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Marius Clemens, Stefan Gebauer, Tobias König

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

Tel. +49 (30) 897 89-0
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The Macroeconomic Effects of a European Deposit (Re-)Insurance Scheme

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

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Abstract

Recent proposals for a still missing European deposit insurance scheme (EDIS) argue in favor of a reinsurance framework. In this paper, we use a regime-switching open-economy DSGE model with bank default to assess the relative efficiency of such a scheme. We find that reinsurance by EDIS is more effective in stabilizing real activity, credit, and welfare than a national fiscal backstop. We demonstrate that risk-weighted contributions to EDIS are welfare-beneficial for depositors and discuss trade-offs policymakers face during the implementation of EDIS. We also find that macroprudential regulation and EDIS can complement each other and that EDIS can prevent bank runs under certain conditions.

JEL: E61, F42, F45, G22, G28

Keywords: Banking Union; Deposit Insurance; Risk-Sharing

[*]DIW Berlin. E-mail address: MClemens@diw.de.

[†]European Central Bank. E-mail address: stefan.gebauer@ecb.europa.eu.

[‡]University of Bonn. E-mail address: tkoenig@uni-bonn.de.

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1 Introduction

The first two pillars of the European Banking Union have already been implemented. However, its third pillar, a European deposit insurance scheme (EDIS), is not yet in place. 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 featuring national banking sectors prone to defaults. 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 DI can become depleted and either national governments or EDIS have to step in to insure bank deposits. To model the two states in which national DI can be active or depleted explicitly, 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 an adverse bank risk shock in the home country, we find that EDIS performs better than the national fiscal backstop or the no-backstop scenario in

[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).

terms of stabilizing the affected country's real activity and financial intermediation. The drop in investment, consumption, and intermediated loans is around 20-35 percent lower in the trough of the crisis with EDIS in the home economy compared to either a fiscal or no backstop.

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 under fiscal reinsurance. Under EDIS, such an increase in government debt is avoided. But there are also disadvantages of EDIS compared with a fiscal backstop: First, banks have to contribute both to the national DI and EDIS, such that the total burden for banks is higher with EDIS. Second, as contributions into EDIS are deductible from national DI payments, the national fund recovery takes the longest with EDIS. Third, 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 on foreign lending and real economic activity.

Given these costs and benefits of EDIS policy makers face different trade-offs. With respect to welfare, we find that EDIS is beneficial for savers in both countries when national insurance funds are exhausted, particularly so for those in the affected economy. 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 design of contribution weights, we show that by weighting the contributions with the country-specific bank default costs the policy maker can mitigate any additional moral hazard, rendering EDIS risk-neutral in the long run. Banks' risk-weighted contributions to EDIS therefore depict a key assumption in our framework, as they imply moral hazard risks to be mitigated in the long run. However, on the union-wide level, household welfare increases in the share of contributions of risky banks, justifying a larger contribution share for the more risky banking sector if the ultimate objective of EDIS is depositor welfare.

In addition to trade-offs policy makers face once EDIS is in place, short-term implementation costs of such a scheme have to be considered as well. We show that diverting funds towards EDIS can temporarily lower national DIs' capacities if the 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 on 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.

Due to the additional risk-sharing provided by EDIS, bank risk-taking, and moral hazard may be fostered when EDIS is in place. Thus, stabilization gains due to enhanced risk-sharing have to be traded off against potential risk-taking incentives impeding financial stability, such that additional regulatory policies may be necessary to complement EDIS. We, therefore, assess the costs and benefits of EDIS in the context of interactions with macroprudential policy. We study explicitly the role of bank capital requirements as an alternative regulatory approach to increasing resilience in the banking sector. We show that under the baseline risk-weighted contributions to the insurance fund, additional risk-sharing under EDIS does not spur additional risk-taking per se in the long run. Only if EDIS contributions are not risk-weighed, EDIS may foster moral hazard leading to structurally higher risk-taking. In such a situation, long-run macroprudential policies may be able to correct unintended EDIS effects. We then turn to the short-term interactions of EDIS and macroprudential regulation and show that the best stabilization effects in terms of real activity and financial intermediation are achieved when both EDIS and macroprudential policies are active. Whenever capital requirements are at low levels, the benefits of EDIS are the largest.

Finally, we assess to what extent EDIS can insure against, and even prevent, costly runs on the banking system. To this end, we extend the model with a novel bank-run mechanism that consists of several elements: Different states of financial distress governed by different levels of bank monitoring costs, an "in-between" state in which depositors wrongly believe to be in the high-distress state, and a sunspot shock that eventually triggers a bank run in this state. We find that bank runs aggravate the depth of a financial crisis, providing further scope for risk-sharing via EDIS. We also show that under certain conditions, EDIS can prevent a bank run in the model.

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

2 Literature

Our study relates to several strands of the macroeconomic literature 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) who develop a two-country banking model à la Gertler and Kiyotaki (2011) with agency costs. In their approach, the degree of financial friction is assumed to be equal across both countries. In our model, we relax this assumption by allowing for heterogeneity in bank riskiness across countries. We do so by extending the analysis of 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 include a detailed government sector.

Second, our analysis also relates to the small literature on macroeconomic models featuring bank-run mechanisms (Angeloni and Faia, 2013; Gertler and Kiyotaki, 2015b; Gertler et al., 2020; Dubois, 2021). We add to the literature by modeling bank runs as a combination of switches between financial regimes and sunspot shocks. Our novel approach allows us to study the interaction of two highly non-linear features explicitly: (i) the depletion of the domestic deposit insurance and (ii) partial bank runs on a subset of banks in response to business cycle shocks. We are aware of only one other study that incorporates partial runs in a macroeconomic general equilibrium setting (Amador and Bianchi, 2022). However, given that their model relates to the U.S. economy and does not feature deposit insurance, they do not discuss risk-sharing via EDIS.

Third, only a few studies have introduced (European) deposit insurance schemes in macroeconomic models,[2] and if so, the design of such frameworks and its relative performance 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. We add to the literature by integrating EDIS and comparing its macroeconomic and welfare effects to different risk-sharing scenarios. Furthermore, our regime-switching approach allows for an explicit analysis of risk-sharing in the form of a re-insurance mechanism, with either EDIS or the government providing backstops. While Dubois (2021) evaluates the implementation of a joint deposit insurance scheme in a two-country model with bank runs, such a re-insurance mechanism and the resulting comparison to other backstop mechanisms than EDIS are not taken up in her study due to the linear setup in her model.

We also contribute to the broader banking 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 (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). Our paper relates to the theoretical literature on deposit insurances but starts with a different macroeconomic approach: The deposit insurance covers the aggregate effects of defaults in the banking sector.[3] Those adverse effects were also found in the empirical literature.

[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-wide regulatory agency and coordination issues between supranational and national regulators have been discussed. Inter alia, the focus has been on banking supervision (Carletti et al., 2021; Colliard, 2020; 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.

[3] Because banks' contributions to deposit insurance are weighted by the aggregate observable bank risk, the implications differ from the previously mentioned papers. We discuss moral hazard in our model in section C of the appendix.

Deposit insurance can indeed lead to more moral hazard and risk-taking (Lambert et al., 2017; 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 (Anginer et al., 2014; Demirgüç-Kunt and Detragiache, 2002). We find instead that under risk-weighted bank contributions, EDIS does not induce additional moral hazard in the long term. Furthermore, we show that EDIS can prevent bank runs from happening. 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. Increasing the share of insured deposits within the European banking sector after the financial crisis of 2007 also reduced risk premiums on deposit rates and fostered bank lending, as shown by (Gatti and Oliviero, 2021). Our paper confirms those findings in a theoretical framework.

3 The Model

In this study, we develop a two-country regime-switching model. The banking sector features bank defaults in the spirit of the euro area closed-economy banking models developed in Mendicino et al. (2018). In addition to the two-country setting, we extend the model further by introducing a government sector and a detailed deposit insurance fund on both the national and the union-wide levels. We analyze risk-sharing via banking and fiscal policies. In the model, patient households in one country provide funds to impatient entrepreneurs in the same country.[4] 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 regulations 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

[4] In line with Gerali et al. (2010), different values in the discount factors determine the borrower-lender relationship between entrepreneurs and households.

obligations and default. Since individual risk profiles of banks are unobservable to depositors, the uninsured bank debt is priced to the expected aggregate bank default risk.[5] 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

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

subject to the budget constraint

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

where $c_t^{P,c}(i)$ depicts current consumption prone to habit formation governed by h_P^c and β_P^c is the households' discount factor. Working hours are given by l_t^c, labor disutility, and the labor supply elasticity are parameterized by φ_P^c and ϕ_P^c. The flow of expenses includes current consumption, and real deposits to be made to domestic banks $d_t^c(i)$, where the latter represents the investment into a diversified portfolio of bank debt. 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.

A fraction κ_t^c of deposits are insured. 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. Idiosyncratic bank risk is unobservable to depositors, so their return is based on the average unit of bank debt in the diversified bank debt portfolio. Household return on bank deposits is thus given by:

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

[5] One can regard this assumption as another type of financial friction justified by market incompleteness under which depositors cannot hedge against bank-specific risk (Mendicino et al., 2018). Depositors are less skilled in evaluating the risk profile of bank assets which is also represented by the monitoring costs depositors face.

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 state-dependent and varies with the available funds in the deposit insurance fund. The fund is financed by a risk-weighted tax imposed on the banking sector which is described in detail below.

3.2 Entrepreneurs

Entrepreneurs engaged in the country c use the respective labor type provided by households as well as capital k_t^c to produce the consumption good $y_t^c(i)$. Each entrepreneur i derives utility from consumption $c_t^{E,c}(i)$ and maximizes expected utility

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

subject to the budget constraint

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

with β_E^c is the time preference factor of the entrepreneur, which is always smaller than the corresponding one of the private households. $p_t^{E,c} = \frac{P_t^{E,c}}{P_t^c}$ denotes the price ratio of the producer price level to the consumer price level and $q_t^{k,c}$ is the relative price of capital. Entrepreneurs in the country c furthermore face borrowing constraints concerning domestic bank lending $b_t^{E,c}$, depending on the capital they hold as collateral.[6] Regulatory LTV ratios apply for funds borrowed in each country, and regulation is determined on the national level. The borrowing constraint is given by

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

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 loans:

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

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

We follow Iacoviello (2005) and assume that the borrowing constraint binds around the steady state such that uncertainty is absent in the model.[7] Thus, in equilibrium, equation 6 holds with equality. The production function is given by

$$y_t^c = (k_{t-1}^c)^{(\alpha^c)}(l_t^c)^{(1-\alpha^c)}. \tag{8}$$

We further derive an expression for the law of motion of firms' net worth along the lines of Gambacorta and Signoretti (2014):

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

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 the firm's net worth, the capital price, and the entrepreneur's leverage χ_t^c in that country:

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

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

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 aggregate equity investment $e_t^{aggr,c}$ 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

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

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

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

The term $\Lambda^c_{t+1}[(1-\theta^c_b)+\theta^c_b\nu^c_{t+1}] = \Lambda^{b,c}_{t+1}$ describes the discount factor of bankers. Each period a fraction $(1-\theta^c_b)$ 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:

$$n^{b,c}_{t+1} = [\theta^c_b + \chi_b(1-\theta^c_b)](n^{c,c}_t \rho^c_{t+1} + n^{c,\neg c}_t \rho^{\neg c}_{t+1}) \tag{13}$$

where ρ^c_{t+1} is the return of equity invested in banks in the same country c and $\rho^{\neg c}_{t+1}$ 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

$$\nu^c_t = E_t\{\Lambda^{b,c}_{t+1}[\zeta^{n,c}_t \rho^c_{t+1} + (1-\zeta^{n,c}_t)\rho^{\neg c}_{t+1}]\} \tag{14}$$

with $\zeta^{n,c}_t = \frac{n^{c,c}_t}{n^{b,c}_t}$ 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^c_{t+1}, following a log-normal distribution.[8] 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 $e^c_t = n^{c,c}_t + RER_t n^{\neg c,c}_t = \zeta^c_e e^c_t + (1-\zeta^c_e)e^c_t$ units of equity from domestic and foreign investors. We denote the equity home bias on banks' balance sheets as ζ^c_e and RER_t depict the real effective exchange rate. Furthermore, each bank pays a total contribution $\frac{\tau^{DI,c}_t}{d^c_t}d^c_t$ to the national deposit insurance scheme, with $\frac{\tau^{DI,c}_t}{d^c_t}$ being the average contribution per one unit of bank debt. Banks maximize their net present value by deciding on the profit-maximizing amount of assets a^c_t and deposits d^c_t subject to a balance sheet constraint and a regu-

[8] The stylized assumption that bank asset returns are heterogeneous is a proxy for heterogeneous exposure to firm-specific lending risk that cannot be hedged due to the incomplete market setting that banks face. Our modeling of the stochastic component is in line with the literature on heterogeneous banking models (Bellifemine et al., 2022).

latory constraint governed by the capital requirement $\bar{\phi}^c$, set by the macroprudential regulator:

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

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

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

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

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. 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

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

and $1 - \Gamma_c(\overline{\omega}_{t+1}^c)$ represents the bank's net share of the deposit contract. $\Gamma_c(\overline{\omega}_{t+1}^c)$ determines the household's gross share of the deposit contract:

$$\Gamma(\overline{\omega}_t^c) = \Phi\left(\frac{\ln(\overline{\omega}_t^c) - \frac{(\sigma^c z_t^{b,c})^2}{2}}{\sigma^c z_t^{b,c}} \right) + \overline{\omega}_t^c \left[1 - \Phi\left(\frac{\ln(\overline{\omega}_t^c) + \frac{(\sigma^c z_t^{b,c})^2}{2}}{\sigma^c z_t^{b,c}} \right) \right], \quad (18)$$

with $\Phi(\cdot)$ denoting a cumulative standard normal distribution.
A bank defaults on its liabilities to depositors when its bank-specific asset return shock lies below the default threshold $\omega_{t+1}^c < \overline{\omega}_{t+1}^c$.
We define the expected share of deposits ending up in default as:

$$G(\overline{\omega}_t^c) = \Phi\left(\frac{\ln(\overline{\omega}_t^c) - \frac{(\sigma^c z_t^{b,c})^2}{2}}{\sigma^c z_t^{b,c}} \right). \quad (19)$$

In both equations 18 and 19, σ^c measures the standard deviation of the idiosyncratic asset return shocks ω^c_{t+1}. A higher variance of the idiosyncratic bank-level shocks coincides with higher realized bank default rates. In addition, we introduce a separate aggregate bank risk shock $z^{b,c}_t$ that represents an exogenous change in the standard deviation parameter σ^c.[9] The bank risk shock $z^{b,c}_t$ follows an AR(1) process.

We define a separate variable for the default rate of banks:

$$\psi^c_t = \Phi\left(\frac{\ln(\overline{\omega}^c_t) + \frac{(\sigma^c z^{b,c}_t)^2}{2}}{\sigma^c z^{b,c}_t}\right). \tag{20}$$

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

$$E_t\{\Lambda^{tot,h}_{t+1}\rho^h_{t+1}\} = \zeta^h_e \nu^h_t + (1-\zeta^h_e)\nu^f_t \tag{21}$$
$$E_t\{\Lambda^{tot,f}_{t+1}\rho^f_{t+1}\} = \zeta^f_e \nu^f_t + (1-\zeta^f_e)\nu^h_t, \tag{22}$$

which describe the no-arbitrage conditions for international bankers.

3.5 National Government

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

$$q^{k,c}_{t+1} b^{g,c}_t = q^{k,c}_t R^{gov,c}_t b^{g,c}_{t-1} + g^c - \tau^c_t, \tag{23}$$

where g^c denotes constant government consumption and τ^c_t denotes the total (lump-sum) income tax paid by private households. Stabilization policy is conducted via a countercyclical income tax feedback rule, which mimics the automatic stabilizers function of the income tax system in a stylized fashion.

$$\frac{\tau^c_t}{\overline{\tau}^c} = \left(\frac{\tau^c_{t-1}}{\overline{\tau}^c}\right)^{\rho^c_{tax}} \left[\left(\frac{y^c_t}{\overline{y}^c}\right)^{\phi^c_y} \left(\frac{b^{g,c}_{t-1} q^{k,c}_t}{\overline{b}^{g,c}}\right)^{\phi^c_d}\right]^{1-\rho^c_{tax}} \tag{24}$$

where $\phi^c_y \leq 0$ and $\phi^c_d \leq 0$ are the weighting parameters for the two target variables and ρ^c_{tax} 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 $\overline{b}^{g,c}$. New debt can be issued during a recession ($y^c_t < \overline{y}^c$)

[9] See among others Christiano et al. (2014) or Mendicino et al. (2018).

or if the 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 level. The return on government debt is thus described by a premium on the risk-free deposit rate increasing in debt levels:

$$R_{t+1}^{gov,c} = \tilde{R}_t^{d,c} + \Phi_{debt}^c [b_t^{g,c} - \overline{b}^{g,c}]^2. \tag{25}$$

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

$$DI_{t+1}^c = DI_t^c + \tau_t^{DI,c} - \kappa_t^c \Omega_{t+1}^c \tag{26}$$

where a share $\kappa_t^c = \bar{\kappa}^c$ of the total default costs Ω_{t+1}^c is insured by the national DI in each country. We calibrate the share of insured deposits to a constant value but allow for state dependence when introducing the regime-switching framework in section 4. Banks pay a contribution $\tau_t^{DI,c}$ to the fund, and the fund capital target γ_{DI}^c is set relative to total outstanding insured deposits in steady state:

$$\overline{DI}^{target,c} = \gamma_{DI}^c \overline{\kappa}^c \overline{d^c}. \tag{27}$$

The costs of deposit default in each country are defined as the difference between the 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

$$\Omega_t^c = [\overline{\omega}_t^c - \Gamma_c(\overline{\omega}_t^c) + \mu^c G^c(\overline{\omega}_t^c)] \frac{R_t^{a,c}}{1-\phi_{t-1}^c} d_{t-1}^c, \tag{28}$$

with $-[\Gamma_c(\overline{\omega}_t^c) - \mu^c G^c(\overline{\omega}_t^c)]$ denoting the households' net share of returns from a diversified bank debt portfolio. In each period, banks contribute the amount $\tau_t^{DI,c}$ to the fund. The contributions are inversely related to the fund level:

$$\tau_t^{DI,c} = \overline{\tau}^{DI,c} + \chi_\tau^c [\overline{DI}^{target,c} - E_t\{DI_t^c\}] \tag{29}$$

with χ_τ^c denoting the sensitivity to the domestic fund level.

