senay, O., and Sutherland, A. (2014). Nominal stability and financial globalization. *Journal of Money, Credit and Banking*, 46:921–959. [13](#)
- Devereux, M. B. and Sutherland, A. (2009). A portfolio model of capital flows to emerging markets. *Journal of Development Economics*, 89:181–193. [19](#)
- Devereux, M. B. and Yetman, J. (2010). Leverage constraints and the international transmission of shocks. *Journal of Money, Credit and Banking*, 42:71–105. [6](#)
- Dräger, L. and Proaño, C. R. (2016). Cross-border banking and business cycles in asymmetric currency unions. Working Paper 161, Macroeconomic Policy Institute. [7](#)
- ECB (2017). The ECB’s corporate sector purchase programme: its implementation and impact. In *ECB Economic Bulletin, Issue 4*, pages 40–45. [2](#), [35](#)
- Gertler, M. and Karadi, P. (2011). A model of unconventional monetary policy. *Journal of Monetary Economics*, 58:17–34. [1](#), [3](#), [4](#), [10](#), [11](#), [15](#), [16](#), [19](#), [21](#), [24](#), [25](#)
- Gertler, M. and Kiyotaki, N. (2011). Financial intermediation and credit policy in business cycle analysis. In Friedman, B. M. and Woodford, M., editors, *Handbook of Monetary Economics*, volume 3, chapter 11, pages 547–599. Elsevier. [1](#), [3](#), [11](#), [14](#)
- Gertler, M., Kiyotaki, N., and Queralto, A. (2012). Financial crises, bank risk exposure and government financial policy. *Journal of Monetary Economics*, 59, Supplement:17 – 34. [17](#), [19](#)
- Ghilardi, M. F. and Peiris, S. J. (2016). Capital flows, financial intermediation and macroprudential policies. *Open Economies Review*, pages 1–26. [29](#), [30](#)



- Hjortsoe, I. (2016). Imbalances and fiscal policy in a monetary union. *Journal of International Economics*, 102:225 – 241. 7
- Juillard, M. and Kamenik, O. (2005). Solving DSGE models: Approximation about the stochastic steady state. Unpublished. 19
- Krenz, J. (2016). Banks' balance sheets and the international transmission of shocks. Working Paper 2016-03, BDPEMS. 25
- Lang, J. H. and Welz, P. (2017). Measuring credit gaps for macroprudential policy. In *Financial Stability Review*, chapter B, pages 144–157. ECB. 30
- Levine, P. and Lima, D. (2015). Policy mandates for macro-prudential and monetary policies in a new Keynesian framework. Working Paper Series 1784, ECB. 29, 30
- Macchiarelli, C., Monti, M., and Vedolin, A. (2017). The corporate sector purchase programme (CSPP): Effectiveness and challenges ahead. In-depth analysis 2017-03, European Parliament. Directorate General for Internal Policies. 33
- Nuguer, V. (2016). Financial intermediation in a global environment. *International Journal of Central Banking*, 12(3):291–344. 3
- Poutineau, J.-C. and Vermandel, G. (2015). Cross-border banking flows spillovers in the eurozone: Evidence from an estimated DSGE model. *Journal of Economic Dynamics and Control*, 51:378 – 403. 7, 19
- Praet, P. (2017). The ECB's monetary policy: past and present. Speech by Peter Praet, Member of the Executive Board of the ECB, at the Febelfin Connect event, Brussels/Londerzeel, 16 March 2017. Available from: <https://www.bis.org/review/r170317a.htm>. 2
- Primiceri, G., Schaumburg, E., and Tambalotti, A. (2006). Intertemporal disturbances. Working Paper 12243, NBER. 19
- Rabitsch, K., Stepanchuk, S., and Tsyrennikov, V. (2015). International portfolios: A comparison of solution methods. *Journal of International Economics*, 97(2):404 – 422. 7
- Schmitt-Grohé, S. and Uribe, M. (2003). Closing small open economy models. *Journal of International Economics*, 61:163–185. 4, 6, 7
- Schmitt-Grohé, S. and Uribe, M. (2004). Optimal simple and implementable monetary and fiscal rules. Working Paper 10253, NBER. 19

Schwanebeck, B. (2017). Unconventional monetary policy in a financially heterogeneous monetary union. Discussion Paper in Economics 41, MAGKS. [3](#)

Tischbirek, A. (2016). Unconventional monetary policy in a currency union with segmentation in the market for government debt. Working paper, University of Lausanne. [3](#)