DIW BERLIN

1873

Discussion Papers

Deutsches Institut für Wirtschaftsforschung 2020

The Macroeconomic Effects of a European Deposit (Re-)Insurance Scheme

Marius Clemens, Stefan Gebauer, Tobias König

IMPRESSUM

DIW Berlin
German Institute for Economic Research
Mohrenstr. 58
10117 Berlin

Tel. +49 (30) 897 89-0
Fax +49 (30) 897 89-200
http://www.diw.de

ISSN electronic edition 1619-4535

Papers can be downloaded free of charge from the DIW Berlin website:
http://www.diw.de/discussionpapers

Discussion Papers of DIW Berlin are indexed in RePEc and SSRN:
http://ideas.repec.org/s/diw/diwwpp.html
http://www.ssrn.com/link/DIW-Berlin-German-Inst-Econ-Res.html

The Macroeconomic Effects of a European Deposit (Re-)Insurance Scheme

Marius Clemens[*], Stefan Gebauer[†], Tobias König[‡]

May 20, 2020

Abstract

While the first two pillars of the European Banking Union have been implemented, a European deposit insurance scheme (EDIS) is still not in place. To facilitate its introduction, recent proposals argue in favor of a reinsurance scheme. In this paper, we use a regime-switching open-economy DSGE model with bank default and bank-government linkages to assess the relative efficiency of such a scheme. We find that reinsurance by both a national fiscal backstop and EDIS is efficient in stabilizing the macro economy, even though welfare gains are slightly larger with EDIS and debt-to-GDP ratios rise under the fiscal reinsurance. We demonstrate that risk-weighted contributions to EDIS are welfare-beneficial for depositors and discuss trade-offs policy makers face during the implementation of EDIS. In a counterfactual exercise, we find that EDIS would have stabilized economic activity in Germany and the rest of the euro area just as well as a fiscal backing of insured deposits during the financial crisis. However, the debt-to-GDP ratio would have been lower with EDIS.

JEL: E61, F42, F45, G22, G28

Keywords: Banking Union, Deposit Insurance, Risk-Sharing

[*]DIW Berlin, BERA. E-mail address: mclemens@diw.de.

[†]DIW Berlin, Freie Universität Berlin. E-mail address: sgebauer@diw.de.

[‡]DIW Berlin, Humboldt-Universität zu Berlin. E-mail address: tkoenig@diw.de.

The views in this paper are those of the authors and do not necessarily reflect the views of DIW Berlin. We thank Mathias Trabandt, Michael C. Burda, Alexander Kriwoluzky, Franziska Bremus, Lutz Weinke, Evi Pappa, Kalin Nikolov, Giovanni Ricco, Mathias Hoffmann and participants at the 13th RGS Doctoral Conference in Economics, the FU Berlin Empirical Macroeconomics Seminar, and the Humboldt-Universität Brown Bag Seminar for useful comments. This paper was written in the context of the SAW-project "European capital markets and macroeconomic stability: The role of equity and debt". Funding from the Leibniz Competition is gratefully acknowledged.

1 Introduction

While the first two pillars of the European Banking Union have been implemented, a European deposit insurance scheme (EDIS) is still not in place. To facilitate its introduction, recent proposals argue in favor of a reinsurance scheme, where European deposit insurance is used only if national deposit insurance is depleted. In this paper, we assess the performance of such a deposit reinsurance scheme in the absorption of macroeconomic and financial shocks. To this end, we develop a two-country dynamic stochastic general equilibrium (DSGE) model and introduce bank default following Mendicino et al. (2018). Our framework features national deposit insurance (DI) schemes, as well as trade and financial linkages, allowing for heterogeneity between countries. We calibrate the model such that empirical moments in macroeconomic and financial time series for Germany (home) and the euro area excluding Germany (foreign) are matched. We then introduce EDIS as a risk-sharing device and study potential gains and losses with respect to welfare, macroeconomic and financial stability.[1]

Our model incorporates three key elements that are important to take bank risk-taking into account and for adequately analyzing the performance of EDIS. First, home and foreign banks can default on their obligations and leave depositors and equity investors with losses. By allowing for bank default, we are able to study the costs and benefits of deposit insurances. Second, national deposit insurances collect payments from national banks. However, in times of severe financial distress, the national deposit insurance can be limited and either national governments or EDIS have to step in to insure bank deposits. Thus, we incorporate regime switches in the model. Third, we introduce two linkages between banks and governments: Banks finance sovereign debt and the fiscal authority provides tax- and debt-financed guarantees in case of bank insolvencies.

We analyze the macroeconomic effects of a European deposit reinsurance mechanism in a situation where national deposit insurances are insufficient. We evaluate different forms of reinsurance: no reinsurance, a national fiscal backstop, and EDIS. In response to adverse bank risk shocks in home, we find that both the national fiscal backstop and EDIS perform equally well in providing reinsurance, with the latter being more effective in stabilizing overall consumption. In the home economy,

[1] Our reinsurance scheme where EDIS would depict a second line of defense after national capacities have been exhausted also resembles closely to the proposals by a group of German and French economists (Bénassy-Quéré et al., 2018) and by the European Parliament (De Lange, 2016).

the drop in consumption is 20 percent lower from peak to trough with EDIS.

However, under the fiscal backstop, insurance transfers directly affect the home country's public finances. While the country's debt-to-GDP ratio remains fairly stable with EDIS, it rises by almost two percent under the fiscal reinsurance. Under EDIS, such an increase in government debt is avoided. However, as banks have to contribute both into the national DI and EDIS, the total burden for home banks is higher with EDIS. Even so, as contributions into EDIS are deductible from national DI payments, the national fund recovery takes longest with EDIS. Financial distress is transmitted to the foreign economy via international trade and financial markets, and foreign banks are also required to contribute more to cover default losses in the home economy with EDIS. This reduces margins for foreign banks, with resulting adverse effects for foreign lending and real economic activity.

With respect to welfare, we find that EDIS is particularly beneficial for savers in a country where national insurance funds are exhausted. Consequently, welfare gains from EDIS are largest in a scenario where national funds in both economies are insufficient to cover losses from bank default. In addition, we study the welfare implications related to two key points raised in recent proposals: the weighting of contributions and short-term implementation costs. With respect to the optimal design of contribution weights, we show that on the union-wide level, household welfare increases in the share of contributions of risky banks, justifying a risk-based contributions scheme if the ultimate objective of EDIS is depositor welfare.

With respect to short-term implementation costs, we assume that the fund is only activated once its target level has been reached. We show that diverting funds towards EDIS can temporarily lower national DIs' capacities if deductibility of EDIS contributions lowers bank payments into national systems. However, while removing deductibility can increase national DIs' capacities, an overburdening of banks through double contributions potentially limits intermediation capacities, with respective adverse effects for financial stability and the real economy. Extending the implementation horizon mitigates peak default rates in the short run, but as national DIs' capacities are lower for longer and contributions are more stretched out, the economic contraction is protracted.

Finally, we assess how EDIS would have performed in Germany and the rest of the euro area during the financial crisis in a counterfactual exercise. We compare EDIS with a benchmark policy, where we assume that national governments would have backed national deposit insurance schemes once their funds would have been exhausted. We find that the stabilization effects of EDIS for GDP and consumption would have been rather small, but debt-to-GDP ratios would have been lower with EDIS. The benefits of EDIS increase substantially once we assume that increases in sovereign bond yields are associated with declines in the value of government bond holdings by banks.

In section 2, we discuss the related literature, before we introduce our baseline DSGE model in section 3. We then describe the data and calibration procedure in section 4, and introduce regime switching and different forms of reinsurance in section 5. We report results of our theoretical and empirical analyses in section 6, and section 7 concludes.

2 Literature

Our study relates to several strands of research on bank risk-sharing and the adequate international coordination of banking policies. First, we contribute to the macroeconomic literature on bank risk-sharing in open economy models. Earlier contributions already embed banking sectors in two-country settings. Some assume a representative global bank to study international spill-over effects of country-specific shocks and their amplification by international banks (Mendoza and Quadrini, 2010; Kollmann et al., 2011; Kollmann, 2013). We deviate from this approach by allowing for heterogeneous degrees of risk across countries' individual banking sectors. To this end, our study closely relates to Dedola et al. (2013), they develop a two-country banking model à la Gertler and Kiyotaki (2011) with agency costs. In their approach, the degree of financial frictions is assumed to be equal across both countries. However, our model instead builds on Mendicino et al. (2018), who rely on a closed-economy model that features bank default and a deposit insurance scheme. They focus on optimal dynamic bank capital regulation, and while their deposit insurance reflects a direct transfer scheme between households, our framework features a deposit fund financed by banks that compensates households in case of bank default. We extend a modified version of their model to the open economy, and explicitly allow for heterogeneity in bank riskiness across both countries.

Only few studies have introduced (European) deposit insurance schemes in macroeconomic models,[2] and if so, design of such frameworks and its relative per-

[2] However, the optimal design of centralized banking supervision has been studied extensively in the theoretical banking literature. Both the optimal degree of transfer of responsibilities to a union-

formance against other forms of risk-sharing has not been studied in great detail. Furthermore, these studies do not analyze deposit insurance designed as a European reinsurance scheme. Dubois (2017) evaluates the implementation of a joint deposit insurance scheme in a two-country model with bank runs, and finds that such a framework potentially increases steady-state consumption and reduces volatility in real economic activity, with ultimately positive welfare effects. While we abstract from bank runs, international banks are subject to endogenous default risk in our model. This allows us to analyze moral hazard and welfare even during non-crisis times. In addition to the introduction of a full-fledged insurance fund, our analysis also compares the macroeconomic effects of a European deposit reinsurance to different risk-sharing scenarios.

Second, we contribute to the broader literature on the design and implications of deposit insurance schemes. On the theoretical side, Diamond and Dybvig (1983) show in their seminal paper that adequately designed deposit insurance schemes can prevent bank runs and reduce liquidity risks, which lowers the likelihood and depth of financial crises and resulting adverse effects for the real economy. However, these benefits are balanced by costs associated to moral hazard, as insurance fosters bank risk-taking behavior (Lambert et al., 2017; Anginer et al., 2014; Bernet and Walter, 2009; Cooper and Ross, 2002). Furthermore, deposit insurance can lead to a decline in market discipline and adverse selection, as the share of undisciplined and incompetent bankers rises once depositors' incentives to monitor bankers and banks incentives to behave disciplined decline (Acharya and Thakor, 2016; Merton, 1977). Empirically, Demirgüç-Kunt and Huizinga (2004) and Demirgüç-Kunt et al. (2014) document the rapid increase in the number of countries that implemented deposit guarantee schemes given their effectiveness in reducing bank runs and liquidity risks. However, there is vast empirical evidence on how deposit insurance can indeed lead to more moral hazard and risk-taking (Pennacchi, 2006; Wheelock and Kumbhakar, 1995), a decline in market discipline (Demirgüç-Kunt and Huizinga, 2004; Calomiris and Jaremski, 2019, 2016; Wheelock and Kumbhakar, 1995), and ultimately to greater instability in financial markets (Demirgüç-Kunt and Detra-

wide regulatory agency and coordination issues between supranational and national regulators have been discussed. Inter alia, the focus has been on banking supervision (Colliard, 2018; Carletti et al., 2016; Beck and Wagner, 2016; Boyer and Ponce, 2012), bank resolution (Górnicka and Zoican, 2016), as well as on bank bailouts and recapitalization (Foarta, 2018). Whereas evidence on the efficiency of supranational regulation is mixed, the findings indicate that some degree of shared responsibilities via a supranational regulatory regime is welfare-beneficial.

giache, 2002). With respect to EDIS, Carmassi et al. (2018) employ bank-level data to estimate EDIS exposure to bank failures and contributions, and study the implications of different EDIS designs and risk-weighted contribution schemes. They find that appropriately designed risk-weighted contributions to EDIS are crucial to achieve a balance between adequate insurance and cross-subsidization between national banking systems. Such cross-subsidies are smaller in a full-fledged EDIS than in a "mixed deposit insurance scheme" more similar to the reinsurance variant we study in our paper if contributions to EDIS are non-deductible.

Third, we connect to the theoretical literature that has recently investigated the doom loop between sovereigns and banks. Farhi and Tirole (2018) discuss different channels through which bad news about government and banking sustainability can induce re-nationalization in financial markets and argue that banking unions can act as commitment devices for fragile debtor countries. Similarly, Acharya et al. (2014) model the increase in bank solvency risk in response to increasing sovereign risk. Relying on credit default swaps (CDS) data, they show that bank bailouts increased sovereign credit risk over the course of the European debt crisis. Consequently, Acharya and Steffen (2016) conclude that both banking and fiscal unions are needed as risk-sharing devices to break the link between weak sovereigns and banks. As a link between both approaches, Brunnermeier et al. (2016) use a two-country bank-sovereign model to propose a risk-sharing mechanism in which banks are incentivized to hold senior tranches of syndicated government bonds backed by euro area member states (ESBies). However, empirical and theoretical evidence suggests that risk-sharing occurs via different channels (Asdrubali et al., 2018, 1996), so that well-designed fiscal policies alone cannot completely mitigate credit or sovereign default risks. Other channels such as capital and credit markets also play a significant role in effective risk-sharing (Hoffmann et al., 2019; Furceri and Zdzienicka, 2015; Afonso and Furceri, 2008; Sørensen and Yosha, 1998).

3 The Model

In this study, we rely on an open-economy model in the spirit of the euro area banking models developed in Gerali et al. (2010) and Mendicino et al. (2018). In order to analyze risk-sharing via banking and fiscal policies, we extend the model by introducing a government sector and a detailed deposit insurance scheme on both the domestic and on a union-wide level. In the model, patient households in one country provide funds to impatient entrepreneurs in the same country.[3] Funds are intermediated by regulated banks which can also invest in domestic government bonds. Regulatory capital requirements are enforced by national regulators. Due to additional regulation on the loan market, entrepreneurs have to fulfill an externally set loan-to-value (LTV) ratio when demanding funds from banks. They can only borrow up to a certain amount of their collateral value at hand, which is given by the stock of physical capital that they own. They furthermore use their collateral capital for the production of consumption goods in the model.

In line with Mendicino et al. (2018), we assume limited liability of banks. In response to idiosyncratic return shocks, banks can decide not to pay back their obligations and to default. Individual uninsured bank debt is priced to the expected aggregate bank default risk. Depositors face monitoring costs (state verification costs) when recovering defaulting banks' assets. This gives rise to containing systemic risk in the banking sector through regulation and deposit insurance.

3.1 Households

The representative patient household i in each country $c \in \{h, f\}$ maximizes expected utility

$$\max_{c_t^{P,c}(i),\, l_t^c(i),\, d_t^c(i)} E_0 \sum_{t=0}^{\infty} (\beta_P^c)^t \left[z_t^{c,c} \log[c_t^{P,c}(i) - h_P^c c_{t-1}^{P,c}(i)] - \frac{\varphi_P^c}{1+\phi_P^c} l_t^c(i)^{1+\phi_P^c} \right] \quad (1)$$

subject to the budget constraint

$$c_t^{P,c}(i) + d_t^c(i) \leq w_t^c l_t^c(i) + \tilde{R}_{t-1}^{d,c} d_{t-1}^c(i) + \Pi_t^{cp,c} + \Pi_t^{bank,c} - \tau_t^c \quad (2)$$

where $c_t^{P,c}(i)$ depicts current consumption prone to habit formation governed by h_P^c, and $z_t^{c,c}$ depicts a consumption preference shock described by an AR-1 process. Working hours are given by l_t^c and labor disutility is parameterized by ϕ_P^c. The flow of expenses includes current consumption, and real deposits to be made to domestic banks $d_t^c(i)$. Resources consist of wage earnings $w_t^c l_t^c(i)$ (where w_t^c is the real wage paid in the country the respective household resides) and gross interest income on last period's deposits placed in domestic banks, $\tilde{R}_t^{d,c}$. The fiscal authority charges lump-sum taxes τ_t^c to finance government consumption. Households receive profits $\Pi_t^{bank,c}$ transferred from exiting bankers and $\Pi_t^{cp,c}$ transferred from capital producers.

[3] Different values in the discount factors determine the borrower-lender relationship between entrepreneurs and households.

Following Mendicino et al. (2018), bank deposits are partially insured by a fraction κ_t^c. Insured bank deposits are always remunerated with the promised rate $R_t^{d,c}$. Uninsured deposits yield the promised rate $R_t^{d,c}$ if the bank is solvent and a fraction $(1-\kappa_t^c)$ of the net recovery value of bank assets in case of default. Household return on bank deposits is thus given by:

$$\tilde{R}_t^{d,c} = R_t^{d,c} - (1-\kappa_t^c)\frac{\Omega_{t+1}^c}{d_t^c(i)} \tag{3}$$

where $\frac{\Omega_{t+1}^c}{d_t^c(i)}$ is the average default loss per unit of deposits. The share of insured deposits, κ_t^c is time-varying and depends on available funds in the deposit insurance scheme. The scheme is financed by a tax imposed on the banking sector which is described in detail below.

3.2 Entrepreneurs

Entrepreneurs engaged in country c use the respective labor type provided by households as well as capital to produce intermediate goods purchased by retailers in a competitive market. Each entrepreneur i derives utility from consumption $c_t^{E,c}(i)$ and maximizes expected utility

$$\max_{c_t^{E,c}(i),l_t^{P,c}(i),k_t^{E,c}(i)} E_0 \sum_{t=0}^{\infty} (\beta_E^c)^t \left[\log c_t^{E,c}(i)\right] \tag{4}$$

subject to the budget constraint

$$c_t^{E,c}(i)+w_t^c l_t^c(i)+q_t^{k,c}k_t^{E,c}(i)+R_t^{E,c}b_{t-1}^{E,c}(i) \leq p_t^{E,c}y_t^{E,c}(i)+b_t^{E,c}(i)+q_t^{k,c}(1-\delta^c)k_{t-1}^{E,c}(i) \tag{5}$$

with $p_t^{E,c} = \frac{P_t^{E,c}}{P_t^c}$ denoting the price ratio of producer price level to consumer price level. Entrepreneurs in country c furthermore face borrowing constraints with respect to domestic bank lending, depending on the stock of capital they hold as collateral.[4] Regulatory LTV ratios apply for funds borrowed in each country, and regulation is determined on the national level. The borrowing constraint is given by

$$R_{t+1}^{E,c}b_t^{E,c}(i) \leq m_E^c E_t\{q_{t+1}^{k,c}(1-\delta^c)k_t^{E,c}(i)\} \tag{6}$$

where the LTV ratio for commercial banks m_E^c is set by a prudential regulator. Rearranging equation 6, one can derive the contractual return on one unit of corporate

[4] In Iacoviello (2005), entrepreneurs use commercial real estate as collateral. However, we follow Gerali et al. (2010) by assuming that creditworthiness of a firm is judged by its overall balance sheet condition where real estate housing only depicts a sub-component of assets.

loans:

$$R_{t+1}^{E,c} = \frac{m_E^c E_t\{q_{t+1}^{k,c}(1-\delta^c)k_t^{E,c}(i)\}}{b_t^{E,c}(i)}. \tag{7}$$

We follow Iacoviello (2005) and assume that the borrowing constraint binds around the steady state such that uncertainty is absent in the model.[5] Thus, in equilibrium, equation 6 holds with equality. The production function is given by

$$y_t^{E,c} = a_t^{E,c}(k_t^{E,c})^{(\alpha^c)}(l_t^c)^{(1-\alpha^c)}. \tag{8}$$

We can furthermore derive an expression for the law of motion of firms' net worth along the lines of Gambacorta and Signoretti (2014):[6]

$$NW_{t+1}^c = \alpha^c \frac{p_{t+1}^{E,c} y_{t+1}^{E,c}}{k_t^{E,c}} + q_{t+1}^{k,c}(1-\delta^c)k_t^{E,c} - R_{t+1}^{E,c} b_t^{E,c}. \tag{9}$$

Entrepreneur consumption $c_t^{E,c}$ depends on firm net worth:

$$c_t^{E,c} = (1-\beta_E^c)NW_t^c, \tag{10}$$

and entrepreneur's capital stock in each country depends on firms' net worth, the capital price and the entrepreneur's leverage in that country:

$$k_t^{E,c} = \frac{\beta_E^c NW_t^c}{q_t^{k,c} - \chi_t^c} \tag{11}$$

with $\chi_t^c = \frac{m_E^c q_{t+1}^{k,c}(1-\delta^c)}{R_{t+1}^{E,c}}$.

3.3 Bankers

Bankers in country c act as international investors. In each period, they invest equity $n_t^{c,c}$ into domestic banks, and $n_t^{c,\neg c}$ in foreign banks, where $\neg c$ denotes the opposite country to country c. In addition, bankers pay dividends div_t^c back to their belonging households. Both equity investment and dividends are financed by bankers' net worth $n_t^{b,c}$. Following Gertler and Kiyotaki (2011) we guess and verify that the value function is linear in net worth, $V_t^{b,c} = \nu_t^c n_t^{b,c}$ where ν_t^c is the shadow value of bankers net worth. The maximization of bankers' wealth can then be written as

$$n_t^{b,c}\nu_t^c = \max_{e_t^{aggr,c}, div_t^c} \left\{ div_t^c + E_t\{\Lambda_{t+1}^c[(1-\theta_b^c) + \theta_b^c \nu_{t+1}^c] n_{t+1}^{b,c}\} \right\} \tag{12}$$

[5] Iacoviello (2005) discusses the deviation from the certainty equivalence case in the appendix C of his paper.