In order to ensure stationarity of the fund level DI_t^c, the following has to hold in steady state: $\bar{\kappa}^c \Omega^c = \overline{\tau}^{DI,c}$. Thus, the contributions banks pay to deposit insurance schemes are calculated on the basis of expected default costs and the overall share of insured deposits. Under this assumption, the default threshold of banks, equation 17, evaluated at the steady state, can be written as:

$$\bar{\omega}^c = (1-\phi)\left(\frac{\tilde{R}^{d,c}}{R^{a,c}} + \frac{\Omega^c}{R^{a,c}d^c}\right). \tag{30}$$

The steady-state default threshold is thus neither affected by the contractual deposit rate, nor by the provided deposit insurance coverage. As a consequence, deposit insurance does not induce additional moral hazard in the long run in our model. Instead, bank defaults, firm loans, and corporate borrowing rates remain unaffected by higher deposit insurance shares in the steady state.[10]

3.7 Goods Market Clearing and Trade

Here we shortly summarize essential market clearing conditions.[11] In both regions, the goods market clearing condition holds in equilibrium:

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

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. 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:

$$RER_t = T_t \frac{p_t^{e,h}}{p_t^{e,f}}. \tag{32}$$

[10]Since individual bank contributions are calculated based on the average costs of default per unit of bank debt, and the risk premium on deposit rates is again defined as the average default costs per unit of bank debt, the beneficial effects of lower deposit rates on banks' profits are exactly offset by the adverse effects of higher contributions. For more details, see section C in the appendix, where we validate our statements on moral hazard both analytically and in a comparative statics analysis.

[11]Capital producing firms and the trade sector are described in detail in the appendix in section A.1 and section A.2.

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

$$tb_t = ex_t^h + T_t im_t^h \tag{33}$$

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 Regime Switching and Risk-Sharing

In the following, 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 DI schemes are exhausted.

4.1 Regime Switching in the Baseline Model

In the analysis, we restrict deposit insurance compensations to states of the world with positive fund levels. Thus, we allow for four states of the economy. In the baseline regime, both national DI schemes and fiscal policies operate as described in sections 3.5 and 3.6, and national DI is unconstrained (regime 1). In the other states of the economy, either one or both national DIs are constrained as national insurance funds are exhausted and no insurance transfers can be provided anymore (see table 1). Thus, the share of insured deposits becomes time-varying:

$$\kappa_t^c = \begin{cases} \bar{\kappa}^c & \text{if } DI_t^c > 0 \\ 0 & \text{if } DI_t^c \leq 0. \end{cases} \tag{34}$$

It follows that whenever the fund is exhausted, $DI_{t+1}^c \leq 0$, the economy enters the constrained regime and no insurance can be provided by the national DI anymore, such that $\kappa_t^c = 0$. This case is consistent with a severe financial crisis scenario in which national insurance schemes become insufficient to cover a large share of bank defaults due to an abrupt and excessive increase in risks in the banking sector.

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

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

Table 1: 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.

one state to the other in each period. Therefore, expectations about the economy's future states are considered in agents' decision rules. Switching from one regime to another is governed by a Markov-switching process:

$$P_{1,j} = \frac{1}{1 + \exp[\alpha_2(DI_t^c - 0)]} \tag{35}$$

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

with $j \in \{2, 3, 4\}$. The transition probabilities follow a sigmoid function with scaling parameters α_1 and α_2. Domestic deposit insurances become depleted during episodes of severe financial distress when bank default rates are high. The probability of entering the constrained regime is one when the fund level is zero or negative (equation 35). The probability of switching back to the unconstrained regime in turn becomes one when bank defaults ψ_t^c drop below a "financial stress" threshold level $\overline{\Psi}^c$ of bank default rates (equation 36).[13] Our analysis is counterfactual in nature since the euro area has not experienced episodes with explicitly exhausted national deposit insurance funds. On the other hand, the euro area potentially entered such a scenario in October 2008, when several heads of government had to pledge that bank deposits would be insured, if necessary by government guarantees.

4.2 Different Risk-Sharing Scenarios

In the following, 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.

[13] We choose the switching threshold $\overline{\Psi}^c$ for each country as the level of default rates at which the sum of future compensations $\kappa_t^c \Omega_{t+1}^c$ are low enough to prevent a second immediate depletion of the deposit fund.

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 $\kappa_t^c = 0$). Bank defaults affect the risk premium on deposit rates unrestrained. The return on deposits net of defaults, given by equation 3, decreases and becomes

$$\tilde{R}_t^{d,c} = R_t^{d,c} - \frac{\Omega_{t+1}^c}{d_t^c}. \tag{37}$$

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 that governments compensate the same share of insured deposits as the deposit insurance, $\overline{\kappa}^c$. The cost of deposit insurance enters the national government budget constraint given by equation 23 which therefore becomes

$$b_t^{g,c} = R_t^{gov,c} b_{t-1}^{g,c} + g_t^c - \tau_t^c + \overline{\kappa^c}\Omega_{t+1}^c \tag{38}$$

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

C. Constrained National DI, European Deposit Insurance Our European Deposit Insurance Scheme (EDIS) 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:

$$DI_{t+1}^{EDIS} = DI_t^{EDIS} + \sum_{c=h,f} \tau_t^{EDIS,c} - \sum_{c=h,f} \kappa_t^{EDIS,c}\Omega_{t+1}^c. \tag{39}$$

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

$$\overline{\omega}_{t+1}^c = (1 - \phi_t^c)\left(\frac{R_t^{d,c}}{R_{t+1}^{a,c}} + \frac{\tau_t^{DI,c} + \tau_t^{EDIS,c}}{R_{t+1}^{a,c} d_t^c}\right). \tag{40}$$

The aggregate contributions to EDIS are given by

$$\tau_t^{EDIS} = \overline{\tau}^{EDIS} + \chi_\tau^{EDIS}[\overline{DI}^{target,EDIS} - E_t\{DI_{t+1}^{EDIS}\}] \tag{41}$$

with χ_τ^{EDIS} denoting the sensitivity to changes in the EDIS fund level. The aggregate contributions defined in equation 41 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 contribute more to the EDIS fund.[14]

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

$$\tau_t^{EDIS,c} = \frac{\kappa_t^c E_t\{\Omega_{t+1}^c\}}{\kappa_t^c E_t\{\Omega_{t+1}^c\} + \kappa_t^{\neg c} E_t\{\Omega_{t+1}^{\neg c}\}} \tau_t^{EDIS} \tag{42}$$

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 6.3.3. We then vary the size of contribution weights and discuss how welfare is affected. A second key element of recent proposals depicts the potential 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.[15]

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:*

$$\tau_t^{DI,c} = \overline{\tau}^{DI,c} + \chi_\tau^c [\overline{DI}^{target,c} - E_t\{DI_{t+1}^c\}] - \tau_t^{EDIS,c}. \tag{43}$$

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

$$\overline{DI}^{target,EDIS} = \gamma^{EDIS}[\overline{\kappa}^h \overline{d}_t^h + \overline{\kappa}^f \overline{d}_t^f]. \tag{44}$$

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

$$\tilde{R}_t^{d,c} = R_{t-1}^{d,c} - (1 - \kappa_t^c - \kappa_t^{EDIS,c})\Omega_{t+1}^c. \tag{45}$$

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

$$\kappa_t^{EDIS,c} = \begin{cases} 0 & \text{if } DI_t^c > 0 \\ \bar{\kappa}^c & \text{if } DI_t^c \leq 0. \end{cases} \tag{46}$$

[14] Our risk weighting hence resembles the "polluter-pays" principle, see Carmassi et al. (2020). As we show in section 6.4, the risk-weighted contributions imply that EDIS does not foster moral hazard related to excessive risk-taking.

[15] In addition to relaxing assumption 1 in section 6.3.3, we also discuss the implication of relaxing assumptions 2 in section 6.3.4.

EDIS is involved as long as the economy is in the constrained regimes, and the national insurance funds get reestablished by bank contributions. Reinsurance via EDIS, therefore, provides additional risk-sharing, as it provides insurance, 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. Therefore, we assume the same payout target per unit of deposit for national DIs and EDIS, $\bar{\kappa}^c$. As we discuss in section 6.4, the introduction of a permanent EDIS framework does not per se induce additional moral hazard in the banking sector in the long run as long as contributions are risk-weighted as defined in equation 43 and total long-run bank contributions are equal to insurance compensations, $\bar{\tau}^{EDIS} = \bar{\kappa}^h \bar{\Omega}^h + \bar{\kappa}^f \bar{\Omega}^f$.[16]

5 Calibration

The empirical validation of our model is based on two different types of parameter values. First, some parameters are preset to conventional values because no direct or indirect counterpart exists for them, but they have been empirically estimated in other studies. In the second group parameter values for which a direct empirical counterpart exists are set such that the first moments in the data are matched by theoretical model moments.

We calibrate parameters in the home economy of the model to match data moments for Germany, while the foreign economy is calibrated to the rest of the euro area. Thus, all reported euro area data moments exclude information on Germany. The empirical data moments are both collected from macroeconomic time series and micro-level data.[17] 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. Banking statistics 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

[16] See appendix section C for a detailed discussion on the latter requirement.

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

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.

5.1 Preset Parameters

Preset parameters include parameters related to policy rules, the deposit insurance fund, or structural parameters. For non-banking parameters, we set conventional parameters from the literature: The capital share is set to 0.3 as is common in the literature.[18] We normalize the labor disutility to one and set the inverse Frisch elasticity of labor supply similar to Mendicino et al. (2018). The habit formation parameter h_p^c is set to 0.8, close to the posterior estimates of Gerali et al. (2010). The trade elasticity is set at 1.5 in line with empirical estimates for the euro area countries by Imbs and Mejean (2017). The bias of the domestic share of traded goods is set at 0.6. Furthermore, key parameters related to euro area-wide financial 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 Basel III.[19] 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). The bank monitoring costs are set to a common value $\mu^c = 0.3$.[20] In the bank-run framework we introduce in section 6.5, monitoring costs will be state-dependent, with higher costs in times of severe financial distress. The larger μ^c, the higher the cost of defaults and the faster the domestic deposit insurances deplete. The sensitivity analysis in section 6.2 shows that the monitoring cost parameter only affects the quantitative results while the qualitative policy implications remain unchanged.

The DI contribution sensitivity parameters χ_τ^c and χ_τ^{EDIS} measure the speed at which national banks pay contributions into the national DI schemes or EDIS. We set the parameter values to $\chi_\tau^c = \chi_\tau^{EDIS} = 0.45$. In the sensitivity analysis in figure 4 and the implementation exercise in figure 7 we show that the peak-to-trough downturn is less severe for smaller policy parameters. As we will show, our

[18] See e.g. Mendicino et al. (2018).

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

[20] See e.g. Mendicino et al. (2018).

calibrated value is conservative in the sense that raising its value to substantially higher levels only marginally decreases the EDIS effect. For the fiscal revenue policy, ϕ_y^c captures the strength of the response of taxes and levies to the output gap. This implicitly accounts for the function of taxes and levies as automatic stabilizers over the business cycle.

5.2 Moment-Matched Parameters

The empirical validation of our model is provided by setting a subset of model parameters such that the first moments in the data are matched by theoretical model moments. 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.

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. As shown in table 3, we set $\overline{\kappa}^{DI,c}$ in accordance with the JRC European Union Banking Sector Statistics.[21] We calibrate the target level of deposit insurance $DI^{target,c}$ to 0.8 percent of outstanding insured deposits, as proposed by the European Commission (European Commission, 2015). The fund level determines at which number of accumulated bank defaults the domestic deposit insurance becomes depleted. For the household discount factor, we assume market participants in both countries have access to a global risk-free asset. We 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 twelve parameters simultaneously to minimize the distance between twelve data moments and their model-implied counterparts. We summarize these moments – six for each country – in table 4 and report the total distance between model moments and data moments. In addition, we summarize the values for each moment, both the model-implied ones and the empirical values for both the rest of the euro area and

[21] See Pagano and Di Girolamo (2017).

Table 2: Preset Parameters

	Parameter	Germany	Rest of the EA
Structural Parameters			
Capital Share in Production	α^c	0.3	0.3
Inverse Frisch Elasticity of Labor Supply	ϕ_P^c	1	1
Labor Disutility	φ_P^c	1	1
Household Habit	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
Policy Parameters			
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
Debt-Elastic Interest Rate	Φ_{debt}^c	0.1	0.1
Banking Parameters			
Bank Capital Requirement	$\overline{\phi}^c$	0.105	0.105
Loan-to-Value Ratio	m_E^c	0.35	0.35
Bank Monitoring Costs (Baseline)	μ^c	0.3	0.3
DI Contribution Sensitivity	χ_τ^c	0.45	0.45
EDIS Contribution Sensitivity	χ_τ^{EDIS}	0.45	0.45
Switching Function Scaling (equ. 35)	α_1	300	300
Switching Function Scaling (equ. 36)	α_2	200	200
Deposit Insurance Regime-Switching Threshold	$\overline{\Psi}^c$	1	1
Bank Risk Shock AR Coefficient	ρ_b^c	0.75	0.75
Bank Risk Shock Standard deviation	σ_b^c	1	1

Germany. Although we set all parameters simultaneously to minimize the overall distance, our routine still allows us to make a statement about the mapping from data moments to model parameters.[22] Return on equities, expected bank defaults and price-to-book ratios are crucial for pinning down the survival rate of bankers θ_b^c, bankers' endowment χ_b^c and the standard deviation for i.i.d. bank asset returns σ^c. 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 important for matching the moments on investment-to-GDP ratios, firm loans-to-GDP ratios, and the spread between the corporate lending and the risk-free rate.

[22]By running the moment-matching algorithm multiple times for different combinations of targeted moments and parameters, we learn about the mapping from data moments to model parameters.

Table 3: Matched Parameters

	Parameter	Germany	Rest of the EA
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
EDIS Fund Target Rate	γ_{EDIS}^c	0.008	0.008
Share of Insured Deposits	$\overline{\kappa}^{EDIS,c}$	0.497	0.512
Government Consumption/GDP	g^c	0.211	0.225
Distance Minimization			
Idiosyncratic Asset			
Return Shock Standard Deviation	σ^c	0.041	0.043
Discount Factor Entrepreneurs	β_E^c	0.970	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	ψ_i^c	5.587	5.411

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

Table 3 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 striking. 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.[23] 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^c.

Under our baseline calibration, the model matches empirically observed first moments for most macroeconomic and financial market variables in Germany and the rest of the euro area well. However, our results for these two sample economies do not imply general validity for other euro-area countries. Therefore, we test the

[23]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 4: Targeted First Moments

	Moment	Model	Data
Germany			
Business Investment/GDP	$\frac{\overline{I}^h}{\overline{Y}^h}$	0.222	0.222
Bank Default Rate	$4 \times \overline{\psi}^h$	1.256	1.065
Return on Equity	$400 \times (\rho^h - 1)$	10.724	6.386
Price-to-Book Ratio	$\overline{\nu}^h$	1.026	0.822
NFC Loans/GDP	$\frac{\overline{b}_e^h}{\overline{Y}^h}$	1.071	1.443
NFC Loan Rate Spread	$400 \times (\overline{R}^{b,h} - \overline{\tilde{R}}^{d,h})$	1.771	2.994
Rest of the EA			
Business Investment/GDP	$\frac{\overline{I}^f}{\overline{Y}^f}$	0.228	0.228
Bank Default Rate	$4 \times \overline{\psi}_t^f$	1.917	1.398
Return on Equity	$400 \times (\rho^f - 1)$	8.144	4.548
Price-to-Book Ratio	$\overline{\nu}^f$	1.300	1.300
NFC Loans/GDP	$\frac{\overline{b}_e^f}{\overline{Y}^f}$	1.429	2.015
NFC Loan Rate Spread	$400 \times (\overline{R}^{b,f} - \overline{\tilde{R}}^{d,f})$	1.397	2.608
Total Distance			**2.836**

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

robustness of our results with respect to a selected parameter set in section 6.2. We define a maximum and a minimum range of plausible values for certain policy and behavioral parameters.