[6] See appendix section A.2 for the derivations of entrepreneurs' net worth, consumption, and capital.

$$s.t. \begin{cases} e_t^{aggr,c} + div_t^c = n_t^{b,c} \\ e_t^{aggr,c} = n_t^{c,c} + n_t^{c,\neg c} \\ n_{t+1}^{b,c} = \rho_{t+1}^c n_t^{c,c} + \rho_{t+1}^{\neg c} n_t^{c,\neg c} \\ div_t^c \geq 0. \end{cases}$$

The term $\Lambda_{t+1}^c[(1-\theta_b^c) + \theta_b^c \nu_{t+1}^c] = \Lambda_{t+1}^{b,c}$ describes the discount factor of bankers. Each period a fraction $(1-\theta_b^c)$ of bankers retires and transfers the net present value of net worth back to the owning households. Households provide a share of start-up equity χ_b to newly entering bankers, and the total amount of bankers stays constant over time. The law of motion for bankers' net worth is thus given by:

$$n_{t+1}^{b,c} = [\theta_b^c + \chi_b(1-\theta_b^c)](n_t^{c,c}\rho_{t+1}^c + n_t^{c,\neg c}\rho_{t+1}^{\neg c}) \tag{13}$$

where ρ_{t+1}^c is the return of equity invested in banks in the same country c and $\rho_{t+1}^{\neg c}$ is the return of equity invested in the other country's banks. In equilibrium it is not optimal to transfer dividends prior to retirement. Therefore, all net worth is invested in either domestic or foreign banks. The shadow value of bankers can then be determined as

$$\nu_t^c = E_t\{\Lambda_{t+1}^{b,c}[\zeta_t^{n,c}\rho_{t+1}^c + (1-\zeta_t^{n,c})\rho_{t+1}^{\neg c}]\} \tag{14}$$

with $\zeta_t^{n,c} = \frac{n_t^{c,c}}{n_t^{b,c}}$ denoting the fraction of bankers' equity invested in domestic banks.

3.4 Corporate Banks

Home and foreign banks provide domestic corporate loans and invest in domestic government bonds. They acquire inside equity via home and foreign bankers, and by issuing deposits. The corporate banking sector features bank default, as the return on assets is prone to idiosyncratic risk ω_{t+1}^c, following a log-normal distribution.[7] Consequently, banks can default on their debts, and saving households face state-verification costs when recovering their deposits. The contracting problem between households and banks is based on the mechanism introduced by Bernanke et al. (1999). Corporate banks receive $e_t^c = n_t^{c,c} + RER_t n_t^{\neg c,c} = \zeta_e^c e_t^c + (1-\zeta_e^c)e_t^c$ units of equity from domestic and foreign investors. We denote the equity home bias on banks' balance sheets as ζ_e^c and RER_t depicts the real effective exchange rate. Banks maximize their net present value by deciding on the profit-maximizing amount of assets a_t^c and deposits d_t^c subject to a balance sheet constraint and a regulatory constraint governed by the capital requirement ϕ_t^c. Furthermore, each bank pays a

[7]See appendix section A.4.1 for the shock's definition.

contribution $\tau_t^{DI,c}$ to the national deposit insurance scheme, relative to the amount of its outstanding deposits:

$$\max_{d_t^c, a_t^c} \int_0^\infty \Lambda_{t+1}^{tot,c} \max\{\omega_{t+1}^c R_{t+1}^{a,c} a_t^c - R_t^{d,c} d_t^c - \tau_t^{DI,c}, 0\} \mathrm{d}F^c(\omega_{t+1}^c) \\ - \zeta_e^c \nu_t^c e_t^c - (1 - \zeta_e^c) \nu_t^{\neg c} e_t^c \quad (15)$$

$$s.t. \begin{cases} a_t^c = d_t^c + e_t^c, \\ e_t^c \geq \phi_t^c a_t^c, \\ a_t^c = b_t^{E,c} + q_{t+1}^{k,c} b_t^{g,c}. \end{cases}$$

Total assets a_t^c earn the average return $R_{t+1}^{a,c}$ and consist of entrepreneur loans $b_t^{E,c}$ and nominal government bonds $q_{t+1}^k b_t^{g,c}$:

$$R_{t+1}^{a,c} = R_{t+1}^{E,c} \frac{b_t^{E,c}}{a_t^c} + R_{t+1}^{gov,c} \frac{q_{t+1}^{k,c} b_t^{g,c}}{a_t^c}.$$

Banks discount their expected net present value with the discount factor $\Lambda_{t+1}^{tot,c} = \zeta_e^c \Lambda_{t+1}^{b,c} + (1 - \zeta_e^c) \Lambda_{t+1}^{b,\neg c}$, that is by weighting home and domestic bankers discount factor with the corresponding amount of equities. The equity investments $\zeta_e^c e_t^c$ and $(1 - \zeta_e^c) e_t^c$ are valued at equilibrium opportunity costs ν_t^c and $\nu_t^{\neg c}$.

The bank is only willing to distribute funds as long as its net present value is positive. As shown in section A.4, the bank participation constraint in equilibrium is given by

$$E_t \left\{ \Lambda_{t+1}^{tot,c} [1 - \Gamma_c(\overline{\omega}_{t+1}^c)] \frac{R_{t+1}^{a,c}}{\phi_t^c} \right\} \geq \zeta_e^c \nu_t^c + (1 - \zeta_e^c) \nu_t^{\neg c} \quad (16)$$

where $\overline{\omega}_{t+1}^c$ depicts the threshold of bank default

$$\overline{\omega}_{t+1}^c = \frac{R_t^{d,c} d_t^c}{R_{t+1}^{a,c} a_t^c} + \frac{\tau_t^{DI,c}}{R_{t+1}^{a,c} a_t^c} = (1 - \phi_t^c) \left(\frac{R_t^{d,c}}{R_{t+1}^{a,c}} + \frac{\tau_t^{DI,c}}{R_{t+1}^{a,c} d_t^c} \right). \quad (17)$$

In equilibrium, condition 16 holds with equality to avoid an infinite supply of loans. By definition, the return on bank equity is given by $\rho_{t+1}^c = [1 - \Gamma_c(\overline{\omega}_{t+1}^c)] \frac{R_{t+1}^{a,c}}{\phi_t^c}$. Consequently, the opportunity cost of equity funding is pinned down in equilibrium by the following conditions:

$$E_t\{\Lambda_{t+1}^{tot,h} \rho_{t+1}^h\} = \zeta_e^h \nu_t^h + (1 - \zeta_e^h) \nu_t^f \quad (18)$$

$$E_t\{\Lambda_{t+1}^{tot,f} \rho_{t+1}^f\} = \zeta_e^f \nu_t^f + (1 - \zeta_e^f) \nu_t^h, \quad (19)$$

which describe the no-arbitrage conditions for international bankers.

3.5 National Government

Each national government can issue real debt $q_{t+1}^{k,c} b_t^{g,c}$ bought by banks across the union,

$$b_t^{g,c} = q_t^{k,c} R_t^{gov,c} b_{t-1}^{g,c} + g_t^c - \tau_t^c, \tag{20}$$

where g_t^c is government consumption and τ_t^c denotes the total (lump-sum) income tax paid by private households. Government consumption is often not directly affected by the business cycle, but rather by structural needs of the economy. Therefore, we assume an AR(1) process for government consumption:

$$g_t^c = (1-\rho_g^c)\overline{g}^c + \rho_g^c g_{t-1}^c + \epsilon_t^g \tag{21}$$

Stabilization policy is conducted via a countercyclical income tax rule

$$\frac{\tau_t^c}{\overline{\tau}^c} = \left(\frac{\tau_{t-1}^c}{\overline{\tau}^c}\right)^{\rho_{tax}^c} \left[\left(\frac{y_t^c}{\overline{y}^c}\right)^{\phi_y^c} \left(\frac{b_{t-1}^{g,c} q_t^{k,c}}{\overline{b}^{g,c}}\right)^{\phi_d^c}\right]^{1-\rho_{tax}^c} \tag{22}$$

where $\phi_y^c \leq 0$ and $\phi_d^c \leq 0$ are the weighting parameters for the two target variables and ρ_{tax}^c is a smoothing parameter. The government reduces the lump-sum tax compared to steady state if actual production or real debt levels are below their steady-state values, $\overline{y}^c$ and $\overline{b}^{g,c}$. After inserting the expenditure and the tax rules into the budget constraint, we can derive the following debt rule:

$$b_t^{g,c} = q_t^{k,c} R_t^{gov,c} b_{t-1}^{g,c} + g_t^c - \overline{\tau}^c \left(\frac{\tau_{t-1}^c}{\overline{\tau}^c}\right)^{\rho_{tax}^c} \left[\left(\frac{y_t^c}{\overline{y}^c}\right)^{\phi_y^c} \left(\frac{b_{t-1}^{g,c}}{\overline{b}^{g,c}}\right)^{\phi_d^c}\right]^{1-\rho_{tax}^c}. \tag{23}$$

New debt can be issued during a recession ($y_t^c < \overline{y}^c$) or if actual debt is below its structural component ($b_t^{g,c} < \overline{b}^{g,c}$). Governments have to pay an additional risk premium to banks if government debt is above its steady state. The return on government debt is thus described by a premium on the risk-free deposit rate increasing in debt levels:

$$R_{t+1}^{gov,c} = \tilde{R}_t^{d,c} + \Phi_{debt}^c [b_t^{g,c} - \overline{b}^{g,c}]^2. \tag{24}$$

3.6 National Deposit Insurance Fund

The national DI guarantees some fraction κ_t^c of deposits by building up a fund that compensates depositors in case of bank default. The deposit insurance fund balance is given by

$$DI_{t+1}^c = DI_t^c + \tau_t^{DI,c} - \kappa_t^c \Omega_{t+1}^c \tag{25}$$

where a share κ_t^c of the total default costs Ω_{t+1}^c is insured by the national DI in each country. Banks pay a contribution $\tau_t^{DI,c}$ to the fund, and the fund capital target is set relative to total outstanding insured deposits in steady state:

$$\overline{DI}^{target,c} = \gamma_{DI}^c \overline{\kappa}^c \overline{d^c}. \tag{26}$$

The costs of deposit default in each country are defined as the difference between forgone return on deposits, $R_{t-1}^{d,c} d_{t-1}^c$, and the share $(1-\mu^c)$ of gross assets $\omega_t^c R_t^{a,c} a_{t-1}^c$ that can be recovered:

$$\Omega_t^c = \int_0^{\overline{\omega}_t^c} \{R_{t-1}^{d,c} d_{t-1}^c - (1-\mu^c)\omega_t^c R_t^{a,c} a_{t-1}^c + \tau_{t-1}^c\} f(\omega^c) d\omega_t^c.$$

Rearranging yields

$$\Omega_t^c = [\overline{\omega}_t^c - \Gamma_c(\overline{\omega}_t^c) + \mu^c G^c(\overline{\omega}_t^c)] \frac{R_t^{a,c}}{1-\phi_{t-1}^c} d_{t-1}^c. \tag{27}$$

In each period, banks contribute the amount $\tau_t^{DI,c}$ to the fund. The contributions are inversely related to the fund level:

$$\tau_t^{DI,c} = \overline{\tau}^{DI,c} + \chi_\tau^c [\overline{DI}^{target,c} - E_t\{DI_{t+1}^c\}] \tag{28}$$

with χ_τ^c denoting the sensitivity to the domestic fund level. Furthermore, whenever national fund capital is below target, the share of covered deposits is reduced:

$$\kappa_t^c = \overline{\kappa}^c - \chi_\kappa^c [\overline{DI}^{target,c} - DI_{t+1}^c], \tag{29}$$

with $\chi_\kappa^c = \frac{\overline{\kappa}^c}{\overline{DI}^{target,c}}$.

3.7 Goods Market Clearing and Trade

Capital producing firms and the trade sector are described in detail in appendices A.6 and A.7.1. Here we shortly summarize essential market clearing conditions. In both regions, the goods market clearing condition holds in equilibrium:

$$y_t^{E,c} = Y_t^c = \zeta^c (p_t^{e,c})^{-\eta^c} c_t^c + g_t^c + (1-\zeta^{\neg c}) \left(\frac{p_t^{e,\neg c}}{T_t}\right)^{-\eta^{\neg c}} c_t^{\neg c} \tag{30}$$

where $c_t^c = c_t^{P,c} + c_t^{E,c} + I_t^c$ denotes the aggregate demand for consumption and investment goods of domestic households and entrepreneurs and $c_t^{\neg c}$ denotes the aggregate demand of foreign households and entrepreneurs. Following Benigno (2004), the terms of trade are foreign producer prices relative to domestic producer prices:

$T_t = \frac{P_t^{e,f}}{P_t^{e,h}}$. National government consumption g_t is assumed to be produced only by national firms. The clearing condition guarantees that the supply of domestically produced goods is equal to domestic and foreign demand.

The real exchange rate can be defined with the help of the terms of trade and the relative consumer prices in both countries:

$$RER_t = T_t \frac{p_t^{e,h}}{p_t^{e,f}}. \tag{31}$$

The trade balance – measured in domestic prices – is defined as the difference between real exports and real imports:

$$tb_t = ex_t^h + T_t im_t^h \tag{32}$$

with $ex_t^h = c_t^{P,fh} + c_t^{E,fh} + I_t^{fh}$ and $im_t^h = c_t^{P,hf} + c_t^{E,hf} + I_t^{hf}$.

4 Calibration

We rely on euro area data to validate the empirical fit of the model. To this end,we find a vector of structural parameter values for which the distance between first moments of empirical distributions and their counterparts generated by the model is minimized. We discuss the moment-matching methodology in more detail in the following sections.

4.1 Data

The empirical data moments are both collected from macroeconomic time series and micro-level data. Real macroeconomic variables for Germany and the euro area are drawn from the European System of Accounts (ESA 2010) quarterly financial and non-financial sectoral data, provided by the European Central Bank (ECB) and Eurostat, as well as from OECD data. The data set includes information on real GDP, real business investment, government consumption, total employment, exports and imports of goods and services, and the current account balance.[8] Banking statistics – corporate bank deposits held by private households, corporate bank loans granted to the non-financial domestic entrepreneur sector, bank holdings of domestic government bonds, the share of deposits covered by deposit insurance

[8]See appendix B for a detailed description of the data set.

and return on bank equity – are in part obtained from the data set on "Monetary Financial Institutions" (MFIs) collected by the ECB, from the Bundesbank time series database and from the "Financial Soundness Database" of the IMF. Data on corporate bank interest rates on household deposits and firm loans are constructed from different sources within the ECB Statistical Data Warehouse and harmonized following Gerali et al. (2010). Bank default rates, price-to-book ratios and the home bias in bank equity are obtained by aggregating micro-level data series from Bloomberg, Thomson Reuters Eikon, and Datastream. For most time series, we employ data for 1999:Q1 to 2019:Q4.[9]

4.2 Methodology

The empirical validation of our model is provided by setting a subset of model parameters such that first moments in the data are matched by theoretical model moments. We split the subset of parameters to be estimated into two groups, depending on whether they affect the deterministic steady state (collected in Θ_{SS}) or not (collected in $\Theta_{\neg SS}$). The first subset of parameters can be calibrated by matching first moments in the data. We follow the approach by Mendicino et al. (2018) and minimize a loss function with equal weights on the distances between respective data moments and model moments.

4.2.1 Preset Parameters

Before initiating the matching process, we set the parameters not determined by moment matching to conventional values (table 1). They include parameters related to policy rules, the deposit insurance fund, or structural parameters on habit formation, the capital share in production, trade elasticity, and labor market characteristics. Furthermore, key parameters related to euro area-wide regulations are assumed to be identical in both countries. First, steady-state bank capital requirements, $\overline{\phi}^c$, are calibrated to 10.5 percent, the level implied by regulations under

[9] The only exceptions depict the share of deposits covered by deposit insurance, which we derive from the yearly estimates in the JRC European Union Banking Sector Statistics (2011 to 2015), bank default rates, which we calculate from CDS spreads of European banks that are available between 2004Q1 and 2019Q4, and domestic government bond holdings covered in the ECB Securities Holdings Statistics which are only available from 2013:Q4 onwards. See appendix B.

Basel III.[10] Second, the steady-state LTV ratio for entrepreneur borrowing, m_E^c is assumed to be identical in both regions and set to 0.35, in line with Gerali et al. (2010).

Table 1: Calibrated Parameters

	Parameter	Germany	Euro Area
Inverse Frisch Elasticity of Labor Supply	ϕ_P^c	1	1
Labor Disutility	φ_P^c	1	1
Household Habit Parameter	h_P^c	0.8	0.8
Trade Elasticity	η^c	1.5	1.5
Home Bias in Traded Goods	ζ^c	0.6	0.6
Capital Share in Production Function	α^c	0.3	0.3
Bank Monitoring Costs	μ^c	0.3	0.3
Debt-Elastic Interest Rate Parameter	Φ_{debt}^c	0.1	0.1
Fiscal Rule, GDP Weight	ϕ_y^c	0.5	0.5
Fiscal Rule, Debt Weight	ϕ_d^c	1.5	1.5
Fiscal Rule, Tax smoothing	ρ_{tax}^c	0.4	0.4
DI Contribution Sensitivity Parameter	χ_τ^c	0.45	0.45
Bank Capital Requirement	$\overline{\phi}^c$	0.105	0.105
Loan-to-Value Ratio	m_E^c	0.35	0.35
EDIS Contribution Sensitivity Parameter	χ_τ^{EDIS}	0.45	0.45
Switching Function Scaling Parameter	α_1	100	100
Preference Shock AR Coefficient	ρ_c^c	0.75	0.75
Productivity Shock AR Coefficient	ρ_a^c	0.75	0.75
Bank Risk Shock AR Coefficient	ρ_b^c	0.75	0.75
Government Consumption Shock AR Coefficient	ρ_g^c	0.75	0.75

4.2.2 Moment-Matched Parameters

Some parameters have a direct first moment counterpart. For these cases – the household discount factor, the home bias in bankers' equity holdings, the steady-state share of insured deposits and the steady-state government consumption-to-GDP ratio – we can immediately set the respective parameter value. We set $\overline{\kappa}^{DI,c}$ in accordance with the JRC European Union Banking Sector Statistics. We calibrate the target level of deposit insurances $DI^{target,c}$ to 0.8 percent of outstanding insured deposits, as proposed by the European Commission (European Commission, 2015).

[10] The requirements under Basel III consist of different buffers, including a core buffer (minimum Tier 1+2 capital) of 8 percent plus a "capital conservation buffer" of 2.5 percent.

The sensitivity of the coverage ratio is determined using empirical evidence on fund level and coverage ratio, $\chi_{\kappa}^{c} = \frac{\overline{\kappa}^{DI,c}}{\overline{DI}^{target,c}}$. The fund level together with the contribution sensitivity parameter determines the regime-switching threshold. For any given default rate above the threshold, $\overline{\Psi}^{c} = 1.780$, the fund level will be close to zero. For the household discount factor, we assume market participants in both countries to have access to a global risk-free asset. We therefore calibrate the steady-state risk-free rates $\overline{R}^{d,c}$ to the quarterly average of the long-term real rate on United States (US) treasuries. Thus, we end up with identical values for the patient households' discount factor $\beta_p^c = \frac{1}{\overline{R}^{d,c}}$ in both economies.

For the remaining first moments, a direct mapping between the empirical values and the parameters of the model is not feasible. Instead, we set these parameters – the survival rate of bankers θ_b^c, bankers' endowment χ_b^c and the standard deviation for i.i.d. bank default risk σ_c – simultaneously to minimize the distance between the remaining model-implied moments and data moments. The firm-specific parameters – the capital depreciation rate δ^c, the adjustment cost parameter ψ_i^c, and the entrepreneur discount factor β_E^c – are set such that theoretical moments match data on investment-to-GDP ratios, firm loans-to-GDP ratios, and the spread between the corporate lending and the risk-free rate.

Table 2 summarizes the parameter values that minimize the distance between the empirical and theoretical first moments. For some parameter values, the differences between Germany and the rest of the euro area are significant. For instance, the home bias in bank equity, ζ_e^c, is larger in Germany than in the rest of the euro area. Since the banking sector in Germany relies to a larger degree on domestic equity, the home bias in equity provision amounts to approximately 80 percent.[11] Furthermore, bank default risk is larger in the rest of the euro area than in Germany, which is reflected in the higher standard deviation of i.i.d. bank risk σ^f. To provide information on the accuracy of the parameter estimates gathered via distance minimization, table 3 summarizes the distances between the time series mean values and the model-implied first moment values.

[11] This can mainly be attributed to the high amount of state-owned "Landesbanken", as well as to the prominence of savings and cooperative banks in Germany.

Table 2: Matched Parameters

	Parameter	Germany	Euro Area
Direct Match			
Discount Factor Households	β_P^c	0.996	0.996
Home Bias in Bank Equity	ζ_e^c	0.805	0.580
DI Fund Target Rate	γ_{DI}^c	0.008	0.008
Share of Insured Deposits	$\overline{\kappa}^{DI,c}$	0.497	0.512
DI Coverage Ratio Sensitivity Parameter	χ_κ^c	41.0579	30.861
EDIS Fund Target Rate	γ_{EDIS}^c	0.008	0.008
Share of Insured Deposits	$\overline{\kappa}^{EDIS,c}$	0.497	0.512
EDIS Coverage Ratio Sensitivity Parameter	χ_κ^{EDIS}	17.310	17.850
Government Consumption/GDP	g^c	0.211	0.225
Regime-Switching Threshold	$\overline{\Psi}^c$	1.780	1.780
Distance Minimization			
Bank Risk Standard Deviation	σ^c	0.041	0.043
Discount Factor Entrepreneurs	β_E^c	0.969	0.980
Household Transfer to Bankers	χ_b^c	0.969	0.710
Capital Depreciation Rate	δ^c	0.067	0.053
Banker Survival Rate	θ_b^c	0.250	0.927
Capital Adjustment Costs Parameter	ψ_i^c	5.709	5.398

Note: The table summarizes the parameter values found by first moments matching. The model parameters are set such that the distance between model-implied steady-state values and data moments is minimized.