6 Results

Based on the policy scenarios defined in the previous section, we first evaluate how shocks emerging in the banking sector affect financial and macroeconomic stability. Therefore, we simulate a series of bank risk shocks $z_t^{b,c}$ that doubles the standard deviation of the idiosyncratic bank-level asset return shocks[24] such that the domestic deposit insurance depletes. Second, we discuss the welfare implications of bank risk shocks and alternative specifications of EDIS. Third, we investigate the short-term

[24]Equations 18-20 describe the underlying relationship between the standard deviation of bank-level asset return shocks σ^c and the aggregate bank risk shock $z_t^{b,c}$.

costs arising from the implementation of EDIS and then analyze the interaction of deposit insurance with macroprudential regulation. Finally, we show that EDIS, as a second line of defense, can prevent the occurrence of a self-fulfilling bank run.

6.1 Banking Crises and the Stabilization Effects of EDIS

We first evaluate the dynamic stabilization capacities of EDIS in presence of a large banking crisis in comparison to the alternative risk-sharing arrangements presented in section 4.2: no reinsurance, and reinsurance by a national fiscal backstop. To this end, we simulate a series of bank risk shocks $z_t^{b,c}$ of a magnitude large enough to deplete the domestic deposit insurance.[25] Consequently, the size of the simulated bank risk shock is based on the calibrated fund level.[26] The number of realized bank defaults caused by the bank risk shock in the simulation provides information on how resilient the European fund target of 0.8 percent is during times of high financial distress. In this regard, the number of bank defaults until the fund depletes should be seen as a lower-bound estimate. For example, the national deposit insurance fund would deplete at a smaller pace when allowing for bail-in debt or outside equity.[27]

Figures 1 and 2 depict impulse responses to a series of adverse bank risk shocks occurring in the home country. The sequence implies that bank default risk remains elevated for three periods, before gradually declining.[28] The regime switch occurs in period three, after which regime two, the regime with depleted national DI in the home economy, prevails for several periods.

Under all policy scenarios, an increase in the home country's bank risk leads to an 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 no-backstop

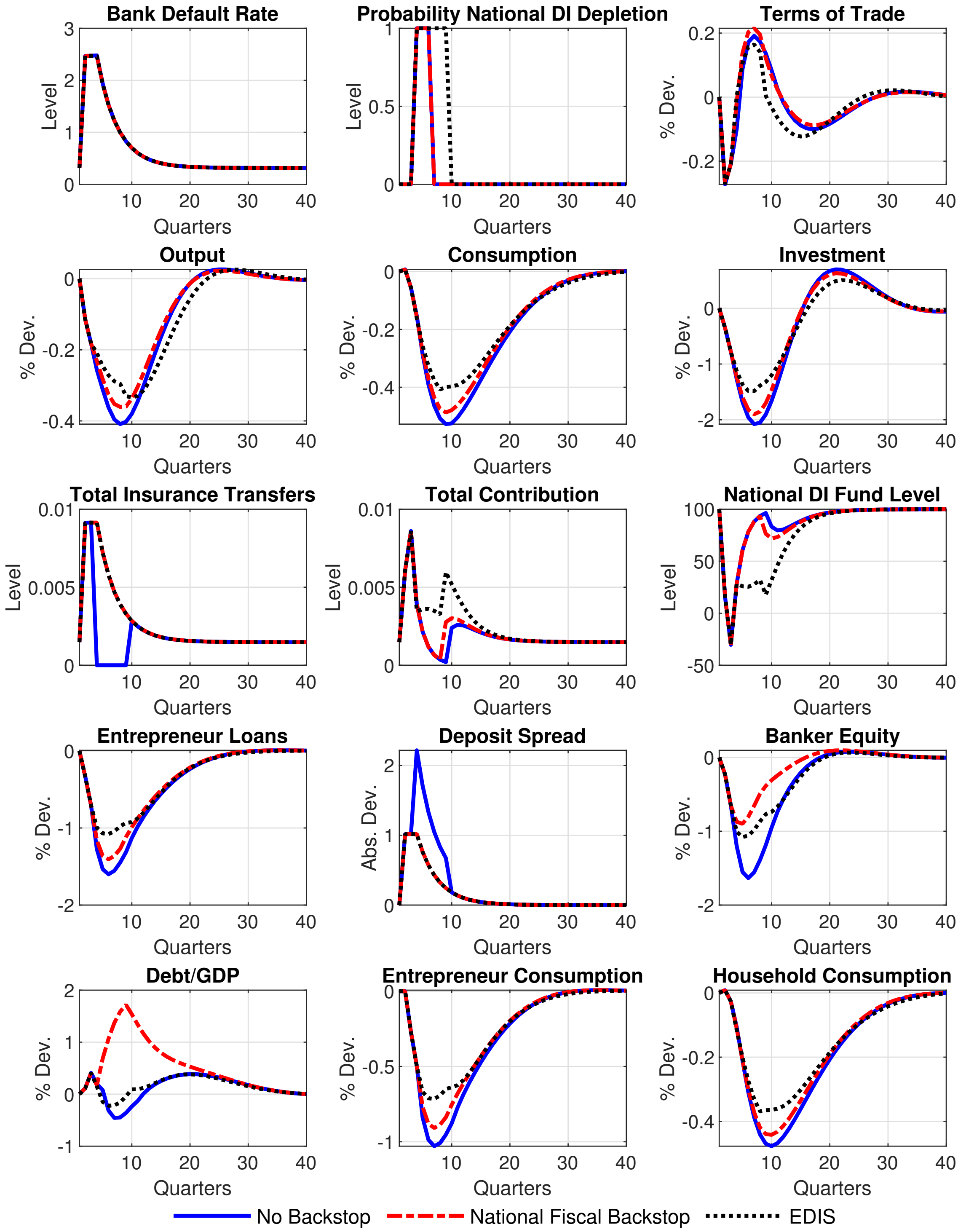
[25] The magnitude of resulting bank defaults under the bank risk shock surpasses observed bank defaults during the Great Recession.

[26] The variance of banks' idiosyncratic risk σ^c is determined via the matching algorithm, in particular by the country's default rate in equilibrium. Choosing a higher level of idiosyncratic risk σ^c would allow for setting the bank risk shock size to a lower value while still achieving a depletion of the domestic fund. Results for the different policy scenarios would turn out qualitatively similar.

[27] Outside equity as a component of the total loss-absorbing capacity (TLAC) of banks acts as a buffer before bank defaults on insured deposits materialize (Mendicino et al., 2017). This is because outside equity is junior to bank liabilities such as insured deposits.

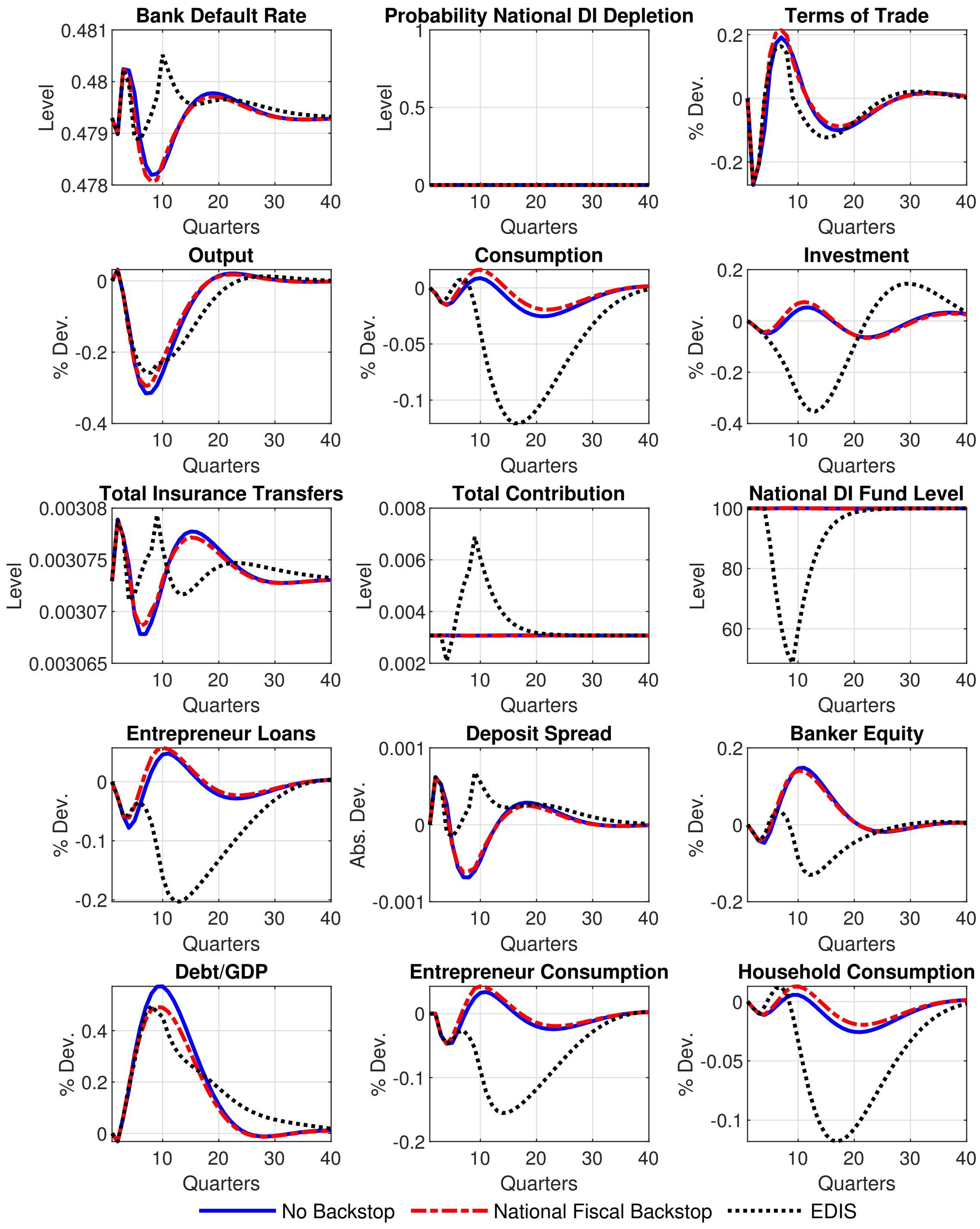
[28] We will simulate the same crisis scenario when we discuss bank runs in section 6.5, where the same sequence of shocks implies that a run can actually occur.

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 4. 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 levels or percentage deviations. Percentage deviations and absolute deviations are from the *unconstrained regime's* deterministic steady state.

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 4. 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 levels or percentage deviations. Percentage deviations and absolute deviations are from the *unconstrained regime's* deterministic steady state.

scenario (blue line) in the home country. The insurance transfers paid to households increase to compensate depositors for their costs due to bank defaults.

Consumption declines less under EDIS than in the other two scenarios, even though across scenarios, the overall consumption response to a banking crisis is benign considering the substantial change in the policy environment. In the home economy, consumption declines by approximately 0.4 percent with EDIS from peak to trough (black dotted line), and the *relative* decline in output is approximately 10 to 20 percent lower with EDIS respectively compared to the other scenarios. For investment and bank loans, the respective figures stand at even 30 to 40 percent, and 30 to 50 percent respectively. Furthermore, 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, 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 payments into the national DI, re-establishing both the initial national fund's level and the EDIS fund's level takes the longest under EDIS. Although contributions are deductible, the burden of re-filling two different deposit insurance funds results in higher total contributions and prolongs the recovery path under EDIS.

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). Bank defaults increase initially, while consumption declines relatively less in the beginning under EDIS. This can be explained by the more favorable economic conditions under EDIS in the home economy transmitting to the foreign economy. Once the EDIS fund level is depleted, foreign banks' contributions to the insurance have to increase again, limiting drastically banks' ability to provide further lending, with respective consequences for economic activity.

In return, bank defaults and bank deposit spreads start to increase again after period six, which further limits foreign banks' lending capacities. In response to lower lending, foreign consumption, and investment decline.

Our results indicate that while EDIS can be beneficial to the country affected by an idiosyncratic banking crisis, consumers in the non-affected economy are hit hardest with risk-sharing via EDIS. For the latter, we find that EDIS has opposing effects on economic conditions: On the one side, EDIS has an expansionary effect on the real activity as trade conditions are relatively favorable and distortions in international financial markets are relatively benign. On the other side, higher total bank contributions to the EDIS fund limit the lending capacity of banks, with adverse effects on credit supply and economic activity. The first channel dominates in the first five to six quarters, whereas the higher contribution burden outweighs the beneficial effects in the medium- to long run. Under EDIS the policy maker thus faces an inter-temporal trade-off between a lower trough when the crisis is the most severe and higher bank contributions and adverse economic conditions in both countries in the medium term. Consequently, the union-wide welfare implications of a common insurance scheme are not clear a priori.

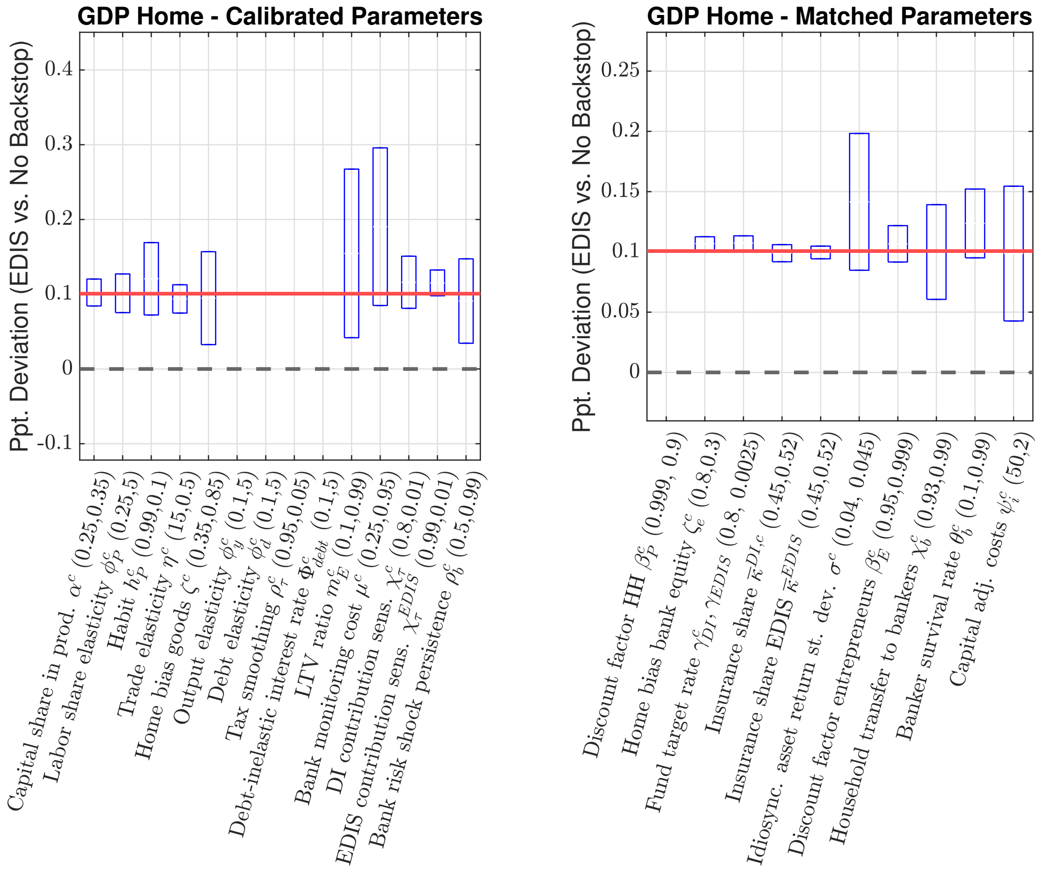
6.2 Robustness

Before turning to the welfare implications of EDIS, we check to what extent our simulation results are robust to changing key parameter values. We do so for two reasons: First, as some model parameters are calibrated in alignment with the literature and thus the model is not fully estimated, parameter uncertainty exists. Second, EDIS would also affect all other euro area countries individually, whose different economic and financial market structures would be reflected in a different parameterization. A robustness analysis can therefore also shed light on how EDIS would perform more generally.

To discuss the robustness of our findings, we simulate the same bank risk shock at home as studied in figure 1 for parameter ranges at home and abroad with and without EDIS. We then take the differences in impulse responses one year after the shock occurs.

We set parameter ranges mainly on the basis of reasonable and commonly applied values in the literature. For some parameters that are estimated less frequently or not at all in the literature, we assess the range of minimum and maximum possible values at which depletion of national deposit insurance occurs. For example, at a high DI target funds rate, the national DI may not deplete in response to the given bank risk shock. Consequently, the EDIS effect is zero in such a case, as EDIS in our framework intervenes as reinsurance only when national DI becomes depleted. Parameter ranges in which the national DI is not exhausted are therefore not considered in our robustness analysis of the EDIS effect. Figures 3 and 4 show results for ranges of calibrated parameters (left panel), as well as for directly and indirectly matched parameters (right panel) in the home and the foreign country.