Table 3: Targeted First Moments

	Moment	Model	Data
Germany			
Business investment/GDP	$\frac{\overline{I}^h}{\overline{Y}^h}$	0.222	0.222
Bank default rate	$4 \times \overline{\psi}^h$	1.255	1.065
Return on equity	$400 \times (\rho^h - 1)$	10.710	6.386
Price-to-book ratio	$\overline{\nu}^h$	1.026	0.822
NFC loans/GDP	$\frac{\overline{b}_e^h}{\overline{Y}^h}$	1.072	1.443
NFC loan rate spread	$400 \times (\overline{R}^{b,h} - \overline{\tilde{R}}^{d,h})$	1.776	2.994
Euro Area			
Business investment/GDP	$\frac{\overline{I}^f}{\overline{Y}^f}$	0.228	0.228
Bank default rate	$4 \times \overline{\psi}_t^f$	1.918	1.398
Return on equity	$400 \times (\rho^f - 1)$	8.154	4.548
Price-to-book ratio	$\overline{\nu}^f$	1.300	1.300
NFC loans/GDP	$\frac{\overline{b}_e^f}{\overline{Y}^f}$	1.428	2.015
NFC loan rate spread	$400 \times (\overline{R}^{b,f} - \overline{\tilde{R}}^{d,f})$	1.396	2.608
Total Distance			**2.837**

Note: The table summarizes the first moments matched via distance minimization during the calibration routine. The model parameters are set such that the distance between model-implied steady-state values and data moments is minimized.

5 Different Forms of Risk-Sharing

In the following, we evaluate how different risk-sharing policies perform in response to exogenous disturbances. In doing so, we study how different risk-sharing arrangements are able to absorb adverse macroeconomic effects in response to exogenous variations in bank default risk. These arrangements will resemble reinsurance frameworks, where either national governments, EDIS, or none of the two steps in once national deposit insurance schemes are exhausted.

5.1 Regime Switching: National Deposit Insurance

In the analysis, we allow for four states of the economy. In the baseline regime, both national deposit insurance schemes and fiscal policies operate as described in sections 3.5 and 3.6, and national deposit insurance is unconstrained (regime 1). In the other states of the economy, either one or both national deposit insurances are constrained as national insurance funds are exhausted and no insurance transfers can be provided anymore (table 4). The regime-switching rule is therefore given by

$$DI_t^c = \begin{cases} DI_t^{c'} & \text{if } \psi_t^c < \overline{\Psi}^c \\ 0 & \text{if } \psi_t^c > \overline{\Psi}^c \end{cases} \tag{33}$$

where

$$DI^{c'}_{t+1} = DI^{c'}_t + \tau_t^{DI,c} - \kappa_t^c \Omega_{t+1}^c \tag{34}$$

following equation 25. The transition probabilities between regimes underlying equation 33 and the regime-switching threshold values Ψ^c are discussed below. We therefore constrain national DI fund capital to be greater or equal to zero in all occasions.

Table 4: Regime Overview

		Home	
		Unconstrained	**Constrained**
Foreign	**Unconstrained**	Regime 1	Regime 2
	Constrained	Regime 3	Regime 4

Note: Countries are either in an unconstrained state where national DI is sufficient, or in a constrained state where national DI funds are exhausted.

The share of insured deposits depends on the level of available fund capital and is characterized by:

$$\kappa_t^c = \overline{\kappa}^c - \chi_\kappa[\overline{DI}^{target,c} - DI_{t+1}^c], \tag{35}$$

with $\chi_\kappa = \frac{\overline{\kappa}^c}{\overline{DI}^{target,c}}$. It follows that whenever the fund is exhausted, $DI_{t+1}^c = 0$, the economy enters the constrained regime and no insurance is provided, $\kappa_t^c = 0$. This case is consistent with a crisis scenario in which, due to (a sequence of) large shocks, fund capital is annihilated and no insurance can be provided by the national DI anymore. We develop a regime-switching framework[12] where agents, being in a certain state, anticipate that the economy transits with a certain Markov probability from one state to the other in each period. Therefore, expectations about future states of the economy are taken into account in agents' decision rules. This allows us to explicitly include potential moral hazard behavior of banks when governments and EDIS promise to bail out depositors.

Our analysis is counterfactual in nature since the euro area has not experienced episodes with explicitly exhausted national deposit insurance funds. The constrained regime is instead designed to resemble episodes of severe financial distress. We assume that during such episodes, bank default rates are extraordinarily high. We define to this end endogenous Markov switching probabilities

$$P_{1,2} = \frac{1}{1 + \exp[-\alpha_1(\psi_t^c - \overline{\Psi}^c)]} \tag{36}$$

$$P_{2,1} = \frac{1}{1 + \exp[\alpha_1(\psi_t^c - \overline{\Psi}^c)]} \tag{37}$$

that depend on the distance between actual bank default rates ψ_t^c and an imposed "high financial stress" threshold level $\overline{\Psi}^c$ of bank default rates. The transition probabilities follow a sigmoid activation function with scaling parameter α_1.

Empirical estimates for the probability of being constrained are hard to obtain. We define the switching threshold $\overline{\Psi}^c$ for each country as the level of default rates at which the insurance fund level, calibrated in table 1, would become negative.

5.2 Risk-Sharing Scenarios

Here, we discuss different forms of risk-sharing that apply once national DI capacity is exhausted. In all scenarios, national DI is in place and unconstrained whenever the economy is in regime 1 and the insurance framework outlined in section 3.6 applies.

[12] We use the RISE toolbox to model a regime-switching environment. See Maih (2015).

A. Constrained National DI, No Additional Risk-Sharing

In this scenario, the national DI is constrained as the DI fund's capital has been annihilated ($DI_t^{c'} \leq 0$ such that $DI_t^c = 0$) and no further insurance can be provided according to equation 35. Bank defaults affect the risk premium on deposit rates unrestrained. The return on deposits net of defaults, given by equation 3, decreases, and becomes

$$\tilde{R}_t^{d,c} = R_t^{d,c} - \frac{\Omega_{t+1}^c}{d_t^c}, \tag{38}$$

when $\kappa_t^c = 0$ and no other form of insurance is provided.

B. Constrained National DI, National Fiscal Backstop

Under this scenario, depositor losses are compensated by national governments once national deposit insurance funds are exhausted. We assume the government to compensate the steady-state share of insured deposits, $\overline{\kappa}^c$. The cost of deposit insurance enters the national government budget constraint given by equation 20 which therefore becomes

$$b_t^{g,c} = R_t^{gov,c} b_{t-1}^{g,c} + g_t^c - \tau_t^c + \overline{\kappa}^c \Omega_{t+1}^c \tag{39}$$

such that obligations from government deposit insurance affect tax and expenditure decisions.

C. Constrained National DI, European Deposit Insurance

Our regime-switching approach closely aligns with the reinsurance system proposed by the European Commission, as EDIS only steps in once national funds are exhausted. Banks in member states are expected to contribute to a European-wide fund. Contributions to EDIS are designed to be ex-ante cost-neutral, i.e. banks can deduct these payments from contributions to national schemes. Therefore, EDIS fund capital evolves according to the law of motion:

$$DI_{t+1}^{EDIS} = DI_t^{EDIS} + \sum_{c=h,f} \tau_t^{EDIS,c} - \sum_{c=h,f} \kappa_t^{EDIS,c} \Omega_{t+1}^c. \tag{40}$$

As in the national insurance case, banks in member states are required to contribute to the fund in each period, such that equation 17 becomes

$$\overline{\omega}_{t+1}^c = (1 - \phi_t^c) \left(\frac{R_t^{d,c}}{R_{t+1}^{a,c}} + \frac{\tau_t^{DI,c} + \tau_t^{EDIS,c}}{R_{t+1}^{a,c} d_t^c} \right). \tag{41}$$

The aggregate contributions to EDIS are given by

$$\tau_t^{EDIS} = \overline{\tau}^{EDIS} + \chi_\tau^{EDIS}[\overline{DI}^{target,EDIS} - E_t\{DI_{t+1}^{EDIS}\}] \tag{42}$$

with χ_τ^{EDIS} denoting the sensitivity to changes in the EDIS fund level. The aggregate contributions defined in equation 42 are the composite of national contributions into EDIS, whereas each country's share is defined by the risk in the national banking sector. We assume riskier banks to contribute more into the EDIS fund.[13]

Assumption 1 (Risk-weighted contributions to EDIS)**.** *The national contributions $\tau_t^{EDIS,h}$ and $\tau_t^{EDIS,f}$ are allocated relative to the bank default rates of each country:*

$$\tau_t^{EDIS,c} = \frac{\psi_{t+1}^c}{\psi_{t+1}^c + \psi_{t+1}^{\neg c}} \tau_t^{EDIS} \tag{43}$$

As the design of bank contributions is a central obstacle in the policy discussions on the introduction of EDIS in Europe, we evaluate alternative specifications of the contribution rule in section 6.2.3. We then vary the contribution weights, and discuss how welfare is affected. A second key element of recent proposals depicts the deductibility of EDIS contributions from payments banks have to make into the national DI funds. In the baseline EDIS, we assume such deductibility of contributions.[14]

Assumption 2 (Deductibility of contributions)**.** *To ensure that total bank contributions do not exceed the level in the scenario without EDIS, we require the contributions to EDIS to be deductible from contributions to national deposit insurances:*

$$\tau_t^{DI,c} = \overline{\tau}^{DI,c} + \chi_\tau^c[\overline{DI}^{target,c} - E_t\{DI_{t+1}^c\}] - \tau_t^{EDIS,c}. \tag{44}$$

The EDIS fund capital target is defined as the sum of the two national DI targets

$$\overline{DI}^{target,EDIS} = \gamma^{EDIS}[\overline{\kappa}^h \overline{d}_t^h + \overline{\kappa}^f \overline{d}_t^f]. \tag{45}$$

Finally, households receive additional compensation under EDIS in case of bank default, such that their risk-adjusted return is now given by

$$\tilde{R}_t^{d,c} = R_{t-1}^{d,c} - (1 - \kappa_t^c - \kappa_t^{EDIS,c})\Omega_{t+1}^c. \tag{46}$$

[13] Our risk weighting hence resembles the "polluter-pays" principle, see Carmassi et al. (2018).

[14] In addition to relaxing assumption 1 in section 6.2.3, we also discuss the implication of relaxing assumptions 2 in section 6.2.4.

Under a reinsurance scheme, EDIS coverage of deposit default is only assumed once the national DI's insurance capacity is exhausted. The payout rule therefore follows

$$\kappa_t^{EDIS,c} = \begin{cases} 0 & \text{if } DI_t^{c'} > 0 \\ \kappa_t^{EDIS,c'} & \text{if } DI_t^{c'} \leq 0 \end{cases} \tag{47}$$

where

$$\kappa_t^{EDIS,c'} = \overline{\kappa}^{EDIS,c} - \chi_\kappa^{EDIS}[\overline{DI}^{EDIS} - DI_t^{EDIS}]. \tag{48}$$

EDIS is involved as long as the economy is in the constrained regimes, and the national insurance funds get reestablished by bank contributions. We assume that during the reestablishing phase, no insurance transfers can be made. Reinsurance via EDIS therefore provides additional risk-sharing, as it insures particularly against large crises. As intended in European Commission (2015), under each scenario, national DIs and EDIS are expected to jointly provide the same level of deposit insurance as present in the purely national system, i.e. deposits of up to €100,000 are intended to still be covered. We therefore assume the same target of payout per unit of deposit for national DIs and EDIS, such that $\overline{\kappa}^c = \overline{\kappa}^{EDIS,c}$.

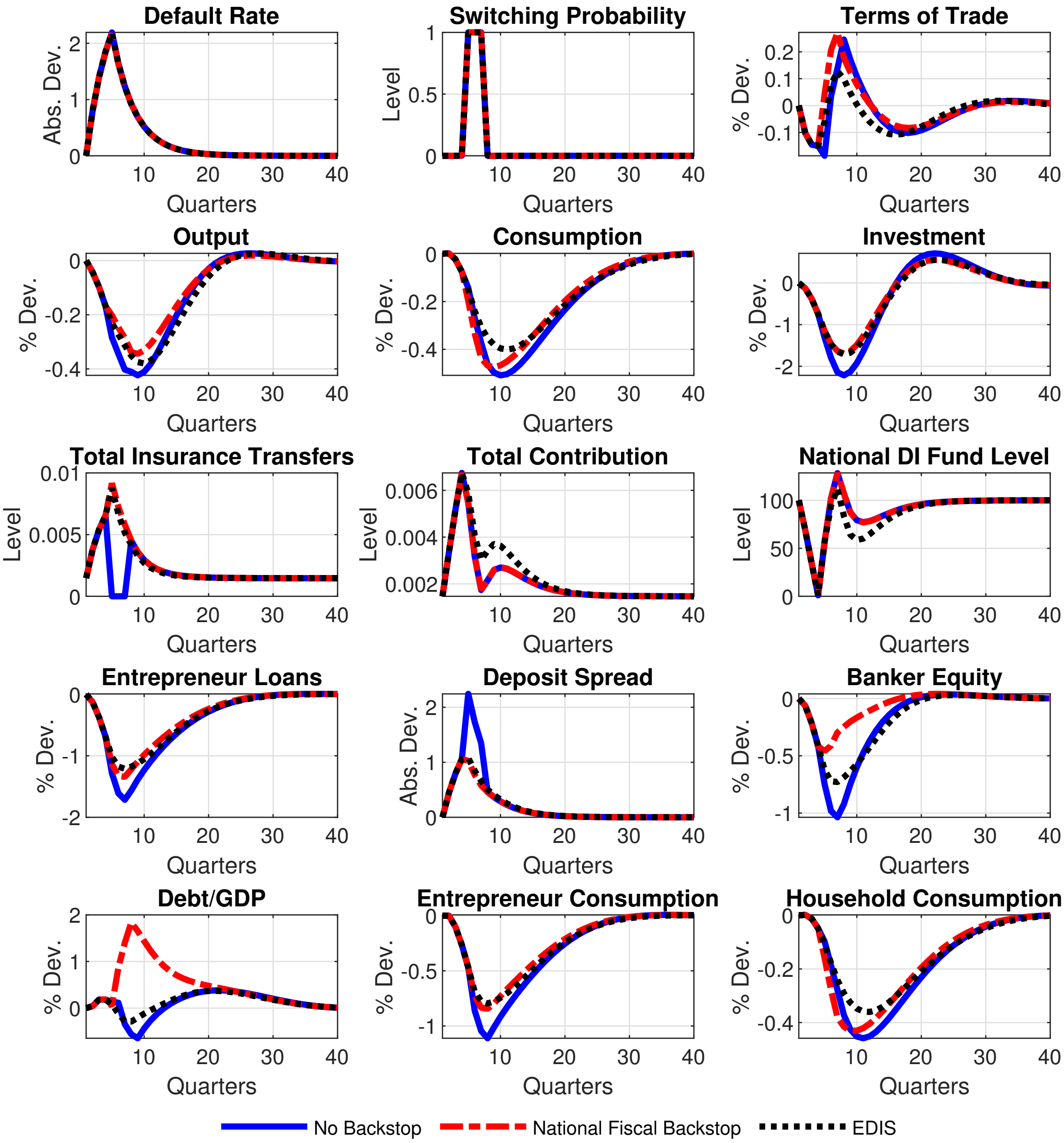
6 Results

Based on the policy scenarios defined in the previous section, we first evaluate how shocks emerging in the banking sector affect the financial sector and the macro economy. Second, we discuss welfare implications of bank risk shocks and alternative specifications of EDIS. Third, we investigate the short-term costs arising from the implementation of EDIS.

6.1 Bank Risk Shock

Figures 1 and 2 depict impulse responses to bank risk shocks occurring in the home country, with deviations from the *unconstrained regime's* deterministic steady state. We show responses under the policy scenarios described in chapter 5.2: no reinsurance, and reinsurance by a national fiscal backstop or EDIS. We simulate a four-period sequence of bank risk shocks driving up the bank default rate in the home country. The regime switch occurs in period five, after which regime 2 prevails for three periods.

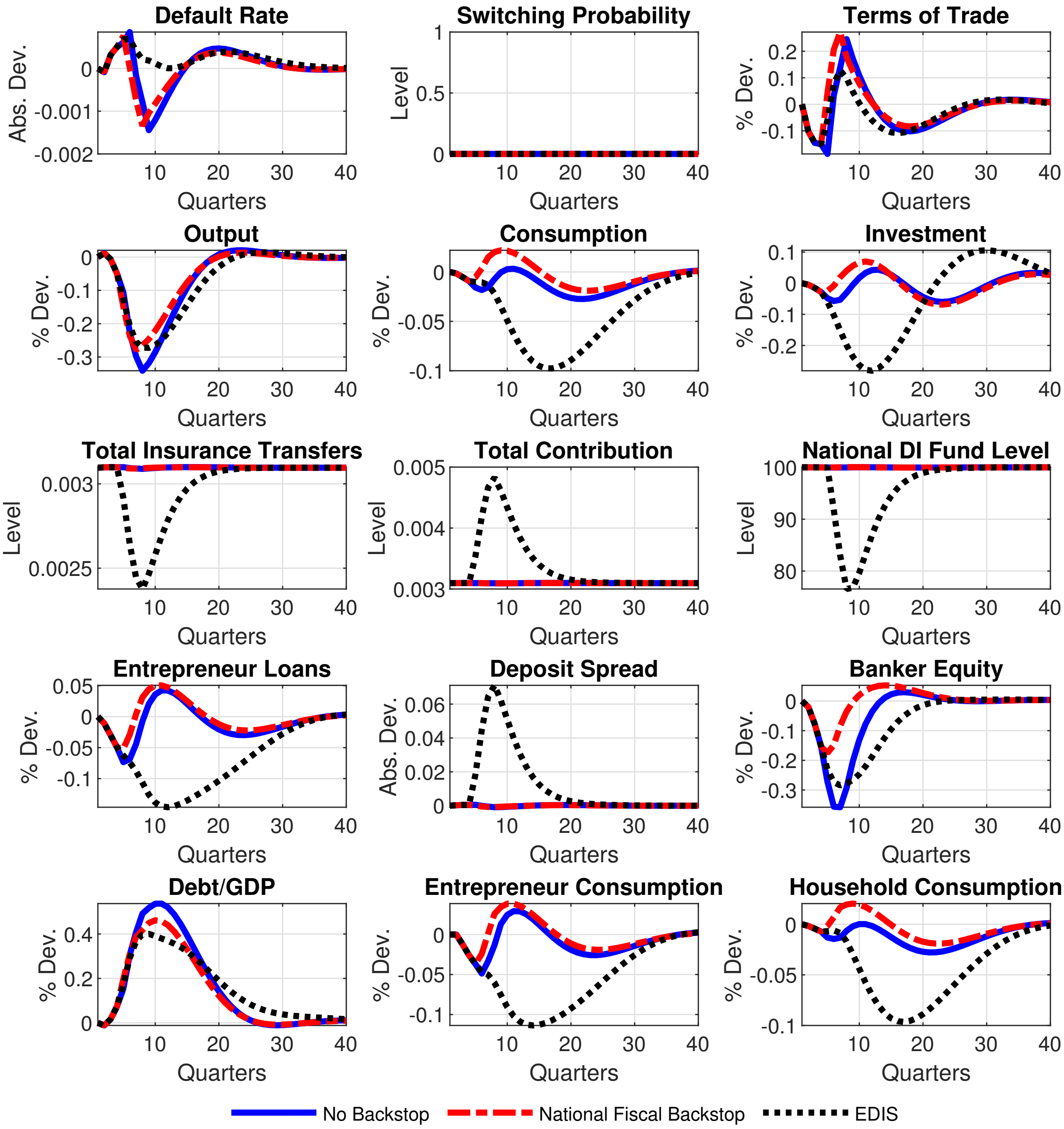
Figure 1: Bank Risk Shock in Home, Impulse Responses in Home



Note: Impulse responses to a sequence of bank risk shocks for different policy scenarios of section 5. Insurance Transfer depicts the amount of insurance provided by national DI, national government, or EDIS. Deposit Spread depicts the spread between the deposit rate and the risk-free rate. Insurance Transfer and Deposit Spread in absolute deviations from steady state, all other variables in percentage deviations.

Under all policy scenarios, an increase in the home country's bank risk leads to a pronounced economic contraction in both economies, resulting in higher risk premia on deposit rates. From peak to trough, the decline in GDP varies between 0.3 and 0.4 percent across scenarios, while the recession is deepest under the national

Figure 2: Bank Risk Shock in Home, Impulse Responses in Foreign



Note: Impulse responses to a sequence of bank risk shocks for different policy scenarios of section 5. Insurance Transfer depicts the amount of insurance provided by national DI, national government, or EDIS. Deposit Spread depicts the spread between the deposit rate and the risk-free rate. Insurance Transfer and Deposit Spread in absolute deviations from steady state, all other variables in percentage deviations.

DI without government bailout or EDIS intervention in the home country (blue line). The insurance transfers paid to households – for those scenarios where deposit insurance by national DIs, national governments, or EDIS is provided – increase to compensate depositors for their costs due to bank defaults.

However, consumption declines less under EDIS than in the other two scenarios. In the home economy, consumption declines by approximately 0.4 percent with EDIS from peak to trough (black dotted line). Compared to the other scenarios, the decline in consumption is therefore 20 percent lower. Furthermore, while differences in the decline of output are benign, the debt-to-GDP ratio increases significantly under the fiscal backstop (red dashed line), as taking over obligations from the constrained national DI directly affects the fiscal budget. With EDIS, the costs and risks of higher bank defaults are shared internationally, and covered by bank contributions instead of public debt. However, as banks are allowed to deduct EDIS contributions from the payments into the national DI, reestablishing both the initial national fund's level and the EDIS fund's level takes longest under EDIS. Still, the contribution burden is highest with EDIS, due to the contributions banks have to pay into both schemes.

The bank risk shock in the home country is transmitted to the foreign economy both via trade and international financial markets. Internationally active equity bankers' losses affect investment and lending conditions in the foreign country's banking system (figure 2). However, actual bank defaults barely increase on impact, with the volatility in the bank default rate being lowest under EDIS. However, under EDIS, international risk-sharing requires higher contributions by foreign banks to cover the costs of bank defaults in the home economy. As these contributions are deductible, fewer funding to cover regular bank defaults in the foreign economy can be collected, such that insurance transfers and the fund level of the national DI decline. In return, bank deposit spreads increase, which further limits foreign banks' lending capacities. In response to lower lending, foreign consumption declines.

In short, our results indicate that while EDIS can be beneficial to the country affected by the country-specific shock, consumers in the non-affected economy are hit hardest with EDIS. Consequently, the union-wide welfare implications of a common insurance scheme are not clear a priori.