Figure 3: EDIS Effect on Home GDP – Parameter Robustness

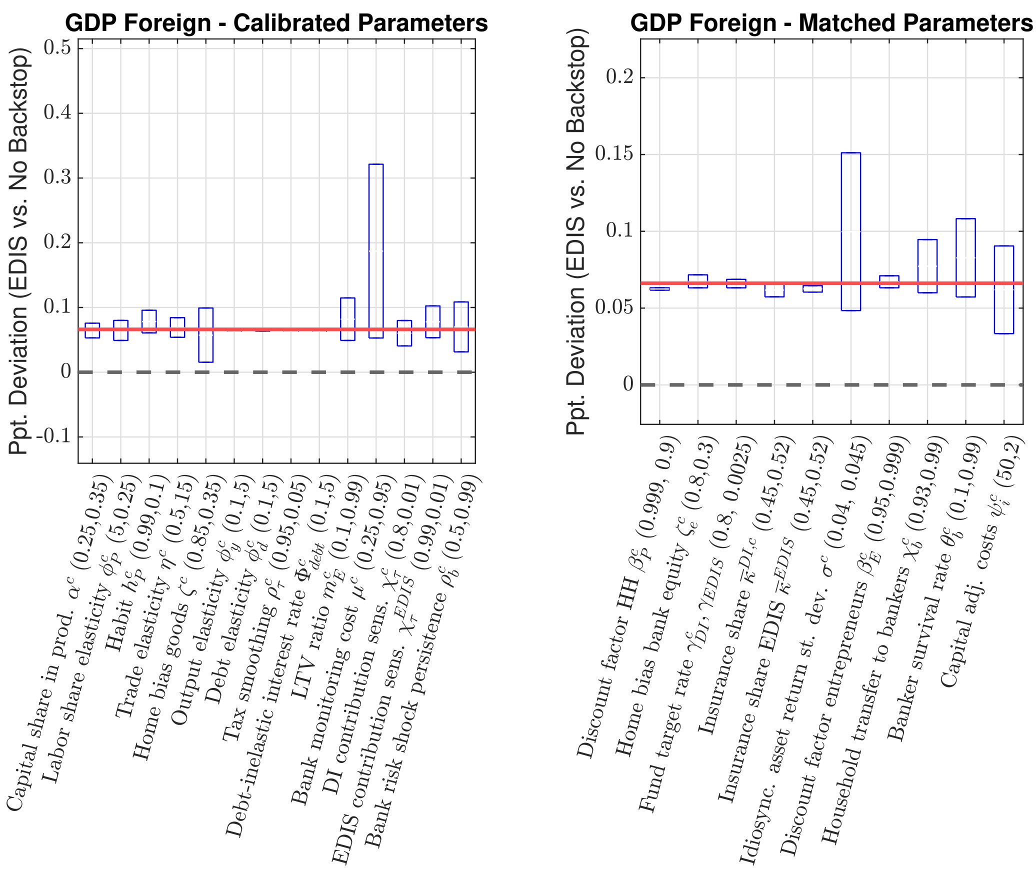


Note: Percentage point (ppt.) deviations of IRFs for GDP between EDIS and no-backstop after one year. Minimum and maximum parameter values in parentheses. When ranges are presented as [min, max], a higher parameter value leads to a larger GDP effect of EDIS (e.g. production elasticity α^c stated as [0.25, 0.35]). If stated as [max, min], a higher parameter value leads to a smaller GDP effect (e.g. capital adjustment costs ψ_i^c stated as [50, 2]).

First, it can be seen that EDIS has a positive effect on domestic GDP across all parameter ranges in which national DI schemes are depleted (figure 3). Under our baseline parameterization, the EDIS effect translates into a 0.1 percentage point difference after the first year (straight red line). Across parameter ranges, the EDIS effect after one year varies between 0.05 and above 0.3 percentage points. Thus, the positive EDIS effect for the country where the shock occurs is very robust to a large set of parameter changes.

Second, the EDIS effect on GDP in the foreign economy, observed one year after the bank risk shock in the home economy occurs, is robust for a wide range of parameter values as well (figure 4). It amounts to a GDP difference of 0.06 percentage points of GDP in our baseline scenario, and ranges between 0.02 and 0.2 percentage points of GDP across all parameter value bands.

Figure 4: EDIS Effect on Foreign GDP – Parameter Robustness



Note: Percentage point (ppt.) deviations of IRFs for GDP between EDIS and no-backstop after one year. Minimum and maximum parameter values in parentheses. When ranges are presented as [min, max], a higher parameter value leads to a larger GDP effect of EDIS (e.g. production elasticity α^c stated as [0.25, 0.35]). If stated as [max, min], a higher parameter value leads to a smaller GDP effect (e.g. capital adjustment costs ψ^c_i stated as [50, 2]).

Third, changes to some parameters have a noticeable effect on the result. Among them are the parameter determining the home bias for goods ζ^c, the LTV ratio m^c_E, and bank monitoring costs μ^c. Furthermore, the volatility of the idiosyncratic asset return shock σ^c is relevant for the magnitude of the EDIS effect. With higher monitoring costs and a higher LTV ratio, defaults are more costly, such that national deposit insurance is exhausted more quickly. Accordingly, EDIS stabilizes to a greater extent. Changes in the home bias goods parameter ζ^c, or inversely the openness of a country, significantly affect the relative performance of EDIS. The more open an economy, the smaller the gains from risk-sharing via EDIS in terms of GDP for the economy affected by the shock. Finally, the stabilization of GDP under EDIS is larger when we increase the standard deviation of the idiosyncratic asset return shocks σ^c. Holding the size of the bank risk shock constant and increasing the idiosyncratic bank-level shocks results in a more severe crisis with a higher share of defaulting banks. In such a crisis, the benefits of EDIS are more pronounced.

Furthermore, an analysis of other parameters of the deposit insurance system is also informative, even if the stabilization effect is not quite as noticeable for these parameters. A higher contribution sensitivity χ_τ^c of the national DI fund increases the GDP stabilization effect somewhat, as banks replenish the respective deposit insurance fund more quickly. The share of insured deposits and the fund target rates are upper-bounded in the robustness analysis. This is because higher share and higher target rates go hand in hand with a higher fund volume of the national deposit insurance. Accordingly, the bank risk shock does not lead to a depletion of national funds. In this case, EDIS does not intervene. In contrast, an insurance share via EDIS is associated with a slightly positive stabilization effect on GDP. With a higher share of household transfers to bankers and a higher banker survival rate, the EDIS effect turns out lower, as both parameters determine the level of bankers' net worth. The more households transfer to banks or the more bankers survive in each period, the higher banks' net worth. With a higher net worth, the default probability is lower, so the introduction of EDIS does not generate quite as large stabilization benefits as in the baseline.

6.3 Welfare Analysis

In the following, we investigate the welfare implications of the different forms of risk-sharing discussed in section 4.2. We first evaluate how the implementation of risk-sharing affects welfare. To account for uncertainty about 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 the 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 policy debates about EDIS. Third, while these analyses assume the existence of different risk-sharing devices in the first place, we also study the 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 is crucial in current proposals. Thus, we shed light on the desirability of such deductions from a welfare perspective.

6.3.1 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

$$Y_t = g(Y_{t-1}, \varepsilon_t), \tag{47}$$

our stochastic steady state satisfies

$$\overline{Y} = g(\overline{Y}, 0). \tag{48}$$

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

$$\lambda^w = (1 - \exp[(V_0^{Pol} - V_0^{Base})(1 - \beta)]) \tag{49}$$

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 the 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

$$V_t \equiv \sum_{c=1}^{2} \sum_{j=1}^{2} \omega_j^c V_{j,t}^c \tag{50}$$

where

$$\omega_j^c = \frac{C^{c\zeta}_{j,t}}{\sum_{c=1}^{2} \sum_{j=1}^{2} C^{c\zeta}_{j,t}} \tag{51}$$

with the welfare weight $\zeta = 1$.[29]

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

6.3.2 Baseline Results

In table 5, we report conditional welfare expressed by the regime-specific stochastic steady states. We thereby condition the presence of bank risk shocks, where we calibrate the size of the shock in one country to match the increase in bank risk necessary to trigger a regime switch. The conditional welfare measure, therefore, considers that agents account for future risks associated with bank risk shocks. We report the relative performance of both variants of EDIS introduced in section 4.2. 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 49. For the baseline V_0^{Base}, we choose the scenario described in section 4.2 where the national government is expected to step in once the national DI is exhausted. Besides the total relative welfare measure we report a welfare decomposition by households and entrepreneurs.

While differences between the government backstop and the EDIS scenarios are relatively small, welfare gains and losses depend on the regime agents finding themselves in the 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 the smallest (regime 1). Agents price in future uncertainty from bank risk shocks and the possibility to enter a regime where either national governments or EDIS has to step in. In contrast, whenever households live in a constrained economy (regimes 2 and 3), their welfare is higher under both EDIS variants than under fiscal backstops. EDIS has positive effects on entrepreneurial welfare in the more risky foreign country, but negative welfare effects in the safer home country. The deductibility of EDIS contributions is in particular welfare-improving in the affected country.

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 government backstops exist.

6.3.3 Welfare Effects of Alternative Contribution Schemes

As discussed in assumption 1, the design of EDIS contributions is still an open issue in policy negotiations. While some approaches favor risk-weighted contribu-

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								
Household Welfare	-0.01	-0.01	-0.10	-0.06	-0.07	0.01	-0.15	-0.03
Entrepreneur Welfare	0.06	0.06	0.01	0.03	0.05	0.08	0.01	0.06
Total	-0.00	-0.00	-0.10	-0.06	-0.05	0.02	-0.13	-0.02
Foreign								
Household Welfare	-0.02	-0.02	-0.07	0.00	-0.20	-0.06	-0.25	-0.04
Entrepreneur Welfare	-0.01	-0.01	-0.02	0.03	-0.14	-0.05	-0.15	-0.01
Total	-0.01	-0.01	-0.02	0.02	-0.15	-0.05	-0.16	-0.02
Union-Wide								
Household Welfare	-0.02	-0.02	-0.08	-0.03	-0.13	-0.02	-0.20	-0.04
Entrepreneur Welfare	0.02	0.02	-0.00	0.03	-0.04	0.02	-0.07	0.02
Total	-0.01	-0.01	-0.06	-0.01	-0.01	-0.02	-0.15	-0.02

Note: Welfare is measured in consumption equivalents (equation 49, $100 \times \lambda^w$) and welfare of borrowers and savers in each country are weighted with Pareto weights (equations 50 and 51). Regimes are defined as in table 1. EDIS 1 refers to the baseline case, EDIS 2 refers to the no-deductibility scenario of EDIS contributions from contributions to national DI.

tions, such risk-based payments can, if applied on the sectoral level, act procyclical and increase financial cycles. We show welfare under different relative contribution schemes in figure 5, where we choose regime 4, a state 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 on the country level (see assumption 1), we allow the weighting of contributions to be governed by parameter α^{RW} in the exercise.[30] The relative contributions from equation 42 thus become

$$\tau_t^{EDIS,h} = \alpha^{RW} \tau_t^{EDIS} \tag{52}$$

$$\tau_t^{EDIS,f} = (1 - \alpha^{RW}) \tau_t^{EDIS}. \tag{53}$$

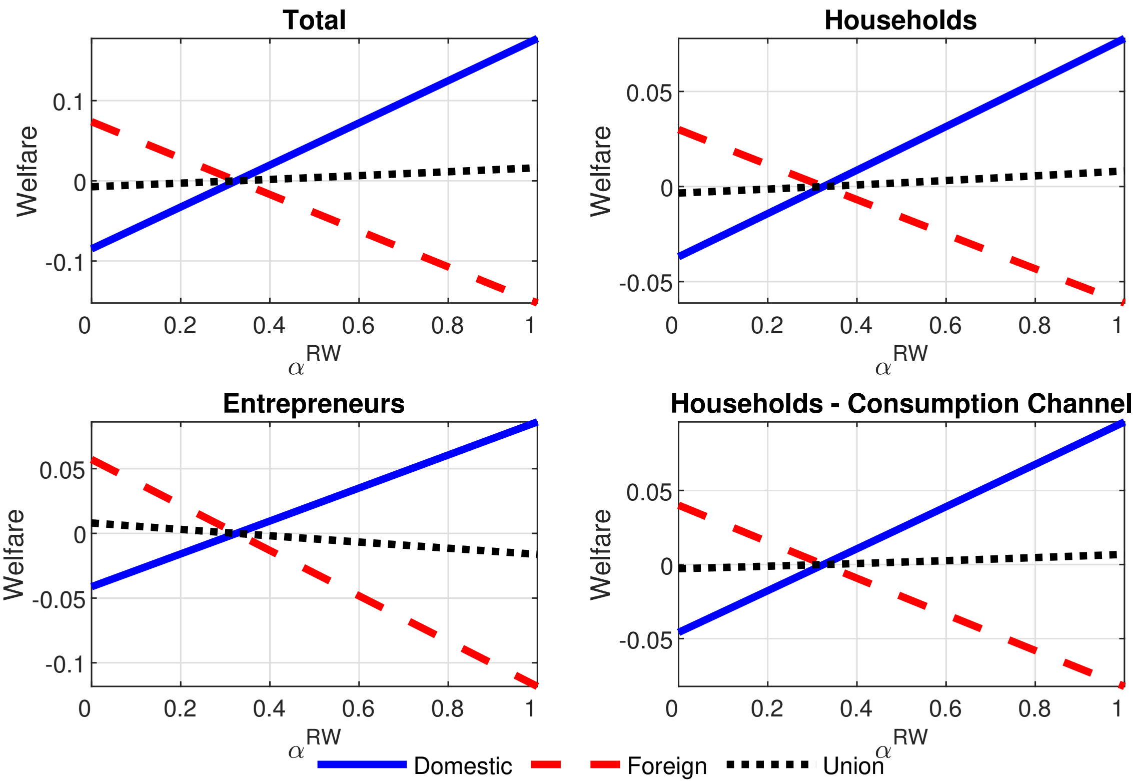
We evaluate welfare in the deterministic steady state and compare it to the steady-state level under the baseline calibration – implying risk weights of 32 percent for the home country and 68 percent for the foreign economy in steady state – following the definition of consumption equivalents in equation 49.[31] For comparability, we

[30] Only the division of those contributions among both countries varies in this exercise. This shall not be confused with the complete abolition of risk-weighted contributions. EDIS contributions are still calculated on the realized bank risk in this section.

[31] 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 costs on insured deposits (equation 42). Thus,

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.

Figure 5: Steady-State Welfare for Alternative Contribution Weights

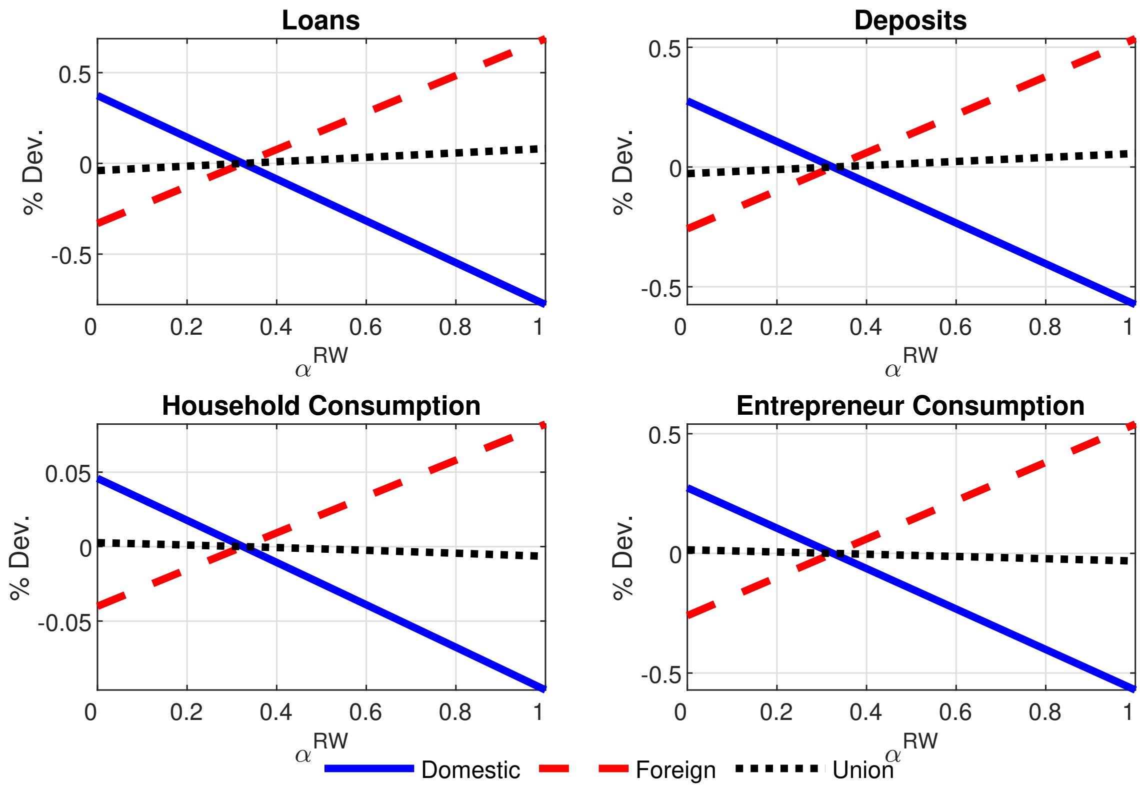


Note: Steady-state welfare for different contribution weights determined by α^{RW} in equations 52 and 53. Welfare is expressed as consumption equivalents (equation 49). For Consumption Channel, we exclude the labor-related term from utility function 1.

In total, low levels of α^{RW} are welfare-improving for the home economy (upper left panel figure 5). 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 6). 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 5). As lower lending dampens economic activity,

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 52 and 53 not comparable.

Figure 6: 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.

also households' income and ultimately consumption decline, leading to a reduction in household welfare if domestic contributions rise (upper right panel figure 5).

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 accrue in the foreign economy.[32] Due to higher Pareto weights, country-wide welfare is primarily driven by households (upper right panel figure 5). For entrepreneurs, a high value of α^{RW} is – on the union-wide level – associated with the largest welfare gains (lower left panel figure 5), 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 mod-

[32] We conducted robustness checks using alternative population weights, including weightings based on discount factors commonly used in the literature, see for instance Rubio (2011), Lambertini et al. (2013), or Gebauer (2021). Also under these alternative schemes, union-wide welfare differentials are negligible for different values of α^{RW}.

erate risk-sharing approach where both risky and save banks contribute is almost equally beneficial.

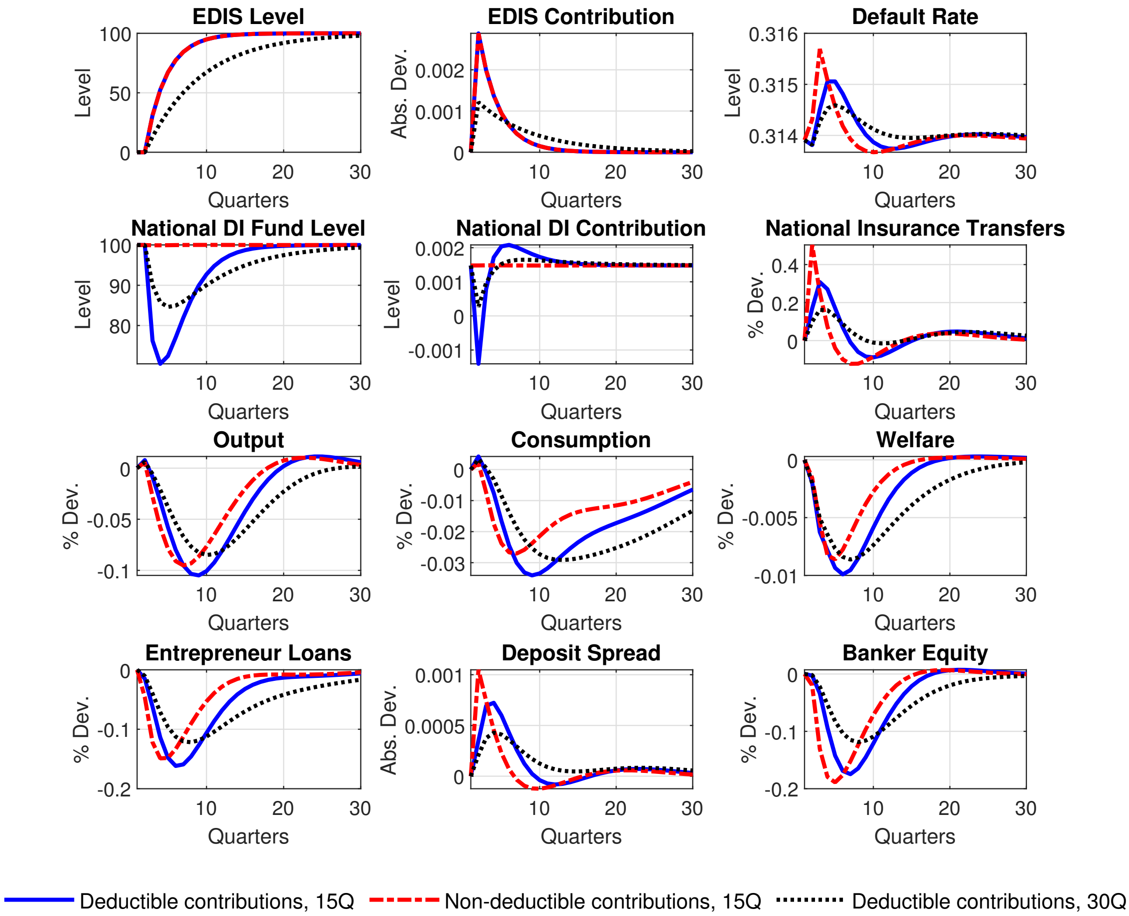
6.3.4 Welfare Effects of EDIS Implementation

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 42. 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 7 and 8, 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 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.

Relaxing assumption 2 ensures constant national DI coverage, but at the same time, the total transfers banks have to absorb an 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. While non-deductible contributions ensure that the national DI's capacities are on target, the double burden due to bank contributions to both insurance schemes can destabilize the financial system, with respective adverse real economic effects. However, the 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 con-

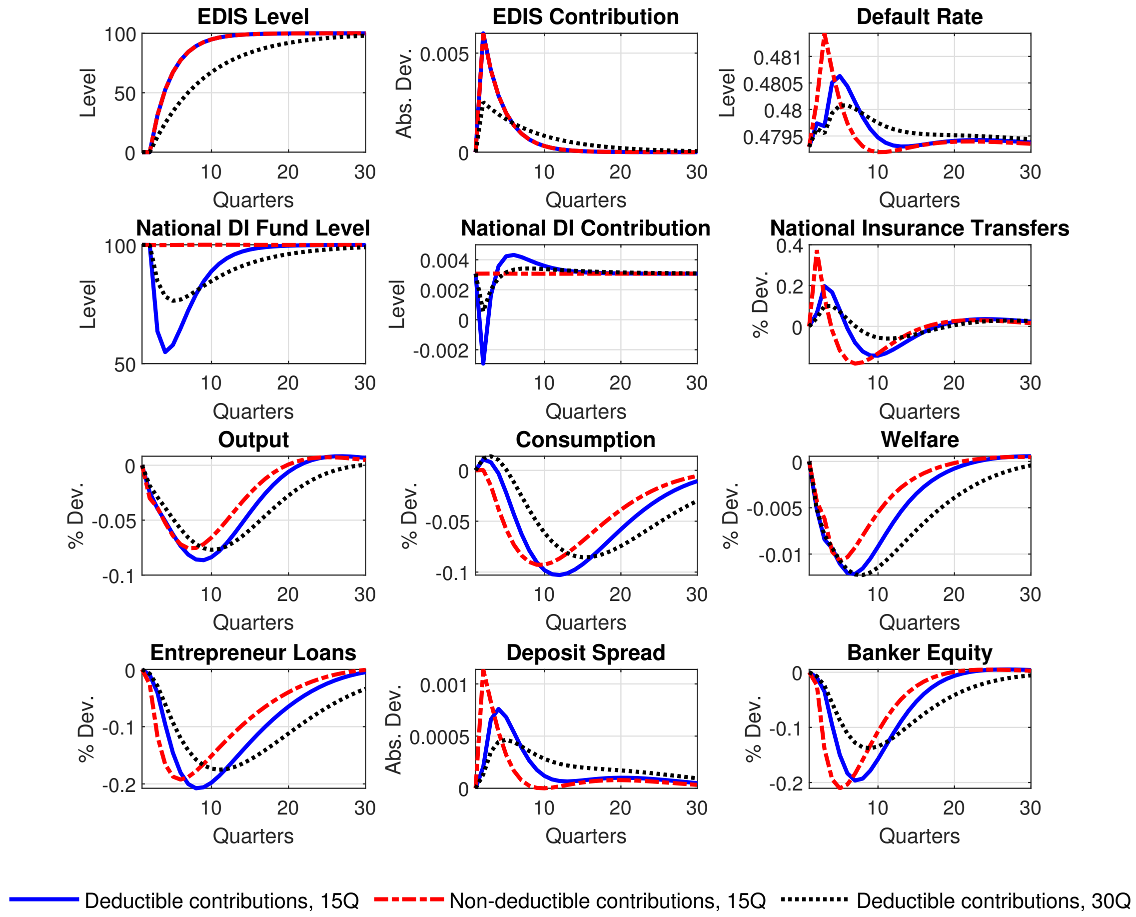
Figure 7: EDIS Implementation, Transition in Home



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 (black line).

tribution 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 7 and 8 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 both economies,

Figure 8: 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 (black line).

the prolonged phase of economic distress ultimately yields an equally pronounced decline and a longer recovery of social welfare compared to the baseline. 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.

6.4 EDIS and Macroprudential Policy

One important aspect of the effectiveness of EDIS relates to its interactions with other policies potentially affecting the banking sector. We, therefore, investigate the interaction of deposit insurance with macroprudential regulation in this section. We focus on bank capital requirements as a lender-side regulatory measure as they, like deposit insurance, directly relate to the financial positions of banks.[33]

Steady-state capital requirements and EDIS In the first exercise, we study the implications of changes in long-run bank capital requirements in both economies. To assess how such changes interact with EDIS, we run the steady-state exercise for two scenarios, one in which only domestic deposit insurances are active and a second in which only EDIS insures depositors in both countries.[34]

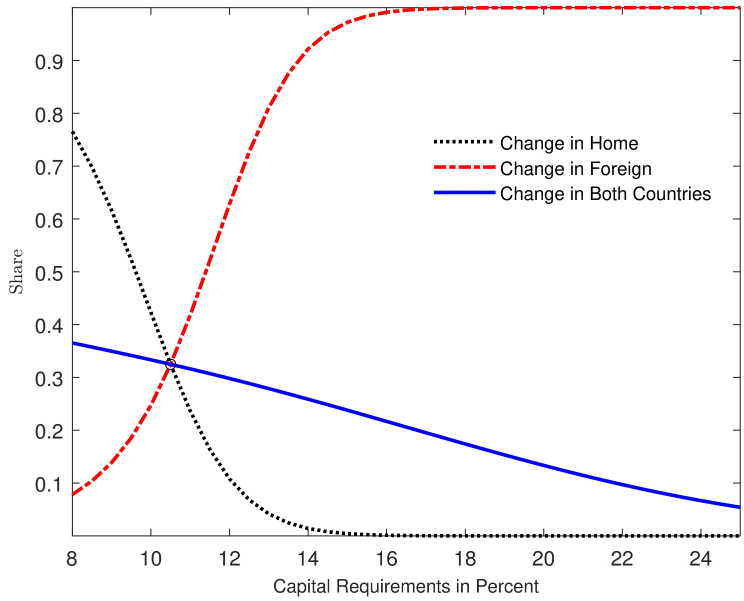
We particularly focus on potential interactions between steady-state capital requirements and banks' obligations to contribute to EDIS, as the design of the contribution rules reflects the core regulatory aspect of a deposit insurance scheme. As shown in figure 5, the risk-weighted contribution scheme given by assumption 1 implies a baseline risk-neutral share of home country contributions of around 32 percent under the baseline calibration. However, as shown in figure 9, changes in steady-state capital requirements affect the baseline risk-weighted contributions of both countries in steady state, with the share of home country contributions increasing with a reduction (an increase) in domestic (foreign) capital requirements: In line with the "polluter pays" principle given by assumption 1, the home country contributes more to the EDIS fund if the degree of macroprudential regulation relative to the foreign economy is lower. If both countries are subject to tighter time-invariant macroprudential regulation, the risk-weighted share of contributions of the home country's banking sector to EDIS is lower, as the relative decline in default costs due to tighter regulation weighs stronger in the home economy.

In a second step, we study how this interaction of macroprudential regulation and risk-weighted EDIS contributions affects the stability of the financial sectors and broader macroeconomic conditions in both countries. In figures 10 and 11, we assess changes in steady-state capital requirements for the boundary cases in which all contributions are either provided by the home or the foreign country's banking

[33] Alternatively, the interaction of deposit insurance with borrower-side macroprudential policies like borrower loan-to-value (LTV) ratios could be studied with the help of our model. We leave this for further research.

[34] The second scenario refers to the steady state of the state in which national DI is fully depleted and only EDIS is active (regime 4 in table 1 with EDIS). It thus resonates more with the European Commission's proposal of a fully integrated European deposit insurance fund to be implemented in the long run than with the re-insurance scheme we studied so far. We focus on the fully integrated scenario in this exercise as we are particularly interested in such long-run equilibrium interactions of (static) capital regulation and EDIS in the steady-state analysis.

Figure 9: Home Country's Risk Weights for EDIS Contributions as a Function of Bank Capital Requirements



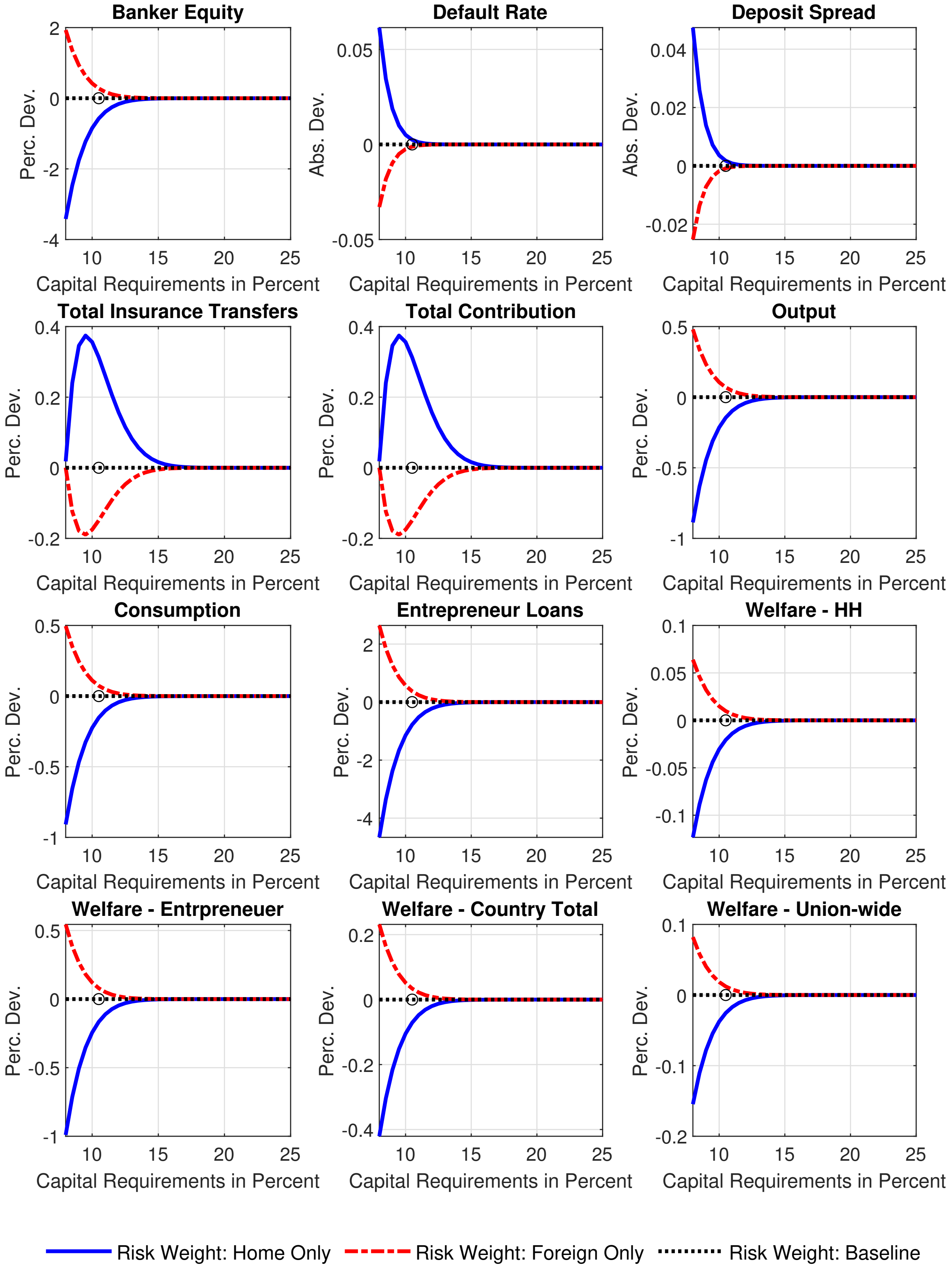
Note: Country-specific contributions to EDIS weighted by expected default costs as specified in equation 42.

sector, i.e. when $\tau_t^{EDIS,h}$ is either equal to zero or one. We compare the results under EDIS with the case where only the national deposit insurances are in place and assume that steady-state capital regulation is identical in both economies.