6.2 Welfare Analysis

In the following, we investigate the welfare implications of the different forms of risk-sharing discussed in section 5.2. To do so, we first evaluate how the implementation of risk-sharing affects steady-state welfare. To account for uncertainty about to future shocks and potential regime switches, we evaluate welfare in the stochastic steady state. Second, we investigate how changes in risk weights that determine each country's contributions to EDIS affect welfare of borrowers and savers in both countries. Whether contributions from more risky banks should be larger or not, and if so, by how much, is not clear a priori, and a central point in the debate about EDIS. Third, while these analyses assume the existence of different risk-sharing devices in the first place, we also study welfare implications of the implementation of EDIS, i.e. of the transition from a scenario with only national deposit insurance to a new permanent steady state with EDIS. Furthermore, the deductibility of banks' contributions to a European fund are crucial in current proposals. Thus, we shed light on the desirability of such deductions from a welfare perspective.

6.2.1 Welfare Calculations

To measure welfare, we compute the stochastic steady states as described in Coeurdacier et al. (2011), relying on a second-order approximation of the structural model relations. Accordingly, the stochastic steady state is the permanent equilibrium where agents anticipate future uncertainty, but where contemporaneous realizations of economic shocks are zero. If the decision rule is given by

$$Y_t = g(Y_{t-1}, \varepsilon_t), \tag{49}$$

our stochastic steady state satisfies

$$\overline{Y} = g(\overline{Y}, 0). \tag{50}$$

In the following exercises, we express welfare under each policy variant in consumption equivalents, i.e. we compute the welfare cost λ^w of each policy scheme vis-à-vis a baseline policy scenario. The welfare loss is given by

$$\lambda^w = (1 - \exp[(V_0^{Pol} - V_0^{Base})(1 - \beta)]) \tag{51}$$

V_0^{Pol} refers to the welfare level under the respective policy scheme that is compared to welfare in the baseline scenario, V_0^{Base}. The discount parameter β refers to the respective discount factor in the respective country and for the respective agent.

We aggregate individual welfare of borrowers and savers with Pareto weights ω_j^c, where j refers to either patient households or entrepreneurs and c again to the respective country. Total welfare is thus given by

$$V_t \equiv \sum_{c=1}^{2} \sum_{j=1}^{2} \omega_j^c V_{j,t}^c \tag{52}$$

where

$$\omega_j^c = \frac{C^{c\zeta}_{j,t}}{\sum_{c=1}^{2} \sum_{j=1}^{2} C^{c\zeta}_{j,t}} \tag{53}$$

with the welfare weight $\zeta = 1$.[15]

6.2.2 Baseline Results

In table 5, we report conditional welfare expressed by the regime-specific stochastic steady states. We thereby condition on the presence of a bank risk shock, where we calibrate the size of the shock in one country to match the increase in bank risk necessary to trigger a regime switch.[16] Our conditional welfare measure therefore assumes that agents account for future risks associated to bank risk shocks.[17] We report the relative performance of both variants of EDIS introduced in section 5.2. While EDIS 1 refers to the baseline case, EDIS 2 refers to a design where assumption 2 is relaxed, i.e. where we abolish the deductibility of EDIS contributions from contributions to the national DI. Thus, in this exercise, the respective EDIS scenario represents V_0^{Pol} in equation 51. For the baseline V_0^{Base}, we choose the scenario described in section 5.2 where the national government is expected to step in once the national DI is exhausted.

While differences between the government backstop and the EDIS scenarios are generally small, relative welfare gains and losses depend on the regime agents find themselves in steady state. Whenever both economies are unconstrained - i.e. national deposit insurances are sufficient to cushion adverse effects from bank defaults - the welfare differences between a government backstop and EDIS are close to zero in most cases (regime 1). Agents price in future uncertainty from bank risk shocks

[15]See Chang et al. (2018).

[16]We tested different shock sizes, and found that welfare effects are robust to smaller shock sizes where regime switches are unlikely. Also, quantitative differences to results in table 5 only matter for implausibly large shock sizes.

[17]We only condition on the bank risk shock to observe direct welfare effects associated to this specific shock.

Table 5: Conditional Welfare - Bank Risk Shock

	Regime 1		**Regime 2**		**Regime 3**		**Regime 4**	
	EDIS 1	EDIS 2	EDIS 1	EDIS 2	EDIS 1	EDIS 2	EDIS 1	EDIS 2
Domestic								
Households	0.00	0.01	-0.20	-0.19	0.11	0.12	-0.09	-0.09
Consumption Channel	0.01	0.01	-0.09	-0.09	0.10	0.10	0.00	0.00
Entrepreneurs	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03
Total	0.00	0.01	-0.17	-0.17	0.10	0.10	-0.08	-0.07
Foreign								
Households	-0.01	-0.01	0.02	0.02	-0.49	-0.49	-0.45	-0.46
Consumption Channel	0.00	-0.01	0.02	0.02	-0.24	-0.24	-0.21	-0.21
Entrepreneurs	-0.01	-0.01	0.00	0.00	0.01	0.02	0.02	0.02
Total	-0.01	-0.01	0.02	0.02	-0.43	-0.44	-0.40	-0.40
Union-Wide								
Households	0.00	0.00	-0.09	-0.09	-0.19	-0.19	-0.27	-0.27
Consumption Channel	0.00	0.00	-0.03	-0.03	-0.07	-0.07	-0.10	-0.10
Entrepreneurs	0.00	0.00	0.01	0.01	0.02	0.02	0.02	0.02
Total	0.00	0.00	-0.08	-0.07	-0.17	-0.17	-0.24	-0.24

Note: Welfare is measured in consumption equivalents (equation 51, $100 \times \lambda^w$) and welfare of borrowers and savers in each country are weighted with Pareto weights (equations 52 and 53). Regimes are defined as in table 4. For Consumption Channel, we exclude the labor-related term from utility function 1.

and the possibility to enter a regime where either national governments or EDIS has to step in. However, the associated welfare costs from these uncertainties are almost identical under both policy scenarios.

In contrast, whenever households live in a constrained economy (regimes 2 and 3), household welfare is higher under both EDIS variants than under government backstops. Thereby, the welfare improvements are in part driven by the consumption part of utility function 1. In addition, the labor component seems to play a significant role, as only a part of the welfare improvement can be explained by the consumption channel. Welfare differences for entrepreneurs under EDIS and the government bailout scenarios are almost negligible.

Strikingly, on the union-wide level, the benefits of EDIS turn out to be highest whenever both countries are constrained (regime 4). Both domestic and foreign households are better off in this scenario than if no European risk-sharing is provided and only national governments backstops exist.

6.2.3 Welfare Effects of Alternative Contribution Schemes

As we discussed in assumption 1, the design of EDIS contributions is still an open issue in policy negotiations. While some approaches favor risk-weighted contributions, such risk-based payments can, if applied on the sectoral level, act procyclical and increase financial cycles. We therefore show welfare under different relative contribution schemes in figure 3, where we choose regime 4, a world in which banks only have to contribute into EDIS, for the comparative static analysis. While in the baseline model, contributions to EDIS are assumed to be risk-weighted (see assumption 1), we allow the weighting of contributions to be governed by parameter α^{RW} in the exercise. The relative contributions from equation 43 thus become

$$\tau_t^{EDIS,h} = \alpha^{RW} \tau_t^{EDIS} \tag{54}$$

$$\tau_t^{EDIS,f} = (1-\alpha^{RW}) \tau_t^{EDIS}. \tag{55}$$

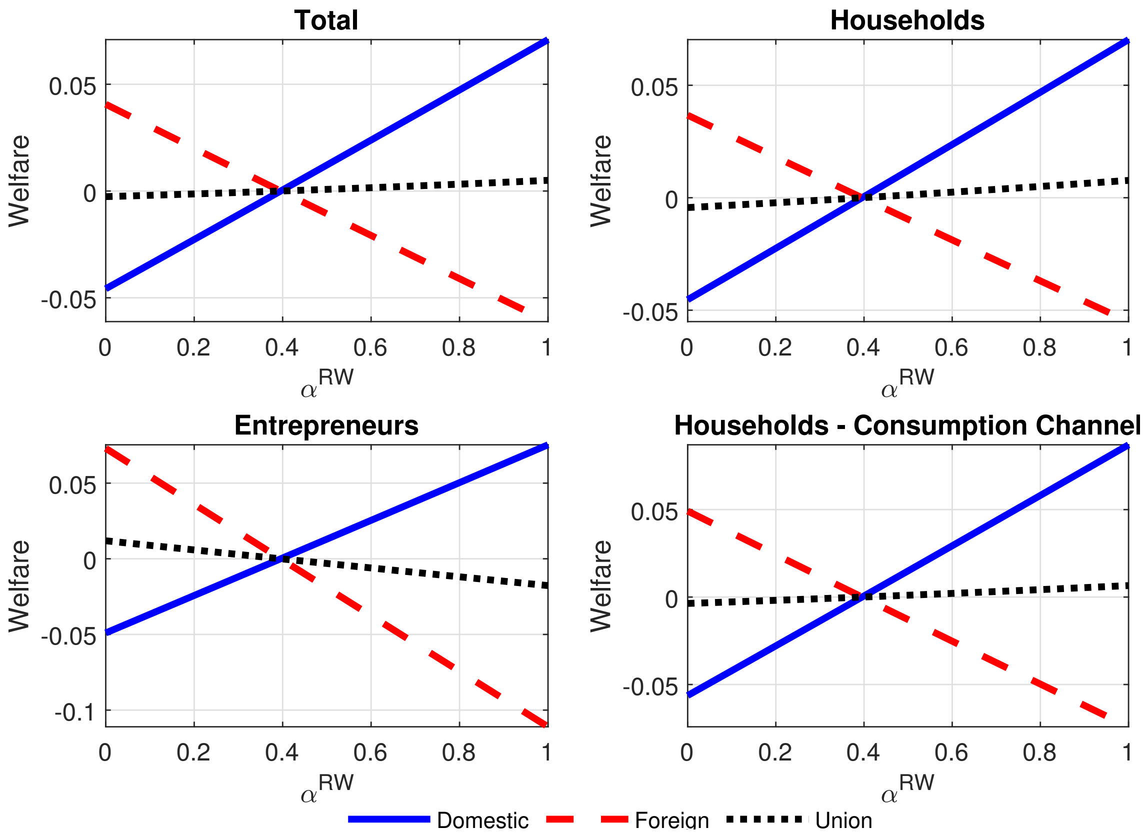
We evaluate welfare in the deterministic steady state, and compare it to the steady-state level under the baseline calibration following the definition of consumption equivalents in equation 51.[18] For comparability, we fix the Pareto weights to the values obtained under the baseline calibration, and evaluate the welfare implications that stem from changes in the welfare components only.

In total, low levels of α^{RW} are welfare-improving for the home economy (upper left panel figure 3). For the foreign economy, the opposite holds as welfare losses are lowest for high values of the contribution parameter. In both economies, higher levels of EDIS contributions limit the funding capacity and increase intermediation costs of banks, such that loans and deposits decline with rising contributions in steady state (figure 4). For firms, the borrowers in the economy, lower lending limits their access to funding, which ultimately lowers entrepreneur consumption and welfare (lower left panel figure 3). As lower lending dampens economic activity, also households' income and ultimately consumption decline, leading to a reduction in household welfare if domestic contributions rise (upper right panel figure 3).

On the union-wide level, welfare differentials are small, even if union-wide welfare gains are largest when α^{RW} is close to zero, and contributions almost entirely

[18] We do not rely on the stochastic steady in this exercise, as under the baseline calibration, the risk weights are defined by the ratio of default rates (equation 43). Thus, the second-order approximations of the baseline model include additional terms that make the stochastic steady states of the baseline model with the ones according to equations 54 and 55 not comparable.

Figure 3: Steady-State Welfare for Alternative Contribution Weights

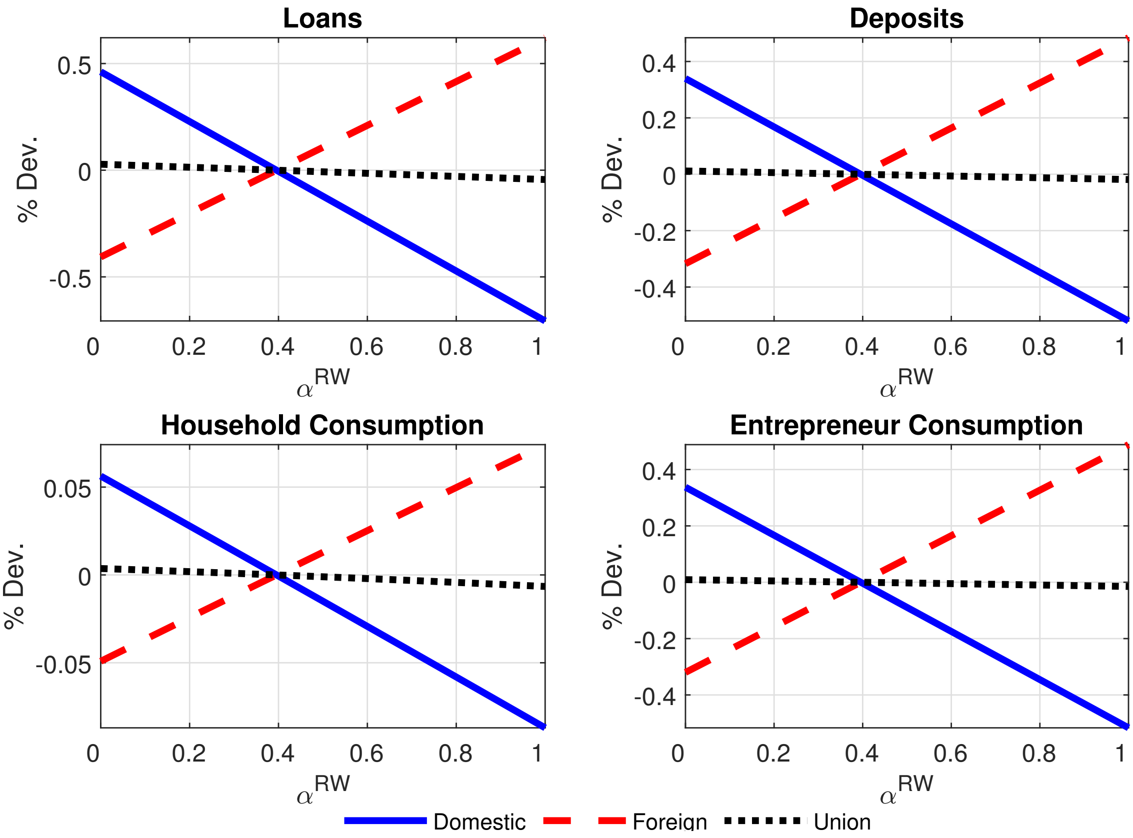


Note: Steady-state welfare for different contribution weights determined by α^{RW} in equations 54 and 55. Welfare expressed as consumption equivalents (equation 51). For Consumption Channel, we exclude the labor-related term from utility function 1.

accrue in the foreign economy.[19] Due to higher Pareto weights, country-wide welfare is primarily driven by households (upper right panel figure 3). For entrepreneurs, a high value of α^{RW} is – on the union-wide level – associated with the largest welfare gains (lower left panel figure 3), but again, differences are minor. Our analysis indicates that an "excessive risk-sharing" scheme is welfare-optimal, i.e. that union-wide welfare losses are minimized whenever risky banks pay all contributions. However, welfare costs from deviating from such an extreme scheme – by increasing save banks' contributions – are negligible. Thus, on the union-wide level, a more moderate risk-sharing approach where both risky and save banks contribute, is almost equally beneficial.

[19]We conducted robustness checks using alternative population weights, including weightings based on discount factors commonly used in the literature, see for instance Lambertini et al. (2013), Rubio (2011), or Gebauer (2020). Also under these alternative schemes, union-wide welfare differentials are negligible for different values of α^{RW}.

Figure 4: Steady-State Variables for Alternative Contribution Weights



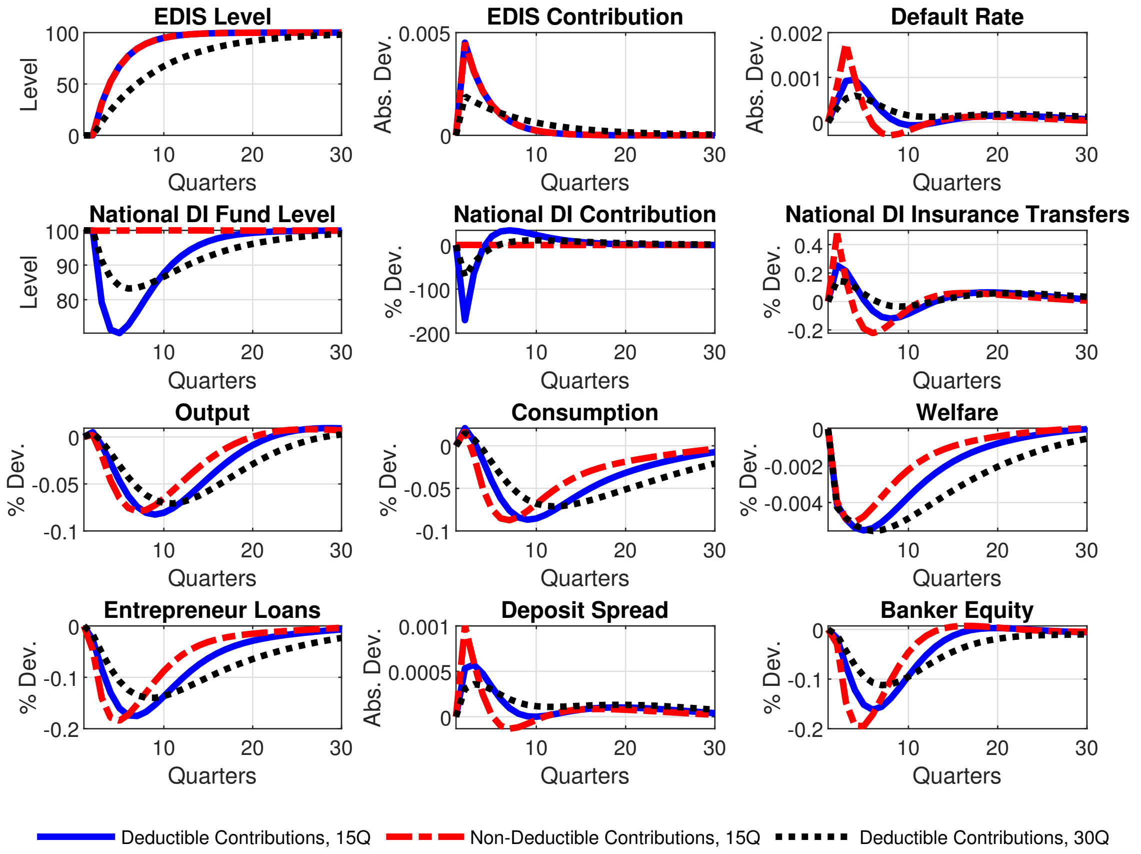
Note: Steady-state levels for different variables for different values of α^{RW}. Deviations are expressed as percentage deviations from steady-state levels under the baseline calibration.

6.2.4 Welfare Effects of EDIS Implementation

So far, we showed that an adequately designed EDIS already in place can stabilize welfare in the presence of financial shocks. However, the implementation of an EDIS fund potentially causes short-term welfare costs, as upfront payments by banks are necessary. We evaluate the initial costs of implementing such a fund by assuming that EDIS is only able to provide insurance once the fund has been filled up to the target level. We assume that fund capital is accumulated over time, as banks contribute to EDIS each period following equation 43. The sensitivity of contributions, χ_{τ}^{EDIS}, is chosen such that after approximately 3.5 years the targeted fund level of EDIS is reached in the baseline scenario. Those payments are risk-weighted as under assumption 1, with the riskier foreign banks bearing the larger share. By assumption 2, contributions to EDIS are deductible in the baseline. We also study a scenario where we relax assumption 2 by removing the deductibility of EDIS contributions. In a third exercise, we increase the duration of EDIS implementation to 7.5 years.

In figures 5 and 6, we show the transition path during the introduction of EDIS. If bank contributions to EDIS increase, their payments to national deposit insurances decline in case of deductibility (blue line). Given ongoing transfers, the national fund levels and ultimately the share of insurance coverage decline. Households anticipate the lower insurance coverage by demanding a higher risk premium on the deposit rate, resulting in lower financial intermediation and a drop in economic activity, together with a decline in welfare.

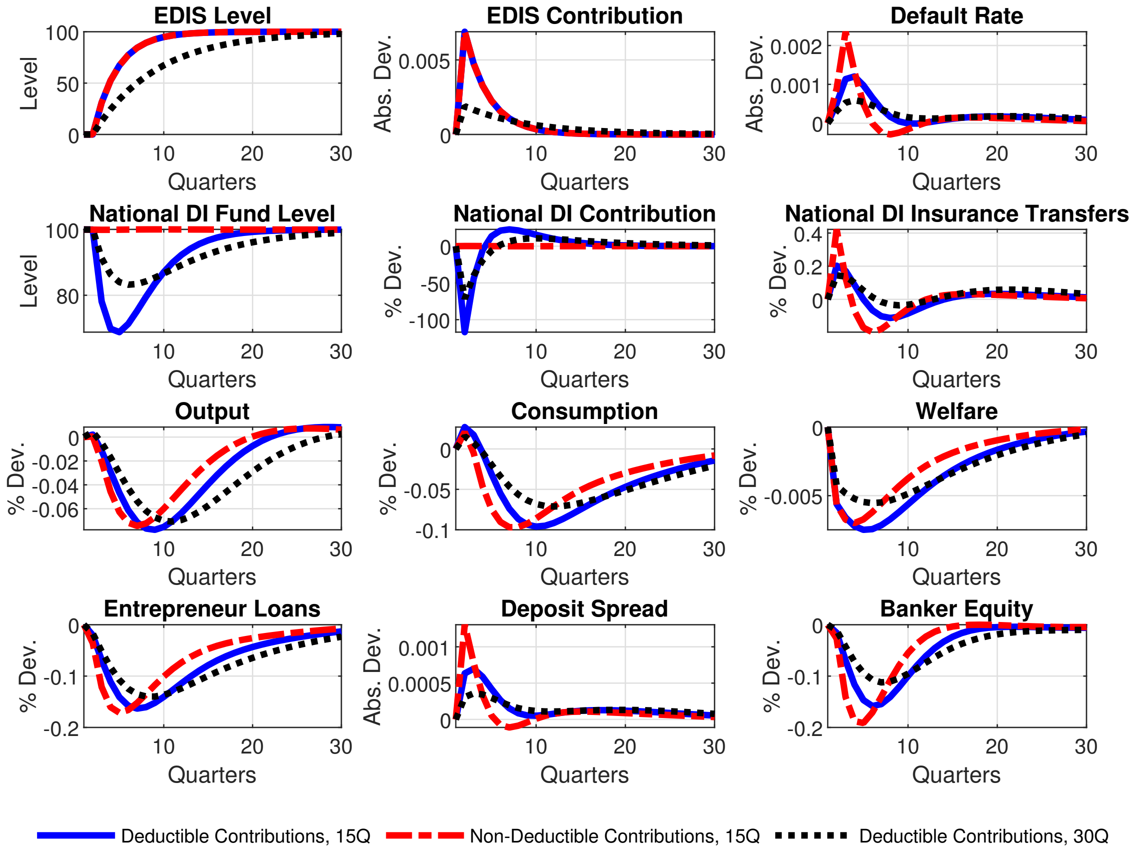
Figure 5: EDIS Implementation, Transition in Home



Note: Transition path of the home economy after the introduction of EDIS in period one. The target EDIS fund level is reached after around 3.5 years in the baseline (red and blue), and after 7.5 years (grey line).