Whenever contributions accrue completely to the home economy's banking sector and capital regulation is low, having EDIS in place is particularly beneficial for the foreign economy, as bank equity holdings are relatively larger, default rates are lower, and economic activity and welfare are higher with EDIS compared to the no-EDIS scenario. In contrast, under an extreme form of the "polluter pays" principle, with the riskier foreign banking sector providing all contributions, EDIS turns out particularly beneficial for the home country whenever macroprudential regulation is lax.

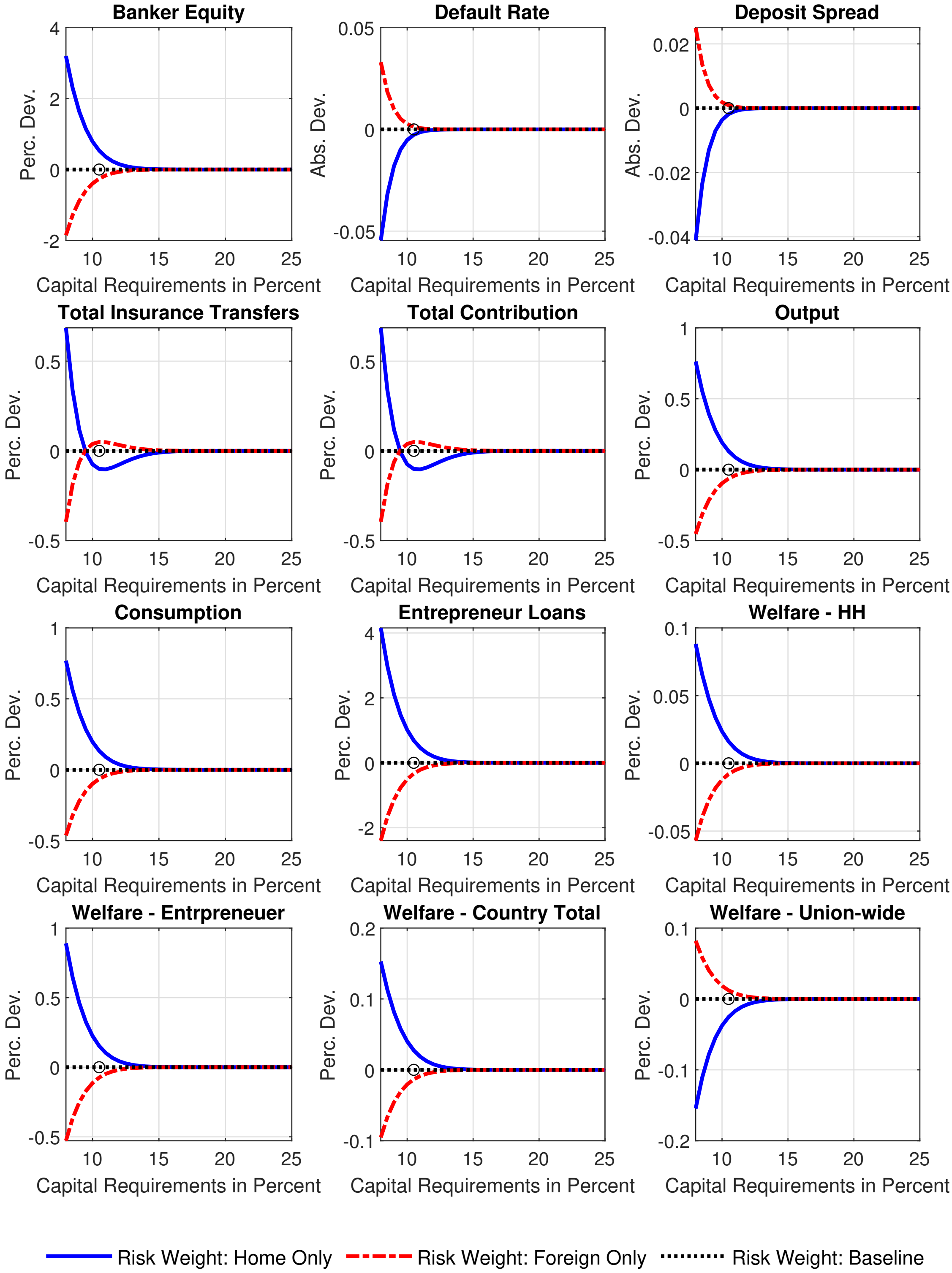
Importantly, as discussed in detail in appendix C, our risk-sharing approach implies that moral hazard may arise in the long run if we deviate from the assumption that insurance payments match contributions – such that the fund level is positive and stable in the long run – which would give rise to a permanent moral hazard motive for banks in both countries via EDIS. In addition, the deviation from risk-weighted contribution schemes might also induce moral hazard for either one of the two countries. In turn, low capital regulation fosters additional risk-taking

Figure 10: Steady-State Differences between EDIS and Domestic DI for Different Levels of Capital Requirements in Both Countries, Percentage Changes in Home



Note: Relative differences in steady-state values of selected variables of the home economy between the European deposit insurance scenario and the domestic deposit insurances. Circle markers represent benchmark steady-state calibration. Changes between both insurance schemes are reported in percentage deviations and are plotted against changes in the capital requirement value in both countries.

Figure 11: Steady-State Differences between EDIS and Domestic DI for Different Levels of Capital Requirements in Both Countries, Percentage Changes in Foreign



Note: Relative differences in steady-state values of selected variables of the foreign economy between the European deposit insurance scenario and the domestic deposit insurances. Circle markers represent benchmark steady-state calibration. Changes between both insurance schemes are reported in percentage deviations and are plotted against changes in the capital requirement value in both countries.

by relaxing the lending constraint given in equation 15 and ultimately lowering the default threshold 17. Consequently, additional risk-sharing via non-risk-neutral EDIS contribution shares turns out particularly beneficial for the banking sector without the obligation to contribute to the insurance fund. However, the relative benefits or impediments from EDIS are negligible whenever capital requirements are high, as the risk-taking channel from deviating contributions is offset by tight regulation. Similarly, whenever contribution schemes are calibrated in line with the risk weights under the baseline, moral hazard vanishes, such that risk-sharing under both EDIS and the national insurances is equally effective.

The findings thus imply that under adequately designed risk-weighted contributions, EDIS does not in itself foster additional risk-taking or moral hazard in the long run. Only if EDIS contributions deviate from the risk-neutral design, EDIS could have diverging effects on financial stability and economic activity in both economies. In such a situation, long-run macroprudential policies may compensate for any unwarranted deviations with EDIS.

While we conclude that moral hazard due to EDIS is not a concern in the long run in our framework with risk-weighted contributions, the cyclical stabilization effects of EDIS discussed in section 6.1 however imply that EDIS may foster bank risk-taking and moral hazard temporarily, as for instance insurance payments are large during a financial crisis, while bank contributions only accrue with a lag. Such short-term intertemporal dynamics in the presence of financial shocks may therefore imply that the scope for a complementary role of macroprudential policy may be larger in the presence of EDIS.

Dynamics of capital requirements and EDIS In addition to analyzing the static long-run interactions of macroprudential policy and EDIS, we investigate the dynamic short-term interactions of both policies, with a view to the extent to which stabilization via EDIS is affected by exogenous changes in capital requirements.

Changes in bank capital requirements can have two opposing effects. On the one side, lower capital requirements potentially increase bank defaults and thus agents in the economy face higher total costs of default. Higher costs of default in turn can act contractionary, decreasing credit, output, and ultimately overall welfare. On the other side, lower capital ratios may force banks to reduce their inside equity and hence to provide more lending to the real economy. This channel has potentially expansionary effects on output and welfare.

In our model, these two opposing channels imply that the link between steady-state capital requirements and long-term macroeconomic activity, financial intermediation, and welfare follows a hump-shaped pattern[35]: Steady-state capital requirements below an optimum value of 12 percent imply that the first channel dominates, whereas for higher steady-state capital ratios the second channel is predominant. In return, a further easing of capital requirements acts contractionary for low levels of the steady-state requirements, while the opposite holds for steady-state requirements above 12 percent.

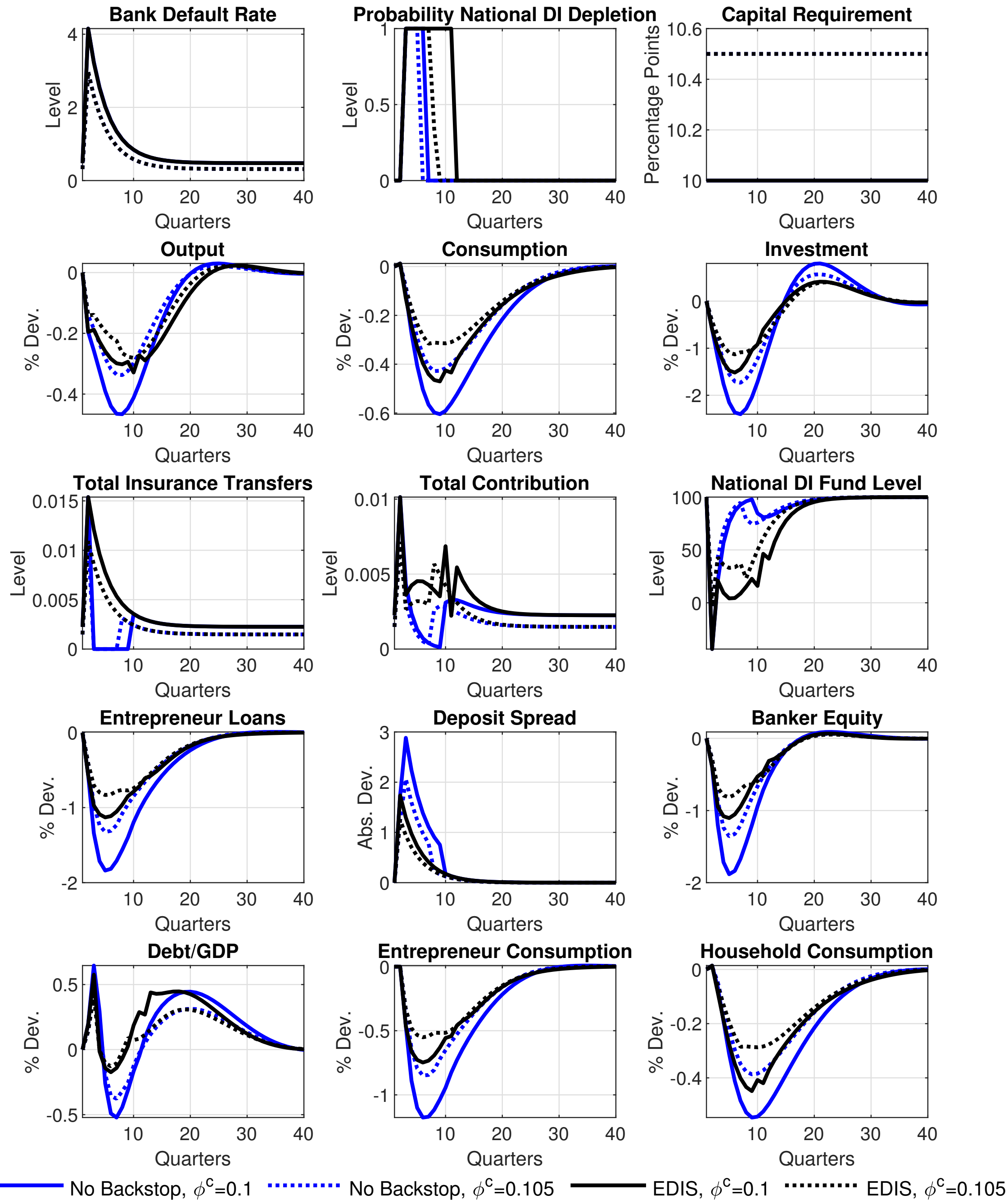
We are interested in two questions: (i) How large are the dynamic stabilization effects of capital requirements on their own? and (ii) how large are the synergies between capital buffers and EDIS? To answer these questions, we repeat the simulation from section 6.1 with the benchmark capital ratio $\phi^c = 0.105$ (dashed line) and a less stringent capital ratio of $\phi^c = 0.1$ (solid line) for both the scenarios with EDIS (black line) and without EDIS (blue line) in figure 12.

Our simulations confirm previous findings that the stabilization properties of macroprudential policy depend largely on the initial level of steady-state capital requirements, relative to the optimal level.[36] We find that below the optimal value of 12 percent, tighter capital requirements, independent of EDIS, lead to a stabilization of output, consumption, and other macroeconomic variables in the presence of an adverse bank risk shock. However, the largest stabilization effects in terms of real activity and financial intermediation are achieved when both EDIS and macroprudential policy are activated, and when the latter is relatively tight: The decline in lending and real economic activity is least pronounced, and bank equity is stabilized the most when both policies are in place and capital requirements are set to 10.5 percent. As already shown in section 6.1, EDIS temporarily reduces the risk for depositors and enables banks to take up more risks and increase lending, while the higher contributions needed to refill the fund accrue mainly ex-post. Thus, if the actual capital ratio is below the optimum level, even under active macroprudential regulation, EDIS has additional potential for stabilizing the banking sector and ultimately economic activity.

[35]We discuss the hump-shaped effect of capital ratios on economic activity in detail in appendix D. The hump-shaped pattern also features in Mendicino et al. (2018, 2020).

[36]We define as the optimal level of capital requirements the value at which output, consumption and loans are maximized, see appendix figure 17. This follows the approach in (Mendicino et al., 2018), with the difference that the welfare optimal level has been considered therein.

Figure 12: Bank Risk Shock under Different Capital Requirement Levels in Home, Impulse Responses in Home



Note: Impulse responses to a bank risk shock triggering a depletion of the domestic deposit insurance fund.

By contrast, when capital requirements are set above the optimal steady-state level, a slight increase in bank default risk would not translate into a depletion of the national deposit insurance in the banking crisis scenario. Therefore, EDIS would not be activated in this case. Thus, with steady-state capital requirements above the optimum, macroprudential policy would act as a substitute for EDIS and compensate for its stabilization effects.

6.5 EDIS and Bank Runs

The previous analysis may underestimate the benefits of deposit insurance schemes as these are also introduced in order to avoid costly bank runs.[37] In this section, we evaluate both the additional stabilization effects of EDIS in the case of a bank-run equilibrium and its ability to prevent runs in the first place. We extend our baseline model with a bank-run mechanism that builds on two necessary ingredients: First, we allow for a distinction between a low and a high financial distress state, with the latter being characterized by a higher cost of monitoring the soundness of the banking system. Second, we introduce a sunspot shock that may trigger a bank run whenever the financial sector is in an "in-between" state where agents wrongly believe the economy to be in a state of high financial distress even though financial sector fundamentals still imply low monitoring costs. We thus follow the model class of self-fulfilling deposit roll-over crisis that gives rise to two equilibria: a no-run equilibrium and a run-equilibrium.[38] Due to limited liability and costly state verification, savers who wrongly expect the default of a number of otherwise fundamentally sound banks[39] are not willing to roll over their deposits to these banks. In return, these banks then face severe liquidity problems rendering the decision to default optimal. Hence, a self-fulfilling bank run occurs.

We will briefly sketch both ingredients of our bank-run mechanism in the following before turning to simulation results.[40]

[37]See Diamond and Dybvig (1983, 1986); Iyer and Puri (2012); Iyer et al. (2016); Martin et al. (2022); Leonello et al. (2022).

[38]See Gertler and Kiyotaki (2015a); Gertler et al. (2020); Amador and Bianchi (2022).

[39]In technical terms, savers believe counterfactually to be already in the high-financial-friction state. Whether savers start believing in non-fundamental values instead of the economy's fundamentals is governed by the sunspot shock.

[40]A detailed description of our bank-run mechanism can be found in appendix section E.

6.5.1 Regime-Switching Financial Friction (RS-FF) Model

While depositor monitoring costs μ^c are time-invariant in the baseline model , we now introduce state dependence in financial distress by allowing for time-varying μ_t^c:

$$\mu_t^c = \begin{cases} 0.3 & \text{if } \psi_t^c < \overline{\Psi}^{c,FF} \\ 0.6 & \text{if } \psi_t^c > \overline{\Psi}^{c,FF} \end{cases} \tag{54}$$

Our framework relates to a strand of the literature highlighting the important role of state-dependent nonlinear financial frictions for the transmission of large financial shocks.[41] In line with Linde et al. (2016), we set the monitoring cost in the high distress state to 0.6[42] and the threshold value $\overline{\Psi}^{c,FF}$ to a quarterly default rate of 2.5.[43]

Consequently, we define the probability that the economy enters the high financial distress state as a function of realized bank defaults:

$$P_{1,j}^{FF} = \frac{1}{1 + \exp[-\alpha_1(\psi_t^c - \overline{\Psi}^{c,FF})]} \tag{55}$$

$$P_{j,1}^{FF} = \frac{1}{1 + \exp[\alpha_1(\psi_t^c - \overline{\Psi}^{c,FF})]}. \tag{56}$$

with $j \in \{2, 3, 4\}$, depending on the distance between actual bank default rates ψ_t^c and the imposed "high financial distress" threshold level $\overline{\Psi}^{c,FF}$. According to the resulting modified version of equation 28, the level of monitoring costs in the different regimes has a direct effect on the real costs of bank defaults:

$$\Omega_{t+1}^c = [\overline{\omega}_{t+1}^c - \Gamma_c(\overline{\omega}_{t+1}^c) + \mu_{t+1}^c G_c(\overline{\omega}_{t+1}^c)] \frac{R_{t+1}^{a,c}}{1 - \phi_t^c} d_t^c. \tag{57}$$

6.5.2 Sunspot Shock and Bank-Run Scenario

The non-linear behavior of monitoring costs is the first necessary condition to introduce bank runs to our model. The second element is a sunspot shock that causes households to believe to be in a high financial distress state where high monitoring costs accrue, even though fundamental values might not support this assessment.