Relaxing assumption 2 ensures constant national DI coverage, but at the same time, the total transfers banks have to absorb increase (red dashed line). The higher total costs result in initially lower bank profits and in less lending as under deductibility, and eventually in a higher rate of bank defaults. Ultimately, real economic activity declines to a similar degree as under the baseline scenario. Thus, wile non-deductible contributions ensure that the national DI's capacities are on

Figure 6: EDIS Implementation, Transition in Foreign



Note: Transition path of the foreign economy after the introduction of EDIS in period one. The target EDIS fund level is reached after around 3.5 years in the baseline (red and blue), and after 7.5 years (grey line).

target, the double burden due to bank contributions to both insurance schemes can destabilize the financial system, with respective adverse real economic effects. However, stress in the financial sector is relatively short-lived, such that financial and real variables, and ultimately welfare return to their initial levels more rapidly as in the baseline scenario. Thus, under both deductible and non-deductible contribution schemes, an intertemporal trade-off between the mitigation of the initial adverse effects for aggregate economic and financial activity, and the duration of the downturn exists. With deductibility, the policy maker can resolve this trade-off by smoothening out the adverse economic and financial effects over a longer horizon.

This intertemporal trade-off is accentuated when the implementation phase of the fund is prolonged. To mitigate short-run costs, the introduction of EDIS could be extended, such that the fund can be established with lower per-period contributions (black dotted line). Figures 5 and 6 reveal that a prolonged implementation of EDIS can indeed mitigate initial costs from a temporarily lower national DI coverage. However, as bank defaults can only partly be insured during the implementation, default costs remain higher for longer. Consequently, the associated decline in economic output and financial activity extends over a longer period. In the home economy, the prolonged phase of economic distress ultimately yields an equally pronounced decline and a longer recovery of social welfare compared to the baseline. In the foreign economy, welfare losses are initially lower as in the other two scenarios. However, as in the home country, recovery is slower when implementation takes longer. Consequently, while a prolonged implementation phase can mitigate short-term disruptions in financial markets, these gains are potentially confronted with a protracted decline in economic activity.

6.3 The Financial Crisis: Stabilization Effects of EDIS

In the following, we conduct a counterfactual analysis that serves two purposes. First, we investigate how EDIS would have performed in Germany and the rest of the euro area, had it been in place during the financial crisis. Second, we study the empirical validity of the model by comparing our model simulations to actual macroeconomic developments between 2008:Q4 and 2012:Q4.

6.3.1 Characterizing the Financial Crisis

In order to analyze how EDIS would have affected the macro economy, we follow Christiano et al. (2015) and suppose that the financial crisis in the euro area was triggered by four major shocks: a preference shock, a financial market shock, a TFP shock and a government spending shock. We extract these shocks by using the procedure proposed by Christiano et al. (2015). Thereby, we calculate for each variable of interest the linear trend from date $x \in \{1991{:}Q1, \dots, 2004{:}Q1\}$ to 2008:Q4. From 2008:Q4 onward, the trend growth rate is extrapolated by an AR(1) process, to derive trend forecasts without the shocks that caused the financial crisis.[20] We then calculate "target gaps", i.e. the differences between actual and projected values at different time horizons. Target gaps represent the estimates of shocks and their economic effects after the 4th quarter 2008. Since their true values are not known,

[20]In Europe, the drop in GDP in the 3rd quarter of 2008 was primarily driven by falling exports, while consumption and loans dropped below long-term levels mainly in the 4th quarter, We therefore set the starting point of our analysis, to the 4th quarter 2008.

we construct the min-max range of the computed gaps.[21] As a first objective of the exercise, we assess the model predictions relying on such target gaps. Second, we evaluate whether a regime switch would have occurred, and compare the outcome of the presumed status quo – a situation where a nationally financed deposit insurance becomes insufficient – with the EDIS scenario.

Following Christiano et al. (2015), for the preference shock, we define a "wedge" which describes a disturbance to the household Euler equation. A positive realization of the consumption wedge can be interpreted as an increasing demand for risk-free assets:[22]

$$\Delta_t^{C,c} = \frac{E_t \pi_{t+1}^c}{\beta R_t^c} - 1.$$

In order to get an observable time series of the consumption wedge, we use the country-specific deposit rates, and the one-quarter ahead core CPI-inflation forecasts from the ECB's Survey of Professional Forecasters. Differences in the consumption wedge between Germany and the rest of the euro area are determined by differences in inflation and deposit rates.

The bank risk shock is modelled as a shock to the default rate. In order to extract an empirical series, we rearrange the default rate equation

$$\Delta_t^{\psi,c} = \Phi\left(\frac{\ln(\overline{\omega}_t^c) + \frac{(\sigma_c z_t^{b,c})^2}{2}}{\sigma_c z_t^{b,c}}\right) \tag{56}$$

where $\Phi(z)$ is the standard normal distribution. We calculate the inverse of the standard normal distribution and solve the equation for the shock term $z_t^{b,c}$.[23] The bank risk shock occurs earlier in Germany, mainly because some German banks had solvency problems already in 2007,[24] before bank default increased further after the collapse of Lehman Brothers (upper second panel). After the provision of additional government aid for failing institutes in the beginning of 2009, bank risk decreased temporarily.[25] With the onset of the European debt crisis and increasing doubts

[21]For some of the euro area time series, such as GDP and components, we have a limited amount of observations, starting only in the mid-1990's. For all countries, only few default rate observations are available. Thus, particularly in this case, the min-max ranges are tight.

[22]See Fisher (2015).

[23]The resulting quadratic equation is solved with the quadratic formula and provides only one economic plausible solution. In this exercise, we also assume that ρ_b^c in equation A.39 is equal to zero.

[24]See Hellwig (2018).

[25]The time series used to determine the steady-state default rates $\overline{\psi^c}$ include the crisis years,

about the stability of the euro area, the probability of bank defaults increased again, also in Germany (upper and lower second panel).

To simulate a government spending shock we use quarterly time series data for government consumption divided by the trend component of factor productivity γ_t^c:

$$\Delta_t^{G,c} = \frac{g_t^c}{\gamma_t^c}. \tag{57}$$

In Germany, the permanent increase of government consumption can be explained with the implementation of substantial spending programs that were already approved in previous years, mainly to foster innovation and education (upper third panel).[26] Due to these programs, the increase in government spending can only in part be attributed to the financial crisis, as purely crisis-related packages terminated in 2010/2011 (red line). In the rest of the euro area, the strong reduction of government consumption (lower third panel) after 2009 can not only be explained by the termination of stimuli packages. If the packages would be the only determinants of government consumption, the decline in spending should resemble its increase during the implementation of these packages. The larger part of the decrease was therefore most probably triggered by austerity policies conducted in several euro area economies at the time.

Finally, the total factor productivity shock is measured as a residual in the production function:

$$\Delta_t^{A,c} = \frac{y_t^{E,c}}{(k_t^{E,c})^{(\varepsilon^{TFP,c})}(l_t^{P,c})^{(1-\varepsilon^{TFP,c})}}. \tag{58}$$

In contrast to the other shocks, we use the European Commission's unobserved component model which relies on the Kalman filter to extract the trend component.[27] However, disentangling the TFP shock's transitory from the permanent component proves difficult, as agents became only gradually aware of the persistence in the decline in euro area productivity during the crisis.[28] Thus, for the rest of the euro area, we assume a highly persistent shock, while in Germany the transitory component dominates.

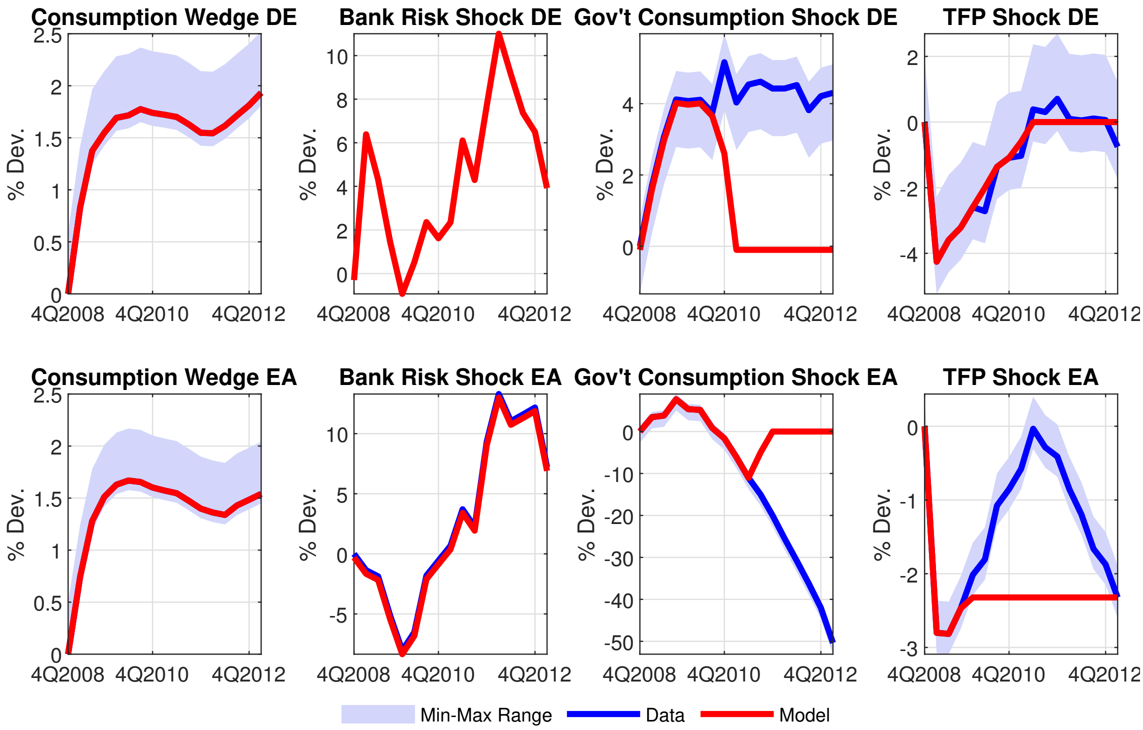
such that a negative realization of the bank risk shock of default rates in figure 7 is still associated with elevated default levels.

[26]The programs included, inter alia, the "Exzellenzinitiative I", the "Hochschulpakt I", and the "Innovationsoffensive".

[27]See Havik et al. (2014).

[28]See Christiano et al. (2015).

Figure 7: The Financial Crisis 2007/2008 in Germany and the Euro Area - Exogenous Variables



Note: Exogenous processes used in the counterfactual analysis. Consumption wedges are computed following Christiano et al. (2015). All variables in percentage deviations from steady state.

6.3.2 Solving and Simulating the Baseline Model

We solve the model by incorporating the shock vectors of the post-2008:Q4 period assuming the law of motions and information sets about the shocks as discussed. For the shock series, we suppose that at date t each agent observes the historical values of the shocks. At each date $s = 15$ during the post-2008:Q4 period, they compute forecasts with model-consistent AR(1) forecast rules. For macroeconomic variables, we follow an analogous procedure. In a first step, we run the model given the shock in period t, assuming that the economy is initially in steady state. In a next step, we adjust initial conditions for each subsequent period $t + s$ to the previous state of the economy and run the model for each period separately.[29] This yields a 1×15 vector for each variable with the actual and the expected values given adjusted information. Finally, to compute the final series we collect all actual values from each period's simulation.

[29] Although agents consider the switching probabilities, we exclude the possibility of switching into a new steady state. Thus, in each simulation the agents expect to converge back to the deterministic steady state of regime 1.

6.3.3 Counterfactual Analysis

The simulated series for six macroeconomic variables are depicted in figure 8 (blue line), together with the empirically observed values (black line) and the min-max range (gray shaded area). As our baseline, we choose the national fiscal backstop scenario, where governments provide deposit insurance once the national DI fund is exhausted (red solid line). In principle, the model is able to replicate the observed dynamics of these variables quite well.[30] However, three aspects have to be taken into account while comparing baseline model results with observed variables.

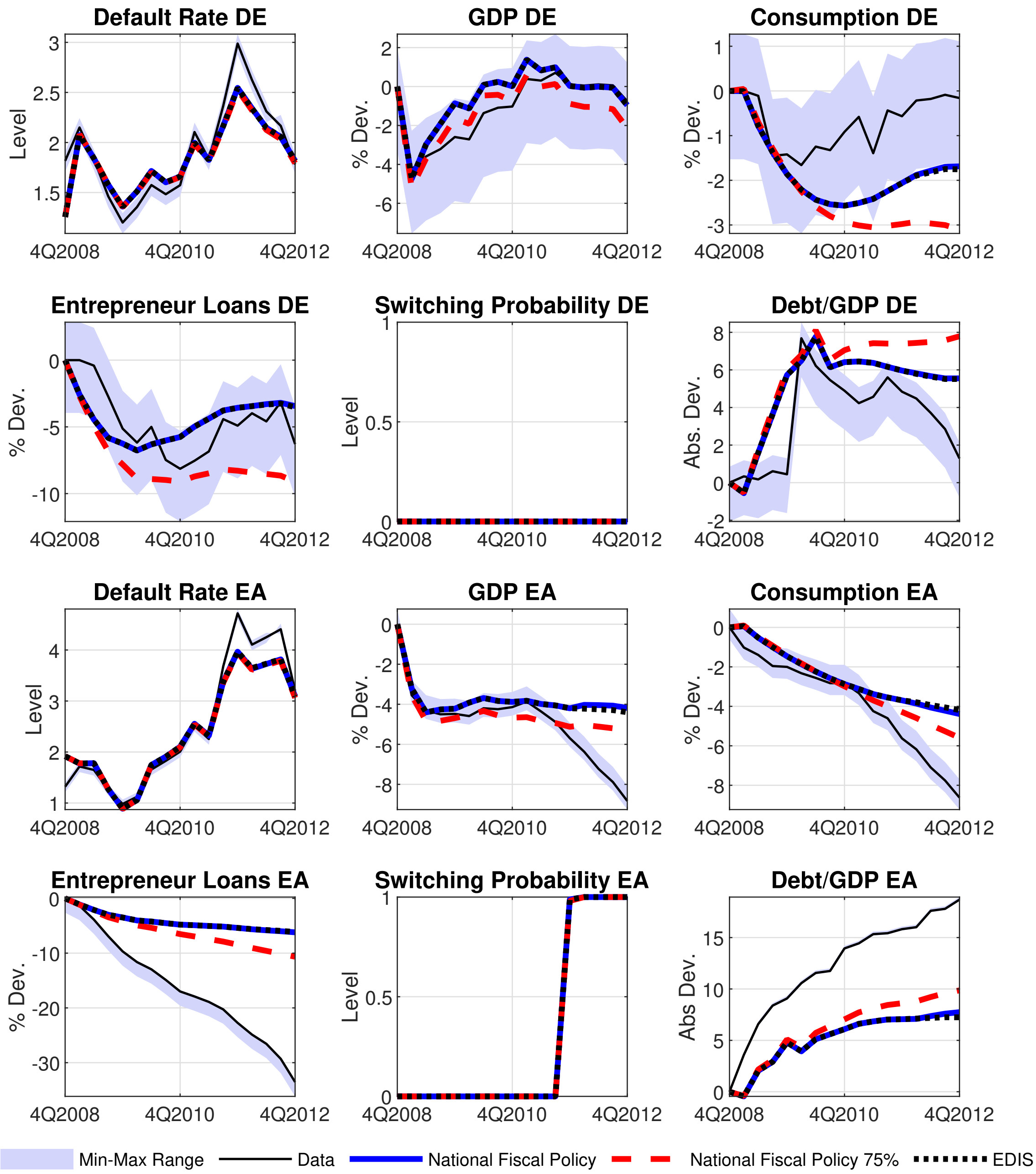
First, as none of the European national DI schemes actually ran out of funds during the financial crisis, we do not observe a true "regime-switch" in the data. However, governments provided both explicit bank bailouts and implicit deposit guarantees during the financial crisis, which we do not explicitly address in the model. Without these measures, the probability of bank defaults would have potentially been higher than observed, which most probably would have led to an exhaustion of national DI funds. Since our model does not consider bank bailouts, it indicates a regime switch instead. Furthermore, while national deposit insurance is mainly privately financed in most EU countries, some countries have explicit fiscal backstops or public-private coinsurance schemes. Since we model the deposit insurance schemes as purely privately financed entities, funds are more rapidly depleted as the real-world data might suggest. Thus, our baseline result can be interpreted as a counterfactual scenario where government bailouts would not have circumvented the depletion of the purely privately financed part of national deposit insurances.

Second, during the European sovereign debt crisis which started in 2010/2011 and which we do not explicitly consider, country-specific shocks played a significant role. For instance, consolidation policies of the German government had small effects because the economic recovery was rapid. In other countries, i.e. Italy, Spain, or Greece, the austerity measures had a strong negative impact on GDP and consumption. We only account for the reduction of government consumption, but not for additional government spending shocks, such as tax and labor market policies that would have further reduced consumption in affected countries to different degrees.

Third, due to bank bailouts government debt increased substantially in some

[30] Christiano et al. (2015) use data for the US back to 1980 and report ranges of roughly 3-5 percentage points for GDP and consumption. With data for Germany, we get similar ranges of for GDP and consumption. However, for the euro area, the range is at 2 percentage points such that our min-max range in the euro area should be interpreted as a rather narrow band.

Figure 8: The Financial Crisis 2007/2008 in Germany and the Euro Area - Endogenous Variables



Note: Endogenous variables simulated with exogenous processes in figure 7. Default rates and switching probabilities in levels, debt-to-GDP ratios in absolute percentage point deviations from steady state. All other variables in percentage deviations steady state.

countries. In return, financial markets questioned the sustainability of high debt levels in some member states, which led to large risk spreads and negative feedback effects to the macro economy and the banking sector. While banks holding sovereign bonds potentially benefit from higher yields on sovereign debt, the negative effects of rising bond yields, particularly in times of financial distress, need to be adequately considered: (1) As bond yields and the underlying bond value are inversely related, rising risk premia and sovereign bond yields are also associated with a decline in bond prices. Consequently, falling bond prices negatively affect the asset side of banks' balance sheets. (2) While this mainly linear yield-price link already affects banks' balance sheets in normal times, bank bailouts can trigger a highly non-linear feedback loop in times of financial distress. As we only partially account for the second channel, we potentially underestimate the negative feedback effect and the macroeconomic dynamics after 2008 in the baseline simulation. We account for the potentially higher non-linear crisis effects by simulating an alternative baseline (red dashed line in figure 8) where we assume that banks face a 75 percent lower return on government bonds than in the baseline.

Besides the two described scenarios, we assume in a third scenario that EDIS, designed as in section 5.2, was already in place before 2008 (black dotted line). The counterfactual scenario with EDIS delivers two key results. First, once the euro area economy switches, the decline in GDP is slightly lower in case of the fiscal backstop. The difference can be explained by differences in the terms of trade reaction (not shown). In case of EDIS, the relative competitiveness of the euro area declines stronger, and the trade balance in the rest of the euro area deteriorates by more.

Second, although macroeconomic differences between the baseline scenario and EDIS are small, the rise in government debt would have been lower with EDIS: The debt-to-GDP ratio increase is approximately half a percentage point lower than in the baseline case. Furthermore, the relative advantage of EDIS increases significantly once we assume that banks' benefits from higher sovereign bond yields are limited due to the fiscal backstop (red dashed line). In both economies, consumption and GDP losses due to the crisis diminish by approximately 2 percent (annualized) with EDIS. The increase of debt-to-GDP ratio is even 2 to 3 percentage points lower.

In short, our results suggests that EDIS would have potentially reduced the risks stemming from a bank-sovereign doom loop. Implicit and explicit costs from bank defaults and bailouts would have been more effectively covered by EDIS funds, which would have limited the burden for constrained sovereigns. Furthermore, the exercise shows that with EDIS, gains and losses from higher bank risks are shared between bank owners, and do not accrue via higher taxes to all economic agents.

7 Conclusion

This paper investigates the macroeconomic and financial effects of a European deposit insurance scheme (EDIS). We analyze the economic effects of a reinsurance scheme in a regime-switching open-economy DSGE model calibrated to match key euro area data moments, and discuss different forms of reinsurance.

We find that a national fiscal backstop and EDIS are able to insure almost equally well against unanticipated increases in bank default risk. However, overall consumption is more stabilized with EDIS in the economy where the shock occurs. Also, debt levels remain broadly stable, while the country's debt-to-GDP ratio rises if a fiscal backstop has to incur deposit insurance. At the same time, the total insurance burden for banks increases as banks are required to contribute to both the national and the European fund, and the national fund's recovery takes longest with EDIS. As financial risks are shared on the European level, foreign banks also need to contribute more with EDIS, with resulting adverse effects for lending and real economic activity.

Welfare gains from EDIS over fiscal reinsurance are largest in a scenario where national DI funds in both economies are exhausted. On the union-wide level, risk-based contribution schemes deliver the largest welfare gains, supporting the "polluter-pays" principle underlying most policy proposals. However, such schemes particularly benefit savers, while borrowers across the union might be better off if the largest part of payments falls to the least risky national banking system.

We also discuss how short-term costs from installing an EDIS fund can be mitigated. We show that whenever the fund has to be filled from bank contributions, the deductibility of EDIS contributions can lower bank payments into national systems, which temporarily lowers national DIs' capacities. Without deductibility, national DIs' capacities are less affected. At the same time, double contributions in both systems potentially lower bank margins and limit their capacities to provide lending. Finally, longer implementation horizons can mitigate bank defaults in the short run, as the bank burden from up-front contributions is stretched over a longer period. However, at the same time, the economic contraction is protracted.

In a counterfactual exercise, we analyze how EDIS would have affected the euro area economy during the financial crisis. Therefore, we extract specific financial crisis shocks. We then simulate a benchmark scenario, where we assume that national governments would have provided deposit insurance once the national schemes would have been exhausted. We find that the differences in the stabilization of GDP and consumption between EDIS and the fiscal backstop would have been rather small. However, the debt-to-GDP ratio would have been lower with EDIS. The benefits of EDIS become significantly larger once we assume that banks profit only partly from increasing debt-elastic government interest rate.

Our findings suggest that a European deposit reinsurance scheme can provide welfare gains on a union-wide level, even though several trade-offs need to be considered in policy decisions. First, while European risk-sharing can enhance macroeconomic and financial stability and increase welfare, overburdening banks with contributions in both national and European insurance schemes can limit lending capacities. Thus, regulators need to adequately design contribution and deductibility schemes to avoid tensions in credit markets. Second, while the long-term benefits of EDIS are potentially significant, short-term costs during the implementation phase need to be taken into account. While expanding the implementation horizon can help mitigating short-run distress in financial markets, smoothing out bank contributions into the future potentially prolongs an economic downturn. If bank contributions are channeled towards EDIS for a longer time, deposit insurance can be insufficient to cover depositor losses in times of distress. Thus, policy makers need to make sure that EDIS, once introduced, is able to provide insurance instantaneously. Also, temporary suspensions of EDIS contributions could be considered during times of acute distress, if EDIS payments are not (yet) available.

References

Acharya, V. V., Drechsler, I., and Schnabl, P. (2014). A Pyrrhic Victory? Bank Bailouts and Sovereign Credit Risk. *The Journal of Finance*, 69(6):2689–2739.

Acharya, V. V. and Steffen, S. (2016). Capital Markets Union in Europe: Why Other Unions Must Lead the Way. *Swiss Journal of Economics and Statistics*, 152(4):319–329.

Acharya, V. V. and Thakor, A. V. (2016). The Dark Side of Liquidity Creation: Leverage and Systemic Risk. *Journal of Financial Intermediation*, 28:4–21.

Afonso, A. and Furceri, D. (2008). EMU Enlargement, Stabilization Costs and Insurance Mechanisms. *Journal of International Money and Finance*, 27(2):169–187.

Anginer, D., Demirgüç-Kunt, A., and Zhu, M. (2014). How Does Deposit Insurance Affect Bank Risk? Evidence from the Recent Crisis. *Journal of Banking and Finance*, 48:312–321.

Asdrubali, P., Kim, S., Pericoli, F., and Poncela, P. (2018). New Risk Sharing Channels in OECD Countries: A Heterogeneous Panel VAR. *JRC Working Papers in Economics and Finance*, (2018/13).

Asdrubali, P., Sørensen, B. E., and Yosha, O. (1996). Channels of Interstate Risk Sharing: United States 1963–1990. *The Quarterly Journal of Economics*, 111(4):1081–1110.

Beck, T. and Wagner, W. (2016). Supranational Supervision: How Much and for Whom? *International Journal of Central Banking*, 12(2):221–268.

Bénassy-Quéré, A., Brunnermeier, M., Enderlein, H., Farhi, E., Fratzscher, M., Fuest, C., Gourinchas, P.-O., Martin, P., Pisani-Ferry, J., Rey, H., Schnabel, I., Véron, N., Weder die Mauro, B., and Zettelmeyer, J. (2018). Reconciling Risk Sharing with Market Discipline: A constructive approach to Euro Area Reform. *CEPR Policy Insight January*, (91).

Benigno, P. (2004). Optimal Monetary Policy in a Currency Area. *Journal of International Economics*, 63(2):293–320.

Bernanke, B. S., Gertler, M., and Gilchrist, S. (1999). The Financial Accelerator in a Quantitative Business Cycle Framework. In Taylor, J. B. and Woodford, M., editors, *Handbook of Macroeconomics*. Elsevier.

Bernet, B. and Walter, S. (2009). Design, Structure and Implementation of a Modern Deposit Insurance Scheme. *SUERF Studies*, 2009/5.

Boyer, P. C. and Ponce, J. (2012). Regulatory Capture and Banking Supervision Reform. *Journal of Financial Stability*, 8(3):206–217.

Brunnermeier, M. K., Garicano, L., Lane, P. R., Pagano, M., Reis, R., Santos, T., Thesmar, D., Van Nieuwerburgh, S., and Vayanos, D. (2016). The Sovereign-Bank Diabolic Loop and ESBies. *American Economic Review*, 106(5):508–512.

Calomiris, C. W. and Jaremski, M. (2016). Deposit Insurance: Theories and Facts. *Annual Review of Financial Economics*, 8:97–120.

Calomiris, C. W. and Jaremski, M. (2019). Stealing Deposits: Deposit Insurance, Risk-Taking, and the Removal of Market Discipline in Early 20$^{\text{th}}$-Century Banks. *The Journal of Finance*, 74(2):711–754.

Carletti, E., Dell'Ariccia, G., and Marquez, R. (2016). Supervisory Incentives in a Banking Union. *IMF Working Paper*, (16/186).

Carmassi, J., Dobkowitz, S., Evrard, J., Parisi, L., Silva, A., and Wedow, M. (2018). Completing the Banking Union with a European Deposit Insurance Scheme: Who is Afraid of Cross-Subsidisation? *ECB Occasional Paper Series*, (208).

Chang, B. H., Chang, Y., and Kim, S.-B. (2018). Pareto Weights in Practice: A Quantitative Analysis Across 32 OECD Countries. *Review of Economic Dynamics*, 28:181–204.

Christiano, L. J., Eichenbaum, M. S., and Evans, C. L. (2005). Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy. *Journal of Political Economy*, 113(1):1–44.

Christiano, L. J., Eichenbaum, M. S., and Trabandt, M. (2015). Understanding the Great Recession. *American Economic Journal: Macroeconomics*, 7(1):110–167.

Coeurdacier, N., Rey, H., and Winant, P. (2011). The Risky Steady State. *American Economic Review*, 101(3):398–401.

Colliard, J.-E. (2018). Optimal Supervisory Architecture and Financial Integration in a Banking Union. *HEC Paris Research Paper*, (FIN-2018-1319).

Cooper, R. and Ross, T. W. (2002). Bank Runs: Deposit Insurnce and Capital Requirements. *International Economic Review*, 43(1):55–72.

De Lange (2016). Draft Report on the Proposal for a Regulation of the European Parliament and of the Council amending Regulation (EU) 806/2014 in order to establish a European Deposit Insurance Scheme. Com/2015/0586 final - 2015/0270 (cod).

Dedola, L., Karadi, P., and Lombardo, G. (2013). Global Implications of National Unconventional Policies. *Journal of Monetary Economics*, 60(1):66–85.

Demirgüç-Kunt, A. and Detragiache, E. (2002). Does Deposit Insurance Increase Banking System Stability? An Empirical Investigation. *Journal of Monetary Economics*, 49(7):1373–1406.

Demirgüç-Kunt, A. and Huizinga, H. (2004). Market Discipline and Deposit Insurance. *Journal of Monetary Economics*, 51(2):375–399.

Demirgüç-Kunt, A., Kane, E., and Laeven, L. (2014). Deposit Insurance Database. *IMF Working Paper*, (14/118).

Diamond, D. W. and Dybvig, P. H. (1983). Bank Runs, Deposit Insurance, and Liquidity. *The Journal of Political Economy*, pages 401–419.

Dubois, C. (2017). The Macroeconomics of Deposit Insurance in a Two-Country Model. *mimeo*.

European Commission (2015). Proposal for a Regulation of the European Parliament and of the Council amending Regulation (EU) 806/2014 in order to establish a European Deposit Insurance Scheme. Com/2015/0586 final - 2015/0270 (cod).

Farhi, E. and Tirole, J. (2018). Deadly Embrace: Sovereign and Financial Balance Sheets Doom Loops. *Review of Economic Studies*, 85(3):1781—1823.

Fisher, J. D. (2015). On the Structural Interpretation of the Smets–Wouters "Risk Premium" Shock. *Journal of Money, Credit and Banking*, 47(2-3):511–516.

Foarta, D. (2018). The Limits to Partial Banking Unions: A Political Economy Approach. *American Economic Review*, 108(4-5):1187–1213.

Furceri, D. and Zdzienicka, A. (2015). The Euro Area Crisis: Need for a Supranational Fiscal Risk Sharing Mechanism? *Open Economies Review*, 26(4):683–710.

Gambacorta, L. and Signoretti, F. M. (2014). Should Monetary Policy Lean Against the Wind?: An Analysis Based on a DSGE Model With Banking. *Journal of Economic Dynamics and Control*, 43(June):146–174.

Gebauer, S. (2020). Welfare-Based Optimal Macroprudential Policy with Shadow Banks. *mimeo.*

Gerali, A., Neri, S., Sessa, L., and Signoretti, F. M. (2010). Credit and Banking in a DSGE Model for the Euro Area. *Journal of Money, Credit and Banking*, 42(1):107–141.

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*. Elsevier.

Górnicka, L. A. and Zoican, M. (2016). Too-International-to-Fail? Supranational Bank Resolution and Market Discipline. *Journal of Banking and Finance*, 65(C):41–58.

Havik, K., Morrow, K. M., Orlandi, F., Planas, C., Raciborski, R., Röger, W., Rossi, A., Thum-Thysen, A., and Vandermeulen, V. (2014). The Production Function Methodology for Calculating Potential Growth Rates Output Gaps. *European Commission Economic Papers*, 535.

Hellwig, M. F. (2018). Germany and the Financial Crises 2007 – 2017. Paper presented at the 4th Annual Macroprudential Conference of the Swedish Riksbank.

Hoffmann, M., Maslov, E., Sørensen, B. E., and Stewen, I. (2019). Channels of Risk Sharing in the Eurozone: What Can Banking and Capital Market Union Achieve? *IMF Economic Review*, 67(3):443–495.

Iacoviello, M. (2005). House Prices, Borrowing Constraints, and Monetary Policy in the Business Cycle. *American Economic Review*, 95(3):739–764.

Kollmann, R. (2013). Global Banks, Financial Shocks, and International Business Cycles: Evidence from an Estimated Model. *Journal of Money, Credit and Banking*, 45(s2):159–195.

Kollmann, R., Enders, Z., and Müller, G. J. (2011). Global Banking and International Business Cycles. *European Economic Review*, 55(3):407–426.

Lambert, C., Noth, F., and Schüwer, U. (2017). How Do Insured Deposits Affect Bank Risk? Evidence from the 2008 Emergency Economic Stabilization Act. *Journal of Financial Intermediation*, 29:81–102.

Lambertini, L., Mendicino, C., and Punzi, M. T. (2013). Leaning Against Boom–Bust Cycles in Credit and Housing Prices. *Journal of Economic Dynamics and Control*, 37:1500–1522.

Maih, J. (2015). Efficient Perturbation Methods for Solving Regime-Switching DSGE Models. *SSRN Electronic Journal*.

Mendicino, C., Nikolov, K., Suarez, J., and Supera, D. (2018). Optimal Dynamic Capital Requirements. *Journal of Money, Credit and Banking*, 50(6):1271–1297.

Mendoza, E. G. and Quadrini, V. (2010). Financial Globalization, Financial Crises and Contagion. *Journal of Monetary Economics*, 57(1):24–39.

Merton, R. C. (1977). An Analytic Derivation of the Cost of Deposit Insurance and Loan Guarantees: An Application of Modern Option Pricing Theory. *Journal of Banking and Finance*, 1(1):3–11.

Pennacchi, G. (2006). Deposit Insurance, Bank Regulation, and Financial System Risks. *Journal of Monetary Economics*, 53(1):1–30.

Rubio, M. (2011). Fixed- and Variable-Rate Mortgages, Business Cycles, and Monetary Policy. *Journal of Money, Credit and Banking*, 43(4):657–688.

Sørensen, B. E. and Yosha, O. (1998). International Risk Sharing and European Monetary Unification. *Journal of International Economics*, 45(2):211–238.

Wheelock, D. C. and Kumbhakar, S. C. (1995). Which Banks Choose Deposit Insurance? Evidence of Adverse Selection and Moral Hazard in a Voluntary Insurance System. *Journal of Money, Credit and Banking*, 27(1):186–201.

A Appendix: The Non-Linear Open Economy Model

A.1 Households

The representative patient household i in each country $c \in \{h, f\}$ maximizes expected utility

$$\max_{c_t^{P,c}(i),\, l_t^c(i),\, d_t^c(i)} \quad E_0 \sum_{t=0}^{\infty} (\beta_P^c)^t \left[z_t^{c,c} \log[c_t^{P,c}(i) - h_P^c c_{t-1}^{P,c}(i)] - \frac{\varphi_P^c}{1+\phi_P^c} l_t^c(i)^{1+\phi_P^c} \right] \quad \text{(A.1)}$$

subject to the nominal budget constraint

$$P_t^c c_t^{P,c}(i) + D_t^c(i) \leq W_t^c l_t^c(i) + \tilde{R}_{t-1}^{d,c,nom} D_{t-1}^c(i) + \Pi_t^{cp,c,nom}(i) + \Pi_t^{bank,c,nom}(i) - \tau_t^{c,nom}(i).$$

We obtain the real budget constraint of households after dividing by the consumer price level P_t^c:

$$c_t^{P,c}(i) + d_t^c(i) \leq w_t^c l_t^c(i) + \tilde{R}_t^{d,c} d_{t-1}^c(i) + \Pi_t^{cp,c}(i) + \Pi_t^{bank,c}(i) - \tau_t^c(i), \quad \text{(A.2)}$$

with $d_t^c(i)$, w_t^c, $\Pi_t^{cp,c}(i)$, $\Pi_t^{bank,c}(i)$, $\tau_t^c(i)$ and $\tilde{R}_t^{d,c}$ all denoting real variables, and $\Pi_t = \frac{P_t^c}{P_{t-1}^c}$ defining consumer price inflation. Current consumption $c_t^{P,c}(i)$ is prone to habit formation governed by h_P^c, and $z_t^{c,c}$ depicts a consumption preference shock described by an AR(1) process. Working hours are given by l_t^c and labor disutility is parameterized by ϕ_P^c. The flow of expenses includes current consumption, and real deposits to be made to domestic banks $d_t^c(i)$. Resources consist of wage earnings $w_t^c l_t^c(i)$ (where w_t^c is the real wage rate for the labor input paid in the country the respective household resides) and gross interest income on last period deposits placed in domestic banks, $\tilde{R}_t^{d,c}$. The fiscal authority charges lump-sum taxes $\tau_t^c(i)$ in real terms to finance government debt. The household receives real profits $\Pi_t^{bank,c}(i)$ from exiting bankers, and $\Pi_t^{cp,c}(i)$ from capital producers. Transferred bank profits are given by

$$\Pi_t^{bank,c}(i) = (1-\theta_b^c)[\rho_t^c n_t^{c,c} + \rho_t^{\neg c} n_t^{c,\neg c} - \chi_t^{b,c}]$$

and the Lagrange function for the patient household is therefore given by:

$$\mathcal{L}^{P,c} = E_0 \sum_{t=0}^{\infty} (\beta_P^c)^t \Bigg[z_t^{c,c} \log[c_t^{P,c}(i) - h_P^c c_{t-1}^{P,c}(i)] - \frac{\varphi_P^c}{1+\phi_P^c} l_t^{P,c}(i)^{1+\phi_P^c}$$

$$- \lambda_t^{P,c} \Big[c_t^{P,c}(i) + d_t^c(i) - w_t^c l_t^{P,c}(i) - \tilde{R}_{t-1}^{d,c} d_{t-1}^c(i) - \Pi_t^{cp,c}(i) - \Pi_t^{bank,c}(i) + \tau_t^c(i) \Big] \Bigg]. \tag{A.3}$$

Following Mendicino et al. (2018), bank debt is partially insured by a fraction κ_t^c. Insured bank debt always pays back the promised rate $R_t^{d,c}$. Uninsured deposits pay back the promised rate $R_t^{d,c}$ if the bank is solvent and a fraction $(1-\kappa_t^c)$ of the net recovery value of bank assets in case of default. The return of households on a unit of bank debt is then given by

$$\tilde{R}_t^{d,c} = R_t^{d,c} - (1-\kappa_t^c)\frac{\Omega_{t+1}^c}{d_t^c}, \tag{A.4}$$

where $\frac{\Omega_{t+1}^c}{d_t^c}$ is the average default loss per unit of bank debt. The share of insured deposits, κ_t^c is time-varying and depends on available funds in the deposit insurance.

The first-order conditions are given by:

1. Consumption:

$$\frac{z_t^{c,c}}{c_t^{P,c}(i) - h_P^c c_{t-1}^{P,c}(i)} - h_P^c \beta_P^c E_t \left\{ \frac{1}{c_{t+1}^{P,c}(i) - h_P^c c_t^{P,c}(i)} \right\} = \lambda_t^{P,c}$$

2. Labor:

$$\varphi_P^c [l_t^{P,c}(i)]^{\phi_P^c} = \lambda_t^{P,c} w_t^c$$

3. Deposit:

$$\beta_P^c E_t \{ \lambda_{t+1}^{P,c} \tilde{R}_t^{d,c} \} = \lambda_t^{P,c}$$

A.2 Entrepreneurs

Entrepreneurs engaged in a certain sector j in country c use the respective labor type provided by households as well as capital to produce intermediate goods that retailers purchase in a competitive market. Each entrepreneur i derives utility from consumption $c_t^{E,c}(i)$ and maximizes expected utility

$$\max_{c_t^{E,c}(i),l_t^{P,c}(i),k_t^{E,c}(i)} E_0 \sum_{t=0}^{\infty} (\beta_P^c)^t \left[\log c_t^{E,c}(i) \right] \tag{A.5}$$

subject to the nominal budget constraint

$$P_t^c c_t^{E,c}(i) + W_t^c l_t^{P,c}(i) + Q_t^{k,c} k_t^{E,c}(i) + R_t^{E,c,nom} B_{t-1}^{E,c}(i) \leq \\ P_t^{E,c} y_t^{E,c}(i) + B_t^{E,c}(i) + Q_t^{k,c}(1-\delta^c) k_{t-1}^{E,c}(i). \tag{A.6}$$

After dividing by the consumer price level P_t^c, one obtains:

$$c_t^{E,c}(i) + w_t^c l_t^{P,c}(i) + q_t^{k,c} k_t^{E,c}(i) + R_t^{E,c} b_{t-1}^{E,c}(i) \leq p_t^{E,c} y_t^{E,c}(i) + b_t^{E,c}(i) + q_t^{k,c}(1-\delta^c) k_{t-1}^{E,c}(i) \tag{A.7}$$

with $p_t^{E,c} = \frac{P_t^{E,c}}{P_t^c}$ denoting the price ratio of producer price level to consumer price level, $q_t^{k,c} = \frac{Q_t^{k,c}}{P_t^c}$ denoting the real price of the capital good. Entrepreneurs in country c furthermore face constraints on the amount they can borrow from domestic banks depending on the stock of capital they hold as collateral. Regulatory loan-to-value (LTV) ratios apply for funds borrowed in each country, and regulation can be determined on the national level. The borrowing constraint is given by

$$R_{t+1}^{E,c} b_t^{E,c}(i) \leq m_E^c E_t\{q_{t+1}^{k,c}(1-\delta^c) k_t^{E,c}(i)\} \tag{A.8}$$

where the LTV ratio for commercial banks m_E^c is set exogenous by the regulator. We follow Iacoviello (2005) and assume that the borrowing constraint binds around the steady state such that uncertainty is absent in the model. Thus, in equilibrium, entrepreneurs face a binding borrowing constraint, such that equation A.8 holds with equality. The production function is given by

$$y_t^{E,c} = a_t^{E,c} (k_t^{E,c})^{(\alpha^c)} (l_t^{P,c})^{(1-\alpha^c)} \tag{A.9}$$

and the return to capital is defined as

$$r_t^{k,c} = \alpha^c \frac{p_t^{E,c} a_t^{E,c} (k_t^{E,c})^{(\alpha^c)} (l_t^{P,c})^{(1-\alpha^c)}}{k_t^{E,c}}. \tag{A.10}$$

Equation A.8 yields the contractual return on one unit of corporate loans:

$$R_{t+1}^{E,c} = \frac{m_E^c E_t\{q_{t+1}^{k,c}(1-\delta^c) k_t^{E,c}(i)\}}{b_t^{E,c}(i)}. \tag{A.11}$$

Entrepreneur Maximization Problem

Entrepreneurs maximize their lifetime consumption stream by deciding on period consumption $c_t^{E,c}(i)$ as well as on labor and capital inputs, $l_t^{P,c}(i)$ and $k_t^{E,c}(i)$, subject to the budget constraint A.7, the borrowing constraint A.8, and the production technology A.9. The Lagrange function is therefore given by:

$$\mathcal{L}^{E,c} = E_0 \sum_{t=0}^{\infty} \beta_E^t \Bigg[\log c_t^{E,c}(i) - \lambda_t^{E,c} \Big[c_t^{E,c}(i) + w_t^c l_t^{P,c}(i) + q_t^{k,c} k_t^{E,c}(i) + m_E^c q_t^{k,c}(1-\delta^c) k_{t-1}^{E,c}(i) - \\ - p_t^{E,c} a_t^{E,c} (k_t^{E,c})^{(\alpha^c)} (l_t^{P,c})^{(1-\alpha^c)} - \frac{m_E^c q_{t+1}^{k,c}(1-\delta^c) k_t^{E,c}(i)}{R_{t+1}^{E,c}} - q_t^{k,c}(1-\delta^c) k_{t-1}^{E,c}(i) \Big] \Bigg]. \tag{A.12}$$