[41] See Linde et al. (2016), Adrian et al. (2019), Harding and Wouters (2022), or Hubrich and Waggoner (2022).

[42] For a discussion on the increasing difficulty of monitoring bank risks whenever the financial sector is in distress, see for instance Linde et al. (2016).

[43] The selection of this value implies that the region in which a run equilibrium is possible coincides with the depletion of the domestic national deposit insurance funds.

Similar to Amador and Bianchi (2022) we allow for partial runs on individual banks. To do so, we assume that there exists a state of the world in which a bank run may occur. We model this state by assuming a relatively large bank risk shock that brings the economy close to switching to the financial distress state while being just too small to actually result in fundamental changes in monitoring costs. Whenever the economy is in this "in-between" state and households are simultaneously hit by the sunspot shock, households wrongly expect additional bank defaults. As a consequence, savers are not willing to roll over all their deposits, such that some banks face severe liquidity problems and have to default. Thus, household beliefs become self-fulfilling and a partial bank run occurs. We illustrate the "in-between" state and the self-fulfilling equilibrium in detail in appendix E.

In the following, we provide more details on the origin of the sunspot shock and its effects. We split the overall probability of a bank default p_t into two components:

$$\underbrace{p_t}_{\text{default}} = \underbrace{p_t^I}_{\text{insolvency}} + \underbrace{p_t^R}_{\text{bank run}} .$$

The probability $p_t^I = \psi_t^c$ of bank insolvencies is determined by the fundamental default threshold $\overline{\omega}_{t+1}^c$ and is the same as in the baseline model. The new component is the probability p_t^R for bank runs. p_t^R depends on the "non-fundamental threshold" $\overline{\omega}_{t+1}^{*,c}$. We motivate the counterfactual default threshold $\overline{\omega}_{t+1}^{*,c}$ by the notion that households - after being hit by the sunspot shock - believe that the return on assets $R_{t+1}^{a,c}$ is lower than its actual fundamental value.[44] Such non-fundamental beliefs result in a counterfactual increase in the default threshold and the default of an additional number of banks. In turn, households ask for risk compensation in the form of higher contractual deposit rates. This second-round effect results in an even stronger increase in the default threshold and expected defaults of banks.[45] In section E of the appendix, we illustrate that the RS-FF model gives rise to the "in-between" state in which self-fulfilling bank runs might occur when aggregate bank risk shocks fulfill the following condition: $\tilde{z}^{*,b,c} < z_t^{b,c} < \overline{z}^{b,c}$. As a consequence, the non-fundamental general equilibrium default threshold that would emerge can be written as:

$$\overline{\omega}_{t+1}^{*,c} = \frac{R_t^{*,d,c} d_t^{*,c}}{R_{t+1}^{*,a,c} a_t^{*,c}} + \frac{\tau_t^{*,DI,c}}{R_{t+1}^{*,a,c} a_t^{*,c}} = (1-\phi_t^c)\left(\frac{R_t^{*,d,c}}{R_{t+1}^{*,a,c}} + \frac{\tau_t^{*,DI,c}}{R_{t+1}^{*,a,c} d_t^{*,c}}\right), \tag{58}$$

[44] Similarly, in Gertler et al. (2020) households believe in a non-fundamentally lower price of bank assets.

[45] The beliefs of households of low non-fundamental asset returns thus have both a direct partial equilibrium effect on the default threshold and an indirect general equilibrium effect.

such that $\overline{\omega}_{t+1}^{*,c} > \overline{\omega}_{t+1}^{c}$.

6.5.3 Bank-Run Simulations

In the following exercises, we simulate a severe banking crisis that causes a depletion of national deposit insurance coverage. Several empirical studies find that banking crises most likely get amplified in the absence of a backstop mechanism provided by deposit insurance or the government stepping in to cover banks' liquidity needs.[46] We show in a first exercise that self-fulfilling bank runs have the potential to amplify a financial crisis and a resulting recession in a situation without any further backstop. To this end, we show the differences in the responses of macroeconomic and financial variables to the same financial shock when allowing for bank runs, compared to our baseline framework without runs.

In a second exercise, we show that EDIS can potentially prevent a bank run. We show that the performance of EDIS is the same as under the baseline model in which the possibility of runs is completely absent. This second exercise depicts the bank-run extension of our baseline analysis of the stabilization effects of EDIS in section 6.1.

Self-fulfilling run after deposit insurance depletion Similar to our baseline analysis in section 6.1, we simulate the economy's response to a sequence of adverse bank risk shocks that increases bank defaults to a peak value of about 2.47 percentage points. The bank default rate is thus above the value obtained in figure 1 and high enough for the economy to enter the "in-between" state.[47] Once the national deposit insurance depletes in period three, the realization of the sunspot shock triggers a bank run.[48]

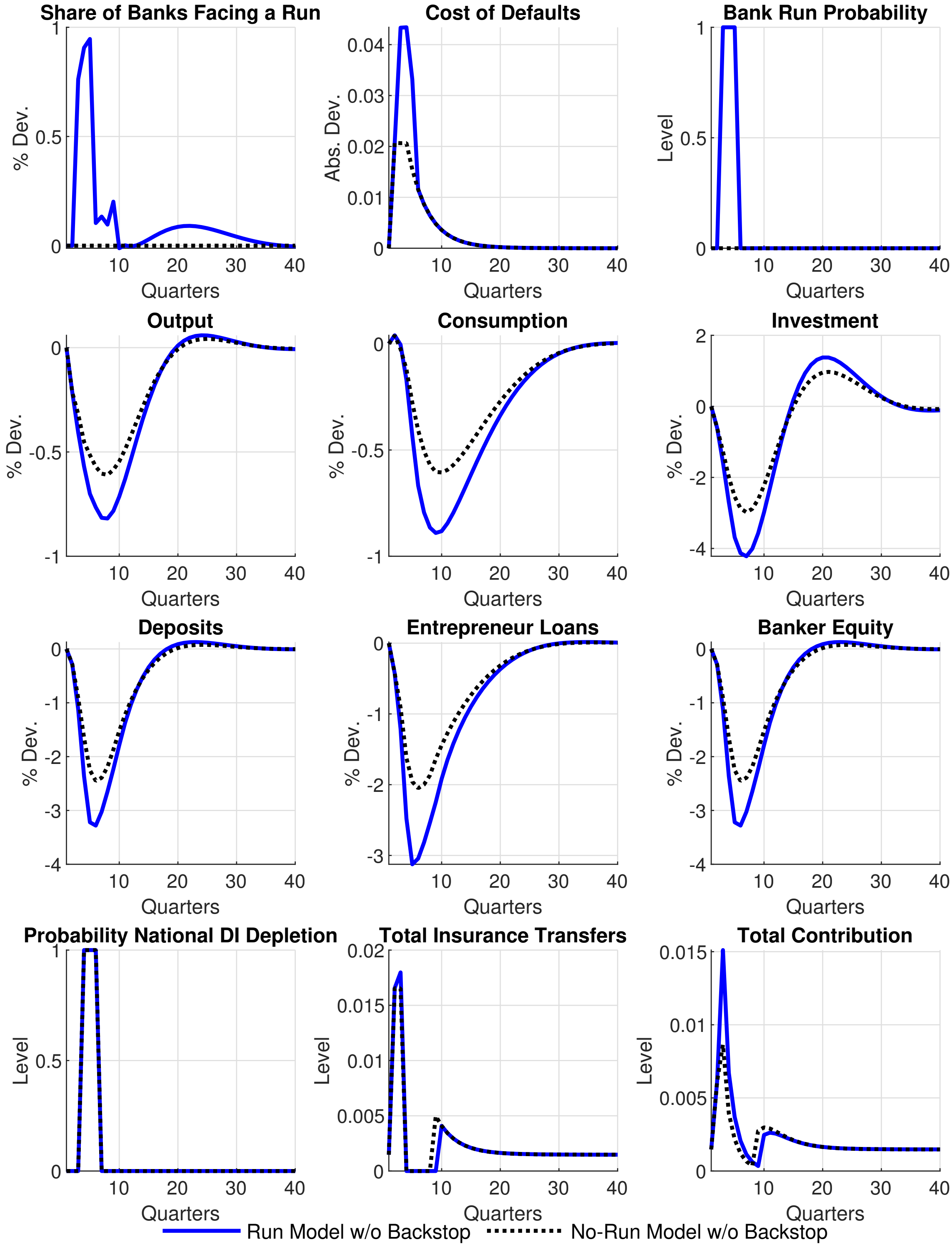
As shown in figure 13, the partial bank run amplifies the recession and worsens the conditions of the banking sector. The higher share of defaulting banks in the run equilibrium causes the economy to switch to the high financial distress state, increasing the costs of default, which double in the periods where the run occurs compared to the benchmark scenario. Over the course of the run, the trough in

[46] See for instance Jasova et al. (2021) or Alves et al. (2021).

[47] See appendix E for a graphical visualization for which shock size the "in-between" state is reached.

[48] In fact, in the scenario of figure 13, we assume the banking crisis to trigger a run (period three) even before the national deposit insurance is depleted (period four).

Figure 13: Bank Risk Shock and Bank Run in Home, Impulse Responses in Home



Note: Impulse responses to a sequence of bank risk shocks. In the bank-run scenarios, the economy is hit by a contemporaneous sunspot shock that triggers a run. The first panel depicts the cumulative percentage share of banks facing a run relative to the no-run equilibrium.

output is approximately 40 percent lower compared to the benchmark case.[49] Savers refuse to roll over deposits to some otherwise fundamentally sound banks. The entire amount of deposits available in the economy is one percentage point lower in the run scenario, translating into similarly lower levels of lending provided to the production sector.

Can EDIS Prevent a Bank Run? We now study whether EDIS can prevent a self-fulfilling bank run. This exercise extends the analysis in section 6.1 in which we evaluate the performance of EDIS after the domestic insurance is depleted.

As before, we simulate an adverse bank risk shock that causes a depletion of the domestic deposit insurance in the home country.[50] In contrast to the scenario of figure 13, the shock itself turns out too small to enter the "in-between" region in which a bank run might occur. However, whenever depositors are not bailed out, the depletion of the domestic insurance additionally increases banks' funding costs and ultimately expected bank defaults. Thus, in the scenario without any depositor compensation, the economy endogenously enters the "in-between" state. We then assume again that households are hit by the sunspot shock in period three, such that a non-fundamental bank run occurs.[51]

We show in figure 14 that in such a situation, EDIS acts as a second line of defense and compensates for additional depositor losses, finally preventing the bank run.[52] We compare three scenarios: (i) the bank-run model with EDIS, (ii) the bank-

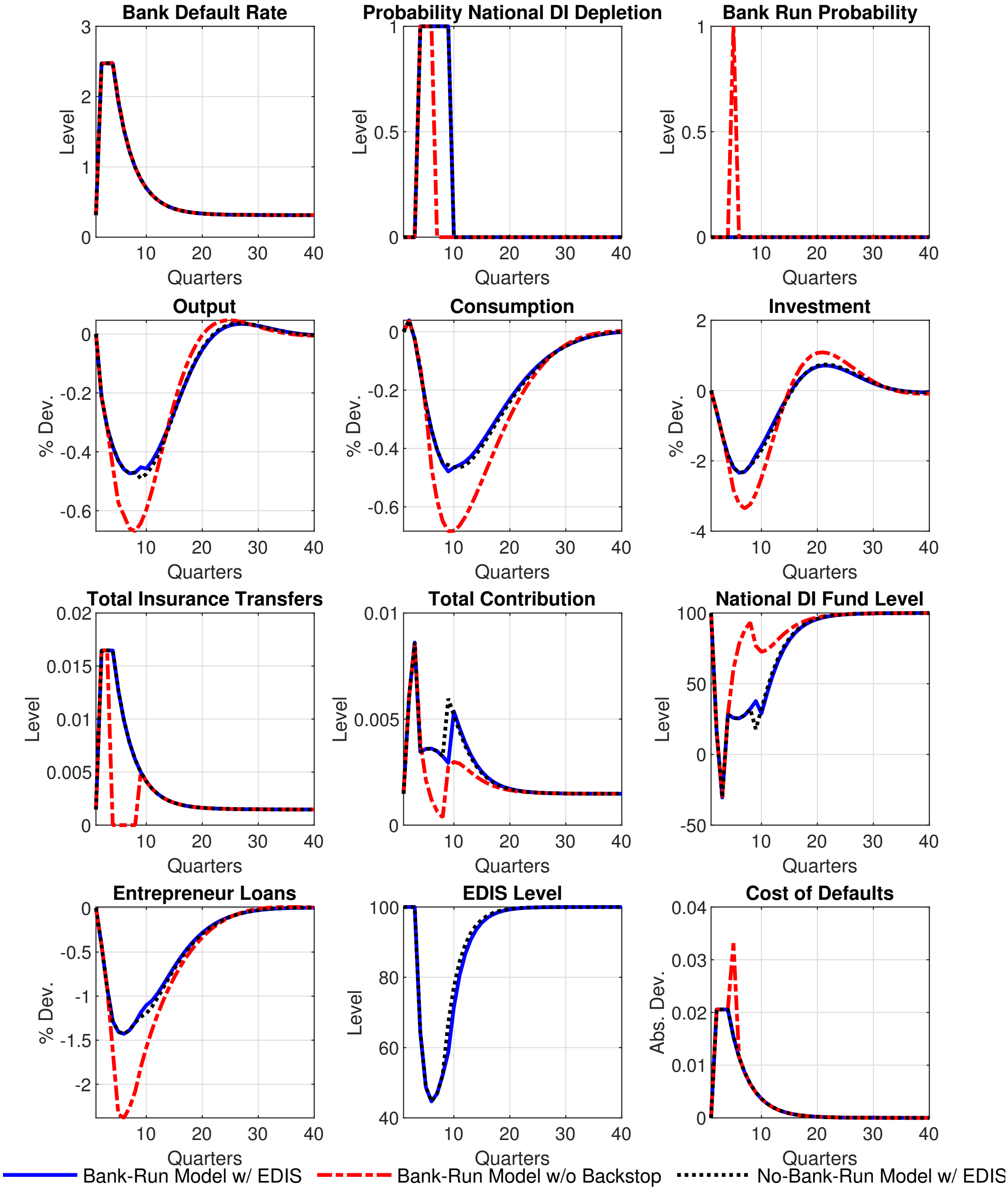
[49]The relative decline in output between both scenarios is comparable to results obtained in Gertler et al. (2020). In this study, a bank run results in a full collapse of the banking system at the trough, reflected in a 100 percent drop in bank net worth compared to a 40 percent drop in the no-bank run case. Translating the relative declines in the troughs – which imply a factor of 2.5 between bank-run and no-bank-run cases – to our results, we obtain a ratio of relative output declines of 2.7, close to a value of around 2.8 implied by figure 2 in Gertler et al. (2020).

[50]In difference to the analysis in section 6.1 the large bank risk shock is followed by two very small bank risk shocks. The reason is that in doing so, we ensure that bank default rates remain close to 2.4 percent also in period two when the domestic deposit insurance becomes depleted.

[51]In contrast to the scenario in figure 13, the baseline scenario in figure implies that the run (period five) occurs only after the national deposit insurance depletes (period four).

[52]The quantitative differences between the "EDIS" scenario in figure 1 and the "No-Bank-Run Model w/ EDIS" scenario of figure 14 are attributed to the extensions to the baseline model included in the RS-FF model. In the RS-FF model, agents take both the possibility of a bank run and a fundamental switch to the distress state into account. In both cases, bank monitoring costs would be higher, and agents' awareness of these additional possible distress states aggravates the recession even if no bank run actually occurs.

Figure 14: Bank Risk Shock and the Prevention of a Run in Home, Impulse Responses in Home



Note: Impulse responses to a sequence of bank risk shocks for different policy scenarios of section 4. In the bank-run scenarios, the economy is hit by a contemporaneous sunspot shock triggering a run. Insurance Transfer depicts the amount of insurance provided by the national DI, national government, or EDIS. Insurance Transfer and Deposit Spread in absolute deviations from steady state, all other variables in percentage deviations.

run model without any backstop, and (iii) the no-run model with EDIS. In period two the domestic insurance is depleted. Under the no-backstop scenario (red dashed line), the depletion causes an additional increase in bank defaults that makes a bank run feasible. In period three the economy under the no-bailout case switches to the run equilibrium, as visualized in the upper-right panel. In the otherwise comparable scenario with EDIS, no bank run occurs as the insurance transfers provided by EDIS prevent entering the “in-between” region, and ultimately the switch to the run equilibrium (blue solid line). Thus, a combination of a large banking crisis driving the economy close to the bank-run feasibility region, the presence of the sunspot shock and the absence of EDIS may trigger a bank run. We thus infer that the existence of EDIS can prevent the occurrence of self-fulfilling bank runs.