The first-order conditions are given by:

1. Consumption:

$$\frac{1}{c_t^{E,c}(i)} = \lambda_t^{E,c}$$

2. Labor:

$$w_t^c = (1-\alpha^c) \frac{p_t^{E,c} y_t^{E,c}(i)}{l_t^{P,c}}$$

3. Capital:

$$\lambda_t^{E,c} \left(q_t^k - \frac{m_E^c E_t\{q_{t+1}^{k,c}(1-\delta^c)\}}{R_{t+1}^{E,c}} \right) = \\ \beta_E^c E_t \left\{ \lambda_{t+1}^{E,c} \left[q_{t+1}^{k,c}(1-\delta^c) + \alpha^c \frac{p_{t+1}^{E,c} y_{t+1}^{E,c}(i)}{k_t^{E,c}} - m_E^c q_{t+1}^{k,c}(1-\delta^c) \right] \right\}$$

Intertemporal Capital Investment Decision

Combining the first-order conditions on the interest rate and capital, the investment Euler equation can be rewritten as:

$$\frac{q_t^{k,c}}{c_t^{E,c}(i)} = -\frac{\chi_t^c}{c_t^{E,c}(i)} + \beta_E^c E_t \left\{ \frac{q_{t+1}^{k,c}(1-\delta^c) + \alpha^c \frac{p_{t+1}^{E,c} y_{t+1}^{E,c}(i)}{k_t^{E,c}(i)} - m_E^c q_{t+1}^{k,c}(1-\delta^c)}{c_{t+1}^{E,c}(i)} \right\}.$$

Following Gambacorta and Signoretti (2014), the definition of the loan-to-value constraint $b_t^{E,c} = \chi_t^c k_t^{E,c} = \frac{m_E^c q_{t+1}^{k,c}(1-\delta^c)}{R_{t+1}^{E,c}} k_t^{E,c}$. Plugging in yields:

$$\frac{q_t^{k,c} - \chi_t^c}{c_t^{E,c}(i)} = \beta_E^c E_t \left\{ \frac{q_{t+1}^{k,c}(1-\delta^c) + \alpha^c \frac{p_{t+1}^{E,c} y_{t+1}^{E,c}(i)}{k_t^{E,c}(i)} - R_{t+1}^{E,c}\chi_t^c}{c_{t+1}^{E,c}(i)} \right\}$$

or:

$$E_t\left\{ \frac{c_{t+1}^{E,c}(i)(q_t^{k,c} - \chi_t^c)}{\beta_E^c c_t^{E,c}(i)} \right\} = E_t\left\{ q_{t+1}^{k,c}(1-\delta^c) + \alpha^c \frac{p_{t+1}^{E,c} y_{t+1}^{E,c}(i)}{k_t^{E,c}(i)} - R_{t+1}^{E,c}\chi_t^c \right\}.$$

Entrepreneurial Net Worth

Net worth of entrepreneurs in the next period is defined as the revenue from sold intermediate goods plus the market value of the capital stock inherited from the previous period minus the cost of labor input and debt:

$$\begin{aligned}
E_t\{NW_{t+1}^c(i)\} &= E_t\{p_{t+1}^{E,c} y_{t+1}^{E,c}(i) - w_{t+1}^c l_{t+1}^{P,c}(i) - R_t^{E,c} b_t^{E,c}(i) + q_{t+1}^{k,c}(1-\delta^c) k_t^{E,c}(i)\} \\
&= E_t\{p_{t+1}^{E,c} y_{t+1}^{E,c}(i) - (1-\alpha^c) p_{t+1}^{E,c} y_{t+1}^{E,c}(i) - R_t^{E,c} b_t^{E,c}(i) + q_{t+1}^{k,c}(1-\delta^c) k_t^{E,c}(i)\} \\
&= E_t\left\{ \left[\alpha^c \frac{p_{t+1}^{E,c} y_{t+1}^{E,c}(i)}{k_t^{E,c}(i)} - R_t^{E,c}\chi_t^c + q_{t+1}^{k,c}(1-\delta^c) \right] k_t^{E,c}(i) \right\},
\end{aligned}$$

which is the period-$t+1$ version of equation 9. Using this expression, the entrepreneurial budget constraint can be simplified, such that

$$E_t\{c_{t+1}^{E,c}(i)\} + q_t^{k,c} k_t^{E,c}(i) = NW_t^c(i) + \chi_t^c k_t^{E,c}(i). \tag{A.13}$$

We guess that next period's entrepreneurial consumption is a fraction of net worth,

$$E_t\{c_{t+1}^{E,c}(i)\} = (1-\beta_E^c) E_t\{NW_{t+1}^c(i)\},$$

and by using equation A.13 and the guess we get

$$\begin{aligned}
& E_t\{c_{t+1}^{E,c}(i)\} = (1-\beta_E^c) E_t\left\{ \left[\alpha^c \frac{p_{t+1}^{E,c} y_{t+1}^{E,c}(i)}{k_t^{E,c}(i)} - R_t^{E,c}\chi_t^c + q_{t+1}^{k,c}(1-\delta^c) \right] \right\} k_t^{E,c}(i) \\
\Leftrightarrow\ & E_t\{c_{t+1}^{E,c}(i)\} = (1-\beta_E^c) E_t\left\{ \left[\frac{E_t\{c_{t+1}^{E,c}(i)\}(q_t^{k,c} - \chi_t^c)}{\beta_E^c c_t^{E,c}(i)} \right] \right\} k_t^{E,c}(i) \\
\Leftrightarrow\ & k_t^{E,c}(i) = \frac{\beta_E^c c_t^{E,c}(i)}{(1-\beta_E^c)(q_t^{k,c} - \chi_t^c)}.
\end{aligned}$$

Plugging into the budget constraint yields the initial guess

$$c_t^{E,c}(i) + q_t^{k,c}\frac{\beta_E^c c_t^{E,c}(i)}{(1-\beta_E^c)(q_t^{k,c}-\chi_t^c)} = NW_t^c + \chi_t^c\frac{\beta_E^c c_t^{E,c}(i)}{(1-\beta_E^c)(q_t^{k,c}-\chi_t^c)}$$

$$\Leftrightarrow c_t^{E,c}(i)\left[1 + q_t^{k,c}\frac{\beta_E^c}{(1-\beta_E^c)(q_t^{k,c}-\chi_t^c)} - \frac{\beta_E^c\chi_t^c}{(1-\beta_E^c)(q_t^{k,c}-\chi_t^c)}\right] = NW_t^c$$

$$\Leftrightarrow c_t^{E,c}(i)\left[\frac{(1-\beta_E^c)(q_t^{k,c}-\chi_t^c) + q_t^{k,c}\beta_E^c - \beta_E^c\chi_t^c}{(1-\beta_E^c)(q_t^{k,c}-\chi_t^c)}\right] = NW_t^c$$

$$\Leftrightarrow c_t^{E,c}(i) = (1-\beta_E^c)NW_t^c$$

depicting equation 10 which can be expressed equivalently as:

$$k_t^{E,c}(i) = \frac{\beta_E^c}{q_t^{k,c}-\chi_t^c}NW_t^c.$$

A.3 Bankers

Each period bankers invest equity into domestic ($n_t^{c,h}$) and foreign banks ($n_t^{c,f}$), and pay dividends div_t^c back to patient households. Equity investment and dividends are financed by bankers' net worth $n_t^{b,c}$. Following Gertler and Kiyotaki (2011), we guess and verify that the value function is linear in net worth, $V_t^{b,c} = \nu_t^c n_t^{b,c}$. Thus the maximization can be written in recursive form as:

$$n_t^{b,c}\nu_t^c = \max_{e_t^{aggr,c},div_t^c}\left\{div_t^c + E_t\{\Lambda_{t+1}^c[(1-\theta_b^c) + \theta_b^c\nu_{t+1}^c]n_{t+1}^{b,c}\}\right\} \tag{A.14}$$

$$s.t. \begin{cases} e_t^{aggr,c} + div_t^c = n_t^{b,c} \\ e_t^{aggr,c} = n_t^{c,c} + n_t^{c,\neg c} \\ n_{t+1}^{b,c} = \rho_{t+1}^c n_t^{c,c} + \rho_{t+1}^{\neg c} n_t^{c,\neg c} \\ div_t^c \geq 0. \end{cases}$$

1. Shadow price of equity for bankers:
   The dividend constraint binds in equilibrium, since it is not optimal to transfer dividends prior to retirement ($div_t^c = 0$). Thus, all net worth is invested in home and foreign banks, $e_t^{aggr,c} = n_t^{b,c}$. Using the the budget constraint

$$n_{t+1}^{b,c} = \rho_{t+1}^c n_t^{c,c} + \rho_{t+1}^{\neg c} n_t^{c,\neg c}$$

   in the value function of bankers yields

$$n_t^{b,c}\nu_t^c = E_t\{\Lambda_{t+1}^c\left[(1-\theta_b^c) + \theta_b^c\nu_{t+1}^c\right](\rho_{t+1}^c n_t^{c,c} + \rho_{t+1}^{\neg c} n_t^{c,\neg c})\}$$

$$\nu_t^c = E_t\left\{\Lambda_{t+1}^{b,c}(\rho_{t+1}^c\frac{n_t^{c,c}}{n_t^{b,c}} + \rho_{t+1}^{\neg c}\frac{n_t^{c,\neg c}}{n_t^{b,c}})\right\}$$

$$\nu_t^c = E_t\{\Lambda_{t+1}^{b,c}[\zeta_t^{n,c}\rho_{t+1}^c + (1-\zeta_t^{n,c})\rho_{t+1}^{\neg c}]\}$$

where $\Lambda^{b,c}_{t+1} = \beta^c_p \frac{\lambda^c_{s,t+1}}{\lambda^c_{s,t}} \left[(1-\theta^c_b) + \theta^c_b \nu^c_{t+1}\right]$, and $\zeta^{n,c}_t = \frac{n^{c,c}_t}{n^{b,c}_t}$ denotes the degree of home bias for bankers' equity investment decisions.

2. Law of motion for bankers' net worth:

   The law of motion for net worth is given by:

$$\begin{aligned} n^{b,c}_{t+1} &= \theta^c_b \left(n^{c,c}_t \rho^c_{t+1} + n^{c,\neg c}_t \rho^{\neg c}_{t+1}\right) + \chi_b(1-\theta^c_b)(n^{c,c}_t \rho^c_{t+1} + n^{c,\neg c}_t \rho^{\neg c}_{t+1}) \\ &= [\theta^c_b + \chi_b(1-\theta^c_b)](n^{c,c}_t \rho^c_{t+1} + n^{c,\neg c}_t \rho^{\neg c}_{t+1}) \end{aligned}$$

A.4 Corporate Banks

Corporate banks receive $e^c_t = n^{c,c}_t + RER_t n^{\neg c,c}_t = \zeta^c_e e^c_t + (1-\zeta^c_e) e^c_t$ units of equity from domestic and foreign investors. We denote the equity home bias on banks' balance sheets as ω^c_e. Banks maximize net present value (NPV), subject to a balance sheet constraint and a capital requirement constraint:

$$\max_{d^c_t, a^c_t} \int_0^\infty \Lambda^{tot,c}_{t+1} \max\{\omega^c_{t+1} R^{a,c}_{t+1} a^c_t - R^{c,d}_t d^c_t - \tau^{DI,c}_t, 0\} \mathrm{d}F_c(\omega^c_{t+1}) \\ - \zeta^c_e \nu^c_t e^c_t - (1-\zeta^c_e)\nu^{\neg c}_t e^c_t \quad \text{(A.15)}$$

$$s.t. \begin{cases} a^c_t = d^c_t + e^c_t \\ e^c_t \geq \phi^c_t a^c_t \\ a^c_t = b^{E,c}_t + q^{k,c}_{t+1} b^{g,c}_t. \end{cases}$$

Banks discount their expected NPV by weighting home and domestic bankers' discount factor with the corresponding amount of equities:

$$\begin{aligned} \Lambda^{tot,c}_{t+1} &= \frac{\zeta^c_e \Lambda^{b,c}_{t+1} e^c_t + (1-\zeta^c_e)\Lambda^{b,\neg c}_{t+1} e^c_t}{e^c_t} \\ &= \zeta^c_e \Lambda^{b,c}_{t+1} + (1-\zeta^c_e)\Lambda^{b,\neg c}_{t+1}. \end{aligned}$$

Each bank is hit by an idiosyncratic asset return shock ω^c_{t+1} that follows a log normal distribution. The equity investments $\zeta^c_e e^c_t$ and $(1-\zeta^c_e)e^c_t$ are valued at equilibrium opportunity cost ν^c_t and $\nu^{\neg c}_t$. If the asset return is sufficiently low after an adverse realization of the idiosyncratic shock, the bank defaults on its debt and obtains zero payoff.

Furthermore, the bank earns the average rate of return $R_t^{a,c}$ on total assets a_t^c. The average return depends on the return on corporate loans and government bonds:

$$
\begin{aligned}
R_{t+1}^{a,c} a_t^c &= R_{t+1}^{E,c} b_t^{E,c} + R_{t+1}^{gov,c} q_{t+1}^{k,c} b_t^{g,c} \\
\Leftrightarrow R_{t+1}^{a,c} &= \zeta_t^{a,c} R_{t+1}^{E,c} + (1-\zeta_t^{a,c}) R_{t+1}^{gov,c},
\end{aligned}
$$

with $\zeta_t^{a,c} = \frac{b_t^{E,c}}{a_t}$ and $R_{t+1}^{gov,c} = R_t^{rfr,c} + \phi_{debt}^c (b_t^{g,c} - \overline{b}^{g,c})^2$, with the loan returns given by equation A.11. Since debt financing is always cheaper than equity financing, the capital constraint always binds:

$$
\begin{aligned}
a_t^c &= b_t^{E,c} + q_{t+1}^{k,c} b_t^{g,c} = \frac{e_t^c}{\phi_t^c} \\
d_t^c &= (1-\phi_t^c)\frac{e_t^c}{\phi_t^c}.
\end{aligned}
$$

Banks can default on their debt if the net asset return turns negative. Then, the constraint $\overline{\omega}_{t+1}^c R_{t+1}^{a,c} a_t^c - R_t^d d_t^c - \tau_t^{DI,c} = 0$ yields the threshold of bank default, $\overline{\omega}_{t+1}^c$:

$$
\overline{\omega}_{t+1}^c = \frac{R_t^{d,c} d_t^c}{R_{t+1}^{a,c} a_t^c} + \frac{\tau_t^{DI,c}}{R_{t+1}^{a,c} a_t^c} = (1-\phi_t^c)\left(\frac{R_t^{d,c}}{R_{t+1}^{a,c}} + \frac{\tau_t^{DI,c}}{R_{t+1}^{a,c} d_t^c}\right).
$$

The bank problem can be rewritten by replacing a_t^c and d_t^c and by splitting the integral:

$$
\begin{aligned}
NPV_{b,t} = &\int_0^{\overline{\omega}_{t+1}^c} \Lambda_{t+1}^{tot,c} 0 \mathrm{d}F_c(\omega_{t+1}^c) \\
&+ \int_{\overline{\omega}_{t+1}^c}^{\infty} \Lambda_{t+1}^{tot,c} \{\omega_{t+1}^c R_{t+1}^{a,c} a_t^c - (R_t^{d,c} + \tau_t^{DI,c}) d_t^c\} \mathrm{d}F_c(\omega_{t+1}^c) - [\zeta_e^c \nu_t^c + (1-\zeta_e^c)\nu_t^{\neg c}] e_t^c \\
&= \int_{\overline{\omega}_{t+1}^c}^{\infty} \Lambda_{t+1}^{tot,c} \left\{ \omega_{t+1}^c R_{t+1}^{a,c} \frac{e_t^c}{\phi_t^c} - (R_t^{d,c} + \tau_t^{DI,c})(1-\phi_t^c)\frac{e_t^c}{\phi_t^c} \right\} \mathrm{d}F_c(\omega_{t+1}^c) - \\
&- [\zeta_e^c \nu_t^c + (1-\zeta_e^c)\nu_t^{\neg c}] e_t^c \\
&= \left(\Lambda_{t+1}^{tot,c} \frac{R_{t+1}^{a,c}}{\phi_t^c} \int_{\overline{\omega}_{t+1}^c}^{\infty} \{\omega_{t+1}^c - \overline{\omega}_{t+1}^c\} \mathrm{d}F_c(\omega_{t+1}^c) - \zeta_e^c \nu_t^c - (1-\zeta_e^c)\nu_t^{\neg c} \right) e_t^c,
\end{aligned}
$$

where the integral can be written as:[31]

$$
\begin{aligned}
&\int_{\overline{\omega}^c_{t+1}}^{\infty} \omega^c_{t+1} \mathrm{d}F_c(\omega^c_{t+1}) - \int_{\overline{\omega}^c_{t+1}}^{\infty} \overline{\omega}^c_{t+1} \mathrm{d}F_c(\omega^c_{t+1}) \\
\Leftrightarrow & E_t\{\omega^c_{t+1} | \omega^c_{t+1} \geq \overline{\omega}^c_{t+1}\}\mathbb{P}\{\omega^c_{t+1} \geq \overline{\omega}^c_{t+1}\} - \overline{\omega}^c_{t+1}\mathbb{P}\{\omega^c_{t+1} \geq \overline{\omega}^c_{t+1}\} \\
\Leftrightarrow & \frac{\left[1 - \Phi\left(\frac{\ln(\overline{\omega}^c_t) - \frac{(\sigma_c z^{b,c}_t)^2}{2}}{\sigma_c z^{b,c}_t}\right)\right]}{\left[1 - \Phi\left(\frac{\ln(\overline{\omega}^c_t) + \frac{(\sigma_c z^{b,c}_t)^2}{2}}{\sigma_c z^{b,c}_t}\right)\right]} \left[1 - \Phi\left(\frac{\ln(\overline{\omega}^c_t) + \frac{(\sigma_c z^{b,c}_t)^2}{2}}{\sigma_c z^{b,c}_t}\right)\right] - \overline{\omega}^c_{t+1}\left[1 - \Phi\left(\frac{\ln(\overline{\omega}^c_t) + \frac{(\sigma_c z^{b,c}_t)^2}{2}}{\sigma_c z^{b,c}_t}\right)\right] \\
\Leftrightarrow & 1 - \Phi\left(\frac{\ln(\overline{\omega}^c_t) - \frac{(\sigma_c z^{b,c}_t)^2}{2}}{\sigma_c z^{b,c}_t}\right) - \overline{\omega}^c_{t+1}\left[1 - \Phi\left(\frac{\ln(\overline{\omega}^c_t) + \frac{(\sigma_c z^{b,c}_t)^2}{2}}{\sigma_c z^{b,c}_t}\right)\right] \\
\Leftrightarrow & 1 - \Gamma_c(\overline{\omega}^c_{t+1}).
\end{aligned}
$$

Due to the contracting problem between patient households and banks, $1 - \Gamma_c(\overline{\omega}^c_{t+1})$ represents the net share the corporate bank receives, and $\Gamma_c(\overline{\omega}^c_{t+1})$ determines the patient household's gross share. Finally, banks are only willing to provide loans as long as the NPV from intermediating funds is positive:

$$
E_t\left\{\Lambda^{tot,c}_{t+1}[1 - \Gamma_c(\overline{\omega}^c_{t+1})]\frac{R^{a,c}_{t+1}}{\phi^c_t}\right\} \geq \zeta^c_e \nu^c_t + (1 - \zeta^c_e)\nu^{\neg c}_t.
$$

In equilibrium, the above condition holds with equality to avoid an infinite supply of loans. By definition, the return on bank equity is given by $\rho^c_{t+1} = \left(1 - \Gamma_c(\overline{\omega}^c_{t+1})\right)\frac{R^{a,c}_{t+1}}{\phi^c_t}$. Consequently, the opportunity cost of equity funding is pinned down in equilibrium by the following condition:

$$
E_t\{\Lambda^{tot,h}_{t+1}\rho^h_{t+1}\} = \zeta^h_e \nu^h_t + (1 - \zeta^h_e)\nu^f_t
$$

and symmetrically by

$$
E_t\{\Lambda^{tot,f}_{t+1}\rho^f_{t+1}\} = \zeta^f_e \nu^f_t + (1 - \zeta^f_e)\nu^h_t.
$$

Finally, the quarterly default rate of banks can be defined as:

$$
\psi^c_t = \Phi\left(\frac{\ln(\overline{\omega}^c_t) + \frac{(\sigma_c z^{b,c}_t)^2}{2}}{\sigma_c z^{b,c}_t}\right).
$$

[31]See section A.4.1.

A.4.1 Idiosyncratic Shocks to Returns

The idiosyncratic shocks in the model follow a log-normal distribution with $\ln(\omega_t^c) \sim N(-0.5\sigma_c^2, \sigma_c^2)$:

$$E\{\omega_t^c | \omega_t^c \geq \overline{\omega}_t^c\} = e^{-\frac{(\sigma_c z_t^{b,c})^2}{2} + \frac{(\sigma_c z_t^{b,c})^2}{2}} \frac{1 - \Phi\left(\frac{\ln(\overline{\omega}_t^c) + \frac{(\sigma_c z_t^{b,c})^2}{2} - (\sigma_c z_t^{b,c})^2}{\sigma_c z_t^{b,c}}\right)}{1 - \Phi\left(\frac{\ln(\overline{\omega}_t^c) + \frac{(\sigma_c z_t^{b,c})^2}{2}}{\sigma_c z_t^{b,c}}\right)}$$

$$= \frac{1 - \Phi\left(\frac{\ln(\overline{\omega}_t^c) - \frac{(\sigma_c z_t^{b,c})^2}{2}}{\sigma_c z_t^{b,c}}\right)}{1 - \Phi\left(\frac{\ln(\overline{\omega}_t^c) + \frac{(\sigma_c z_t^{b,c})^2}{2}}{\sigma_c z_t^{b,c}}\right)}$$

The expected share of deposits ending up in default in the next period is defined as:

$$\begin{aligned}
G(\omega_{t+1}^c) &= E\{\omega_{t+1}^c | \omega_{t+1}^c < \overline{\omega}_{t+1}^c\} \mathbb{P}\{\omega_{t+1}^c < \overline{\omega}_{t+1}^c\} \\
&= \int_0^{\overline{\omega}_{t+1}^c} \omega_{t+1}^c f(\omega_{t+1}^c) d\omega_{t+1}^c \int_0^{\overline{\omega}_{t+1}^c} f(\omega_{t+1}^c) d\omega_{t+1}^c \\
&= \frac{\Phi\left(\frac{\ln(\overline{\omega}_t^c) - \frac{(\sigma_c z_t^{b,c})^2}{2}}{\sigma_c z_t^{b,c}}\right)}{\Phi\left(\frac{\ln(\overline{\omega}_t^c) + \frac{(\sigma_c z_t^{b,c})^2}{2}}{\sigma_c z_t^{b,c}}\right)} \Phi\left(\frac{\ln(\overline{\omega}_t^c) + \frac{(\sigma_c z_t^{b,c})^2}{2}}{\sigma_c z_t^{b,c}}\right) \\
&= \Phi\left(\frac{\ln(\overline{\omega}_t^c) - \frac{(\sigma_c z_t^{b,c})^2}{2}}{\sigma_c z_t^{b,c}}\right).
\end{aligned}$$

The deposit contract guarantees that in the no-default case ($\omega_{t+1}^c \geq \overline{\omega}_{t+1}^c$), the bank pays a fixed rate of asset returns $\frac{\overline{\omega}_t^c R_t^{a,c}}{1-\phi_{t-1}^c} - \tau_{t-1}^{DI,c}$ to the households. The bank keeps the difference $(\omega_{t+1}^c - \overline{\omega}_{t+1}^c)\frac{R_t^{a,c}}{1-\phi_{t-1}^c} - \tau_{t-1}^{DI,c}$ for herself. In case of default ($\omega_{t+1}^c < \overline{\omega}_{t+1}^c$), the bank does not receive any return and the household pays a fraction μ_c for recovery. Thus, the household payoff is $(1-\mu_c)\left(\frac{\overline{\omega}_t^c R_t^{a,c}}{1-\phi_{t-1}^c} - \tau_{t-1}^{DI,c}\right)$. The gross share of deposits going to patient households is defined as:

$$\begin{aligned}\Gamma(\overline{\omega}_t^c) &= \int_0^{\overline{\omega}_t^c} \omega_t^c f(\omega_t^c) d\omega_t^c + \overline{\omega}_t^c \int_{\overline{\omega}_t^c}^{\infty} f(\omega_t^c) d\omega_t^c \\ &= E\{\omega_t^c | \omega_t^c < \overline{\omega}_t^c\} \mathbb{P}\{\omega_t^c < \overline{\omega}_t^c\} + \overline{\omega}_t^c \mathbb{P}\{\omega_t^c \geq \overline{\omega}_t^c\} \\ &= \frac{\Phi\left(\frac{\ln(\overline{\omega}_t^c) - \frac{(\sigma_c z_t^{b,c})^2}{2}}{\sigma_c z_t^{b,c}}\right)}{\Phi\left(\frac{\ln(\overline{\omega}_t^c) + \frac{(\sigma_c z_t^{b,c})^2}{2}}{\sigma_c z_t^{b,c}}\right)} \Phi\left(\frac{\ln(\overline{\omega}_t^c) + \frac{(\sigma_c z_t^{b,c})^2}{2}}{\sigma_c z_t^{b,c}}\right) + \overline{\omega}_t^c \left[1 - \Phi\left(\frac{\ln(\overline{\omega}_t^c) + \frac{(\sigma_c z_t^{b,c})^2}{2}}{\sigma_c z_t^{b,c}}\right)\right] \\ &= \Phi\left(\frac{\ln(\overline{\omega}_t^c) - \frac{(\sigma_c z_t^{b,c})^2}{2}}{\sigma_c z_t^{b,c}}\right) + \overline{\omega}_t^c \left[1 - \Phi\left(\frac{\ln(\overline{\omega}_t^c) + \frac{(\sigma_c z_t^{b,c})^2}{2}}{\sigma_c z_t^{b,c}}\right)\right].\end{aligned}$$

Due to positive monitoring costs, the net share of returns from a diversified deposit portfolio patient households receive is given by:

$$\Gamma(\overline{\omega}_t^c) - \mu_c G(\omega_t^c) = \underbrace{\left(1 - \mu_c\right) \Phi\left(\frac{\ln(\overline{\omega}_t^c) - \frac{(\sigma_c z_t^{b,c})^2}{2}}{\sigma_c z_t^{b,c}}\right)}_{\text{share of return under default}} + \underbrace{\overline{\omega}_t^c \left[1 - \Phi\left(\frac{\ln(\overline{\omega}_t^c) + \frac{(\sigma_c z_t^{b,c})^2}{2}}{\sigma_c z_t^{b,c}}\right)\right]}_{\text{share of return under no default}}.$$

With the threshold going to infinity in the limit, the net share of returns converges to $\lim_{\overline{\omega}_{t+1}^c \to \infty} \Gamma(\overline{\omega}_t^c) - \mu_c G(\omega_{t+1}^c) = 1 - \mu_c$.

A.5 National Deposit Insurance Fund

The national deposit insurance guarantees some fraction κ_t^c of deposits by building up a fund that compensates depositors in case of bank default. The deposit insurance fund balance is given by

$$DI_{t+1}^c = DI_t^c + \tau_t^{DI,c} - \kappa_t^c \Omega_{t+1}^c \tag{A.16}$$

where a share κ_t^c of the total default costs Ω_t^c is insured by the national DI in each country. Banks pay a contribution $\tau_t^{DI,c}$ to the fund, and the fund capital target is set relative to total outstanding deposits in the steady state:

$$DI_t^{target,c} = \gamma_{DI}^c \overline{d^c}. \tag{A.17}$$

The costs of deposit default in each country are defined as the difference between forgone return on deposits, $R_{t-1}^{d,c} d_{t-1}^c$, and the share $(1-\mu^c)$ of gross assets $\omega_t^c R_t^{a,c} a_{t-1}^c$ that can be recovered, net of the contributions to the national DI:

$$\Omega_t^c = \int_0^{\overline{\omega}_t^c} \{R_{t-1}^{d,c} d_{t-1}^c - (1 - \mu_c) \omega_t^c R_t^{a,c} a_{t-1}^c + \tau_{t-1}^{DI}\} f(\omega_t^c) d\omega_{t-1}^c. \tag{A.18}$$

From the banks' balance sheet and capital requirement constraint we get

$$d_{t-1}^c = (1-\phi_{t-1}^c)a_{t-1}^c, \tag{A.19}$$

and from the default threshold:

$$R_{t-1}^{d,c} = \frac{\overline{\omega}_t^c R_t^{a,c}}{1-\phi_{t-1}^c} - \frac{\tau_{t-1}^{DI,c} R_t^{a,c}}{R_t^{a,c} d_{t-1}^c}, \tag{A.20}$$

we can rewrite the costs of default as:

$$\begin{aligned}
\Omega_t^c &= \int_0^{\overline{\omega}_t^c} \left\{ \left(\frac{\overline{\omega}_t^c}{1-\phi_{t-1}^c} - \frac{\tau_{t-1}^{DI,c}}{R_t^{a,c} d_{t-1}^c} \right) R_t^{a,c}(1-\phi_{t-1}^c)a_{t-1}^c - (1-\mu_c)\omega_t^c R_t^{a,c} a_{t-1}^c + \tau_{t-1}^{DI} \right\} f(\omega_t^c) d\omega_t^c \\
&= \int_0^{\overline{\omega}_t^c} \left\{ \overline{\omega}_t^c - \frac{\tau_{t-1}^{DI,c}(1-\phi_{t-1}^c)}{R_t^{a,c} d_{t-1}^c} - (1-\mu_c)\omega_{t-1}^c + \frac{\tau_{t-1}^{DI}(1-\phi_{t-1}^c)}{R_t^{a,c} d_{t-1}^c} \right\} f(\omega_t^c) d\omega_t^c R_t^{a,c} a_{t-1}^c \\
&= \left[\int_0^{\overline{\omega}_t^c} \overline{\omega}_t^c f(\omega_t^c) d\omega_t^c - (1-\mu_c) \int_0^{\overline{\omega}_t^c} \omega_t^c f(\omega_t^c) d\omega_t^c \right] R_t^{a,c} a_{t-1}^c \\
&= \left[\overline{\omega}_t^c \Phi\left(\frac{\ln(\overline{\omega}_t^c + \frac{(\sigma_c z_t^{b,c})^2}{2})}{\sigma_c z_t^{b,c}} \right) - (1-\mu_c)\Phi\left(\frac{\ln(\overline{\omega}_t^c) - (\frac{(\sigma_c z_t^{b,c})^2}{2})}{\sigma_c z_t^{b,c}} \right) \right] R_t^{a,c} a_{t-1}^c \\
&= \left[\overline{\omega}_t^c \Phi\left(\frac{\ln(\overline{\omega}_t^c + \frac{(\sigma_c z_t^{b,c})^2}{2})}{\sigma_c z_t^{b,c}} \right) - \Phi\left(\frac{\ln(\overline{\omega}_t^c) - (\frac{(\sigma_c z_t^{b,c})^2}{2})}{\sigma_c z_t^{b,c}} \right) + \mu_c \Phi\left(\frac{\ln(\overline{\omega}_t^c) - (\frac{(\sigma_c z_t^{b,c})^2}{2})}{\sigma_c z_t^{b,c}} \right) \right] R_t^{a,c} a_{t-1}^c \\
&= \left[\overline{\omega}_t^c - \overline{\omega}_t^c + \overline{\omega}_t^c \Phi\left(\frac{\ln(\overline{\omega}_t^c + \frac{(\sigma_c z_t^{b,c})^2}{2})}{\sigma_c z_t^{b,c}} \right) - \Phi\left(\frac{\ln(\overline{\omega}_t^c) - (\frac{(\sigma_c z_t^{b,c})^2}{2})}{\sigma_c z_t^{b,c}} \right) + \mu_c G(\omega_{t+1}^c) \right] R_t^{a,c} a_{t-1}^c \\
&= [\overline{\omega}_t^c - \Gamma(\overline{\omega}_t^c) + \mu_c G(\omega_{t+1}^c)] R_t^{a,c} a_{t-1}^c.
\end{aligned}$$

Finally, we get:

$$\Omega_t^c = [\overline{\omega}_t^c - \Gamma_c(\overline{\omega}_t^c) + \mu_c G_c(\overline{\omega}_t^c)] \frac{R_t^{a,c}}{1-\phi_{t-1}^c} d_{t-1}^c. \tag{A.21}$$

Banks contribute to the fund in each period by the amount $\tau_{t-1}^c d_t^c$, and the contribution rate is given by the following rule:

$$\tau_t^{DI,c} = \overline{\tau}^{DI,c} + \chi_\tau^c [\overline{DI}^{target,c} - E_t\{DI_{t+1}^c\}]. \tag{A.22}$$

Furthermore, whenever national fund capital is below target, the share of covered deposits is reduced:

$$\kappa_t^c = \overline{\kappa}^c - \chi_\kappa^c [\overline{DI}^{target,c} - DI_{t+1}^c]. \tag{A.23}$$

A.6 Capital-Producing Firms

Competitive capital producers create new capital, repair depreciated capital, and are owned by saving households. Firms maximize profits by choosing investment I_t^c,

$$\max_{I_t^c} E_t \sum_{\tau=t}^{\infty} (\beta_p^c)^\tau \frac{\Lambda_{\tau+1}^c}{\Lambda_\tau^c} \left\{ (q_\tau^{k,c} - 1) I_\tau - f^c \left(\frac{I_\tau^c}{I_{\tau-1}^c} \right) I_\tau^c \right\}, \tag{A.24}$$

where $f(\cdot)^c$ denotes the functional form of investment adjustment costs, which, following Christiano et al. (2005), is given by:

$$\frac{\psi_i^c}{2} \left(\frac{I_t^c}{I_{t-1}^c} - 1 \right)^2 \tag{A.25}$$

ψ_i^c measures the inverse elasticity of net investments to changes in the price of capital $q_t^{k,c}$. The first order condition defines the price of capital as follows:

$$q_t^{k,c} = 1 + f_t^c(\cdot) + f_t^{c\prime}(\cdot) \frac{I_t^c}{I_{t-1}^c} - \beta_p^c E_t \left\{ \frac{\Lambda_{t+1}^c}{\Lambda_t^c} {f_{t+1}^c}'(\cdot) \left(\frac{I_{t+1}^c}{I_t^c} \right)^2 \right\} \tag{A.26}$$

A.7 Market Clearing

A.7.1 International Goods Market

In each country perfectly competitive firms produce the final demand by aggregating a continuum of domestically produced an imported goods for households, entrepreneurs and capital producer. The aggregate demand bundle for domestic households, entrepreneurs and capital producers is compound by the following technology:[32]

$$x_t^c = \left[(\zeta^c)^{\frac{1}{\eta^c}} (x_t^{c,c})^{\frac{\eta^c - 1}{\eta^c}} + (1 - \zeta^c)^{\frac{1}{\eta^c}} (x_t^{c,\neg c})^{\frac{\eta^c - 1}{\eta^c}} \right]^{\frac{\eta^c}{\eta^c - 1}}, \tag{A.27}$$

where x_t^c is a placeholder for household and entrepreneurs consumption demand ($c_t^{p,c}$, $c_t^{E,c}$) and capital producers investment demand (I_t^c). $\zeta_c > 0$ measures the degree of openness of the final good, the fraction of goods produced in the foreign economy. η^c denotes the elasticity of substitution between home- and foreign-produced goods. From the profit maximization of the final good produces we can derive the optimal demand functions for home and imported goods:

$$x_t^{c,c} = \zeta^c (p_t^{e,c})^{-\eta^c} x_t^c \tag{A.28}$$

[32]From the perspective of the foreign economy the consumption bundle aggregation is structurally equal.

$$x_t^{c,\neg c} = (1-\zeta^h)(p_t^{e,c}T_t)^{-\eta^c} x_t^c \tag{A.29}$$

Following Benigno (2004), the terms of trade are foreign producer prices relative to domestic producer prices: $T_t = \frac{P_t^{e,f}}{P_t^{e,h}}$. National government consumption g_t is assumed to be produced only by national firms. The clearing condition guarantees that the supply of domestically produced goods is equal to domestic and foreign demand.

The real exchange rate can be defined with the help of the terms of trade and the relative consumer prices in both countries:

$$RER_t = T_t \frac{p_t^{e,h}}{p_t^{e,f}}. \tag{A.30}$$

In both regions the goods markets clearing condition hold in equilibrium:

$$y_t^{E,c} = Y_t^c = \zeta^c (p_t^{e,c})^{-\sigma^c} c_t^c + g_t^c + (1-\zeta^{\neg c}) \left(\frac{p_t^{e,\neg c}}{T_t} \right)^{-\sigma^{\neg c}} c_t^{\neg c} \tag{A.31}$$

where $c_t^c = c_t^{P,c} + c_t^{E,c} + I_t^c$ denotes the aggregate demand for consumption and investment goods of domestic households and entrepreneurs and $c_t^{\neg c}$ denotes the aggregate demand of foreign households and entrepreneurs. The trade balance - measured in domestic prices - is defined as difference between real exports and real imports:

$$tb_t = ex_t^h + T_t im_t^h, \tag{A.32}$$

with $ex_t^h = c_t^{P,fh} + c_t^{E,fh} + I_t^{fh}$ and $im_t^h = c_t^{P,hf} + c_t^{E,hf} + I_t^{hf}$.

A.7.2 International Financial Market

Market clearing on the international financial market implies that the supplied equity from bankers have to satisfied the demand for equity for both domestic and foreign banks:

$$e_t^h = n_t^{h,h} + \frac{1}{RER_t} n_t^{f,h}, \tag{A.33}$$

$$e_t^f = n_t^{f,f} + RER_t n_t^{h,f}. \tag{A.34}$$

Further, since bankers will not pay dividends prior retirement, invested equity has to match total bankers net worth:

$$n_t^{b,h} = n_t^{h,h} + n_t^{h,f}, \tag{A.35}$$

$$n_t^{b,f} = n_t^{f,f} + n_t^{f,h}. \tag{A.36}$$

A.7.3 Shock Processes

Household Preference Shock:

$$z_t^{c,c} = (1 - \rho_c^c)\overline{z}^{c,c} + \rho_c^c z_{t-1}^{c,c} + \epsilon_t^c \tag{A.37}$$

Productivity Shock:

$$a_t^{E,c} = (1 - \rho_a^c)\overline{a}^{E,c} + \rho_a^c a_{t-1}^{E,c} + \epsilon_t^a \tag{A.38}$$

Bank Risk Shock:

$$z_t^{b,c} = (1 - \rho_b^c)\overline{z}^{b,c} + \rho_b^c z_{t-1}^{b} + \epsilon_t^b \tag{A.39}$$

Government Consumption Shock:

$$g_t^c = (1 - \rho_g^c)\overline{g}^c + \rho_g^c g_{t-1}^c + \epsilon_t^g \tag{A.40}$$

B Appendix: Data

Real GDP: Real gross domestic product, euro area 19 (fixed composition) and Germany, deflated using GDP deflator (index), calendar and seasonally adjusted data (National accounts, Main aggregates (Eurostat ESA2010)).

Government consumption: Real government consumption, euro area and Germany, deflated using GDP deflator (index=2015), calendar and seasonally adjusted data (National accounts, Main aggregates (Eurostat ESA2010)).

Real exports of goods and services: Exports of goods and services, Germany, chain-linked volumes, calendar and seasonally adjusted data (national accounts, main aggregates (Eurostat ESA2010)).

Real imports of goods and services: Imports of goods and services, Germany, chain-linked volumes, calendar and seasonally adjusted data (national accounts, main aggregates (Eurostat ESA2010)).

Current account balance: Current account balance as percentage of GDP, euro area 19 (fixed composition) and Germany (OECD Main Economic Indicators data base).

Real business investment: Real gross fixed capital formation (GFCF) of non-financial corporations, euro area 19 (fixed composition), deflated using GDP deflator (index=2015), calendar and seasonally adjusted data (national accounts, main aggregates (Eurostat ESA2010)).

Total employment: Total employment in persons, total economy, all activities, euro area 19 (fixed composition) and Germany, calendar and seasonally adjusted data (national accounts, employment (Eurostat ESA2010)).

GDP Deflator: Euro area: Price level is based on HICP inflation, index year 2015, euro area 19 (fixed composition), calendar and seasonally adjusted data (Indices of Consumer prices, (Eurostat)). Germany: Price level is based on HICP inflation, index year 2015, calendar and seasonally adjusted data (Statistisches Bundesamt).

Total government bond holdings: Euro area and Germany: Holdings by euro area MFIs (excluding central banks) of short- and long-term maturity debt securities issued by general government resident in EU countries, sample 1997:Q4 to 2019:Q1, changing composition, deflated using GDP deflator (index=2015), (national central banks, balance sheet items ECB SDW).

Corporate bank loans: Real outstanding amounts of commercial bank (MFIs excluding ESCB) loans to non-financial corporations, euro area (changing composition), deflated using HICP, calendar and seasonally adjusted data.

Corporate bank deposits: Real deposits placed by euro area households (overnight deposits, with agreed maturity up to two years, redeemable with notice up to 3 months), outstanding amounts, euro area (changing composition), deflated using HICP, calendar and seasonally adjusted data.

Bank equity holdings by home and foreign investors: Positions held by domestic shareholder to total positions held by euro area residents, all bank entities in the euro area and Germany directly supervised by the ECB (Shareholders Report, Thomson Reuters Eikon).

Share of deposits covered by deposit insurance: Share of deposits covered by national insurance scheme, annual data 2011 to 2015, euro area 19 (GDP-weighted average) and Germany (JRC European Union Banking Statistics).

Bank default rates: Expected bank default based on credit default swap spreads. Expected defaults are calculated by authors using the CDS spreads and US 5y-treasury yields as a proxy for the risk-free rate. We include all bank entities in the euro area and Germany directly supervised by the ECB (Datastream for CDS spread).

Bank equity returns: Return on equity in percent, deposit takers, euro area 19 (Financial Soundness Indicators, IMF).

Bank price-to-book ratios: Euro area: Price-to-book ratio for European banks based on the "EURO STOXX Banks" index, sample 1998:Q4 to 2019:Q1 (Bloomberg). Germany: Price-to-book ratio of German banks based on (1) a weighted average of P/B ratios of German banks (before 2003:Q1) and (2) the "DAX SECTOR BANKS" index, sample 1999:Q4 to 2019:Q1 (from 2003:Q1, both Bloomberg).

Interest rate on corporate bank loans: Annualized agreed rate (AAR) on commercial bank loans to non-financial corporations with maturity over one year, euro area (changing composition), new business coverage. Before 2003: Retail interest Rates Statistics (RIR), not harmonized data. Starting 2003:Q1: MFI Interest Rate Statistics (MIR), harmonized data.

Interest rate on corporate bank deposits: Commercial bank interest rates on household deposits, weighted rate from rates on overnight deposits, with agreed maturity up to two years, redeemable at short notice (up to three months), euro area (changing composition), new business coverage. Before 2003: Retail interest Rates Statistics (RIR), not harmonized data. Starting 2003:Q1: MFI Interest Rate Statistics (MIR), harmonized data.

United States 5-year yields on treasuries: 5-year nominal yields on US treasuries. Proxy for the nominal risk-free rate used in the calculation of bank default rates from CDS spreads. (Board Of Governors of the Federal Reserve System).

United States real long-term treasury yields: Long-term real rate average on outstanding TIPS with maturities of more than 10 years (US Department of the Treasury).