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 reinsurance by EDIS is more effective in stabilizing real activity, credit, and welfare than a national fiscal backstop. The drop in output is approximately 10 to 20 percent lower with EDIS, while respective figures for investment, consumption, and intermediated loans range between 20 to 50 percent. 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 the longest with EDIS. As financial risks are shared on the European level, foreign banks also need to contribute more to EDIS, with resulting adverse effects on lending and real economic activity. Our results indicate that the costs and benefits of EDIS are unequally distributed between countries, households, and entrepreneurs

Consequently, we analyze the welfare implications of a common insurance scheme. Welfare gains from EDIS over fiscal backstop 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.

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 to mitigate 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.

Concerning the interaction of EDIS with macroprudential policies, we find that while EDIS does not foster moral hazard in the form of excessive risk-taking by banks in the long run under our risk-weighted contribution scheme, deviating from such an approach implies that under low levels of macroprudential regulation, EDIS is particularly beneficial for the economy with a riskier banking sector, as risk-taking pays off proportionally more there. In such a situation, higher steady-state capital requirements may compensate for excessive risk-taking. Similarly, due to the intertemporal dynamics of EDIS transfers and contributions, temporary risk-taking may be fostered under EDIS over the financial cycle. Again, the best stabilization outcome is therefore achieved when both EDIS and capital regulation are active. Finally, we find that allowing for bank runs aggravates the depth of a financial crisis in our model, and show that EDIS can help to prevent such costly runs in the first place under certain conditions.

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A Complementary Parts of Two-Country Regime-Switching Model

In this appendix, we provide more details on the capital-producing sector, the international financial markets, and international trade of the model presented in section 3.

A.1 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,

$$\max_{I_t^c} E_t \sum_{\tau=t}^{\infty} (\beta_p^c)^\tau \frac{\Lambda_{\tau+1}^c}{\Lambda_\tau^c} \left\{ (q_\tau^{k,c} - 1) I_\tau - f^c \left(\frac{I_\tau^c}{I_{\tau-1}^c} \right) I_\tau^c \right\}, \tag{59}$$

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

$$\frac{\psi_i^c}{2} \left(\frac{I_t^c}{I_{t-1}^c} - 1 \right)^2 \tag{60}$$

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:

$$q_t^{k,c} = 1 + f_t^c(\cdot) + f_t^{c\prime}(\cdot) \frac{I_t^c}{I_{t-1}^c} - \beta_p^c E_t \left\{ \frac{\Lambda_{t+1}^c}{\Lambda_t^c} {f_{t+1}^c}'(\cdot) \left(\frac{I_{t+1}^c}{I_t^c} \right)^2 \right\} \tag{61}$$

A.2 Market Clearing

International Goods Market In each country, perfectly competitive firms produce the final good by aggregating a continuum of domestically produced and imported goods. The aggregate demand bundle for domestic households, entrepreneurs, and capital producers is compounded by the following technology:

$$x_t^c = \left[(\zeta^c)^{\frac{1}{\eta^c}} (x_t^{c,c})^{\frac{\eta^c-1}{\eta^c}} + (1-\zeta^c)^{\frac{1}{\eta^c}} (x_t^{c,\neg c})^{\frac{\eta^c-1}{\eta^c}} \right]^{\frac{\eta^c}{\eta^c-1}}, \tag{62}$$

where x_t^c is a placeholder for household and entrepreneur consumption demand ($c_t^{p,c}$, $c_t^{E,c}$) and capital producer investment demand (I_t^c). Parameter $\zeta_c > 0$ measures the degree of openness of the final good sector, the fraction of goods produced in the foreign economy. η^c denotes the elasticity of substitution between goods produced in either the home or foreign economy. Final goods producers' profit maximization yields the optimal demand functions for domestically produced and imported goods:

$$x_t^{c,c} = \zeta^c (p_t^{e,c})^{-\eta^c} x_t^c \tag{63}$$

$$x_t^{c,\neg c} = (1-\zeta^h)(p_t^{e,c} T_t)^{-\eta^c} x_t^c \tag{64}$$

Following Benigno (2004), the terms of trade are defined as 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 is defined by the terms of trade and the relative consumer prices in both countries:

$$RER_t = T_t \frac{p_t^{e,h}}{p_t^{e,f}}. \tag{65}$$

In both countries the goods markets clearing condition holds in equilibrium:

$$y_t^c = \zeta^c (p_t^{e,c})^{-\sigma^c} c_t^c + g_t^c + (1-\zeta^{\neg c}) \left(\frac{p_t^{e,\neg c}}{T_t} \right)^{-\sigma^{\neg c}} c_t^{\neg c} \tag{66}$$

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

$$tb_t = ex_t^h + T_t im_t^h, \tag{67}$$

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

International Financial Market Market clearing on the international financial market implies that equity supplied by international bankers has to accommodate equity demand by both domestic and foreign banks:

$$e_t^h = n_t^{h,h} + \frac{1}{RER_t} n_t^{f,h}, \tag{68}$$

$$e_t^f = n_t^{f,f} + RER_t n_t^{h,f}. \tag{69}$$

As bankers will not pay dividends prior to retirement, invested equity has to match the bankers' net worth:

$$n_t^{b,h} = n_t^{h,h} + n_t^{h,f}, \tag{70}$$

$$n_t^{b,f} = n_t^{f,f} + n_t^{f,h}. \tag{71}$$

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).

C Deposit Insurance and Moral Hazard

In this section, we show that domestic deposit insurance schemes do not induce any moral hazard in the long run. The same results hold for the introduction of a permanent EDIS that would replace the domestic schemes.

As stated in assumption 1, bank contributions to deposit insurance schemes are calculated on the basis of expected default costs and the overall share of insured deposits. To discuss how providing deposit insurance is linked to bank risk-taking and moral hazard, we investigate the effect of an increase of the share of insured deposits $\bar{\kappa}^c$ in steady state both analytically and in a comparative statics analysis.

Higher insurance shares reduce the risk premium on the deposit rate in equation 3. As a result, the lower contractual deposit rate $R_t^{c,d}$ affects the banks' first-order condition. In steady state, contractual deposit rates affect the optimal level of assets and deposits banks hold via the default threshold equation 17. Combining both equations yields an alternative expression for the steady-state default threshold:

$$\bar{\omega}^c = (1-\phi)\left(\frac{\tilde{R}^{d,c}}{R^{a,c}} + \frac{(1-\bar{\kappa}^c)\Omega^c}{R^{a,c}d^c} + \frac{\tau^{DI,c}}{R^{a,c}d^c}\right). \tag{72}$$

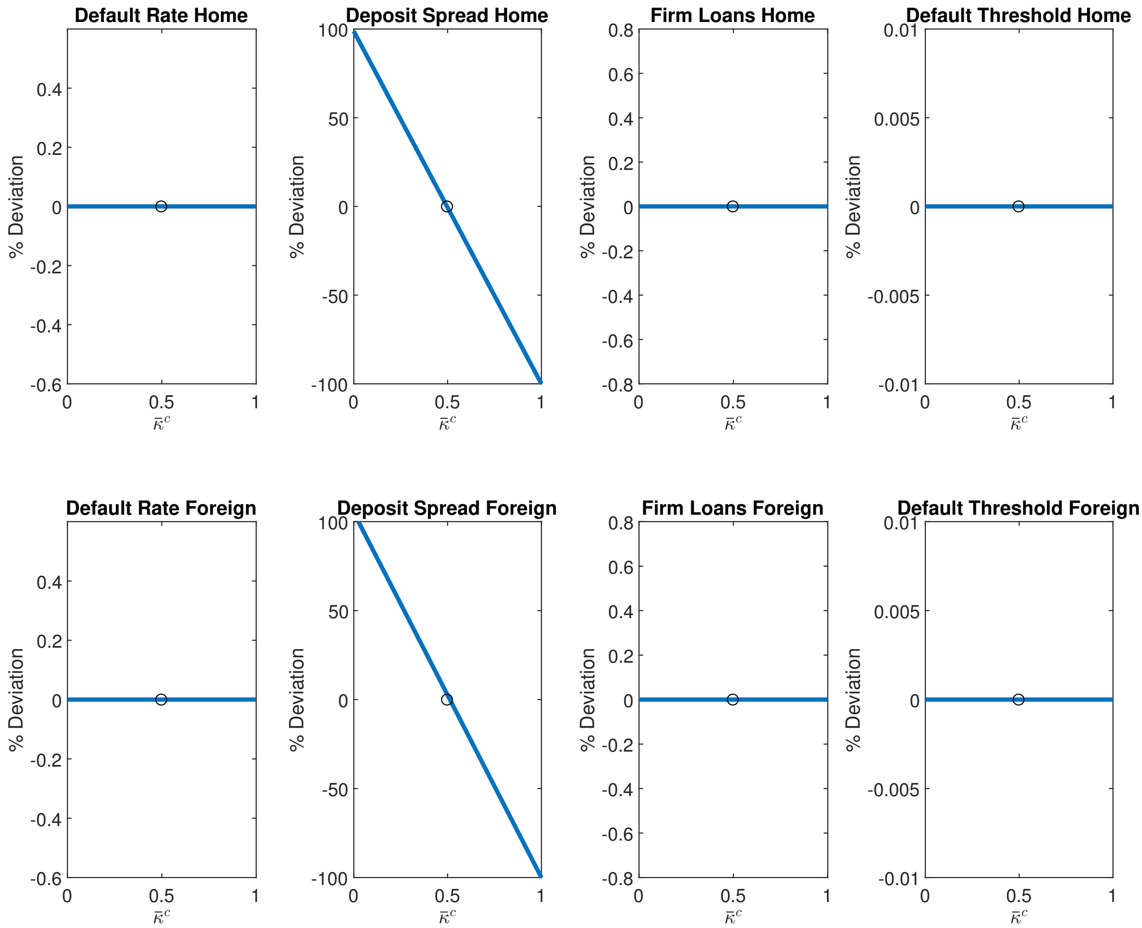
Increasing deposit insurance coverage via raising $\bar{\kappa}^c$ would only result in higher bank risk – and ultimately defaults – if, and only if $\bar{\kappa}^c\Omega^c > \tau^{DI,c}$. However, in such a situation, outflows would permanently surpass inflows, and the insurance fund's capital would converge to zero over time. Thus, in the long run, the following condition has to hold with equality: $\bar{\kappa}^c\Omega^c = \tau^{DI,c}$. Using this insight yields the following condition for the default threshold:

$$\bar{\omega}^c = (1-\phi)\left(\frac{\tilde{R}^{d,c}}{R^{a,c}} + \frac{\Omega^c}{R^{a,c}d^c}\right).$$

Consequently, in the long-run equilibrium, the default threshold, the spread between lending and borrowing rates, and intermediate firm loans remain unaffected by $\bar{\kappa}^c$. Hence, the adverse effects of higher bank contributions offset exactly the potential beneficial effects of a deposit insurance on banks' profits via lower contractual deposit rates.

In the next analysis we demonstrate that deposit insurance could in general cause an increase in moral hazard in the long run when we deviate from the condition $\bar{\kappa}^c\Omega^c = \tau^{DI,c}$.

Figure 15: Risk-Adjusted Contributions



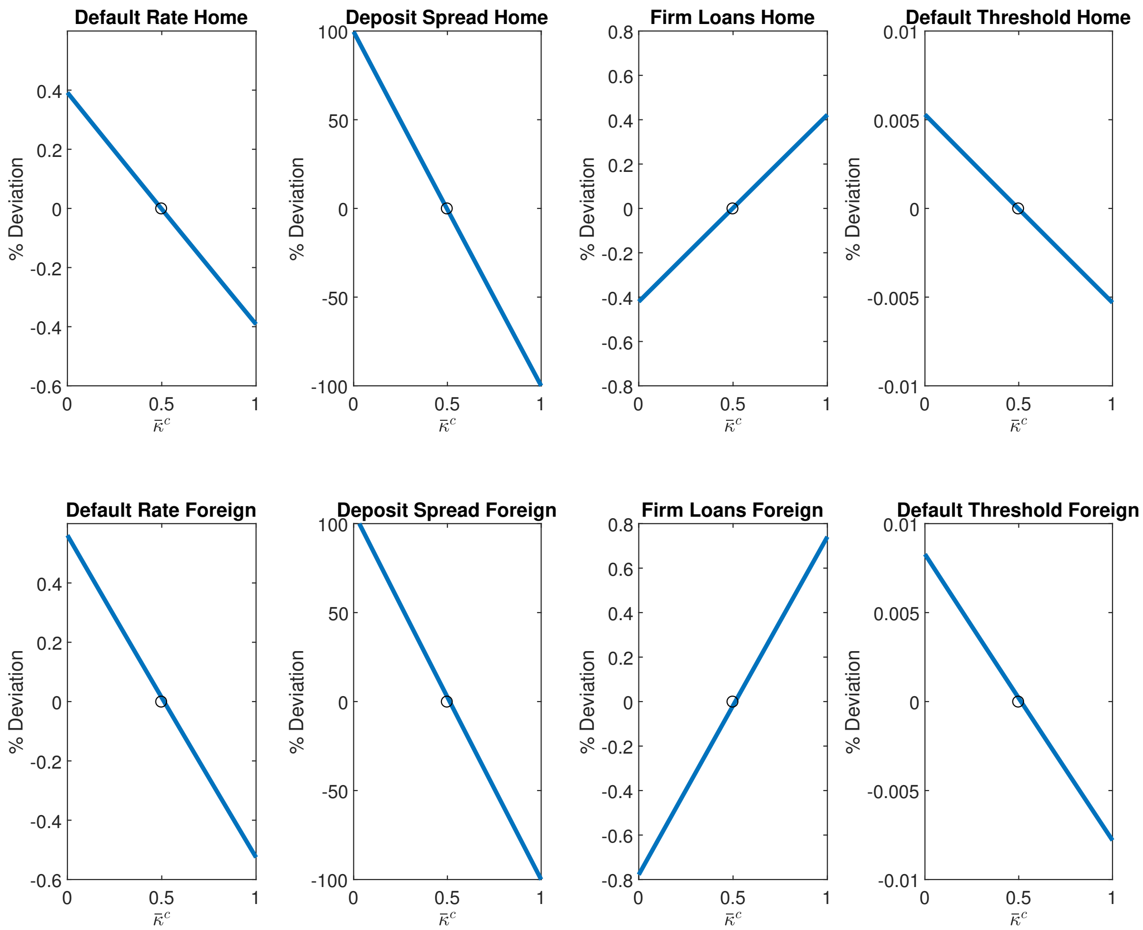
Note: Comparative statics analysis for simultaneously varying deposit insurance coverage $\bar{\kappa}^c$ in both countries $c \in \{h, f\}$. Steady-state deposit insurance outflows equal steady-state deposit insurance inflows: $\bar{\kappa}^c\Omega = \tau$. Circle markers represent benchmark steady-state calibration. All values are denoted in percentage deviations from benchmark steady state.

We run a comparative statics analysis based on the model steady state, by varying the share of insured deposits $\bar{\kappa}^c$. As shown in figure 15, as long as banks' risk-adjusted contributions to the insurance fund exactly balance with outflows, $\bar{\kappa}^c \Omega^c = \tau^{DI,c}$, neither defaults nor the volume of intermediate loans are affected. Only if we relax the assumption of balanced outflows and inflows, such that contributions are not risk-weighted anymore, increased lending activity and thus higher leverage and the resulting increase in bank defaults indicate moral hazard, as depicted in figure 16.[53] Thus, both national deposit insurances and EDIS, as described in our benchmark model, do not induce additional moral hazard to the banking sector in the long run.

In difference to the steady-state conditions outlined above, deposit insurance funds' outflows and inflows do not need to match in the short run. Increasing the insurance coverage temporarily can potentially increase bank risk-taking when bank contributions governed by the policy rule 29 at the same time remain largely unchanged. As shown in figure 1, this may be the case when a country is hit by a financial crisis. In such a situation, insurance outflows increase promptly, while contributions remain muted for some time. However, in order to maintain fund capital levels at the desired levels in the long run, contributions have to increase accordingly after some time. The initial benefits of higher deposit coverage in the early periods of the crisis are traded off with adverse effects due to relatively higher bank contributions in later periods, to make up for exhausted insurance funds. Thus, the scope for additional risk-taking is limited in the long run, such that our deposit insurance framework does not induce significant moral hazard.

[53]The comparative statics analysis violates the baseline condition that the long-run fund outflows have to balance the long-run fund inflows. We can only solve this model version in steady state.

Figure 16: No Risk-Adjusted Contributions



Note: Comparative statics analysis for simultaneously varying deposit insurance coverage $\bar{\kappa}^c$ in both countries $c \in \{h, f\}$. Steady-state deposit insurance inflows are constant at $\bar{\tau}$, not affected by variations of $\bar{\kappa}^c$. Circle markers represent benchmark steady-state calibration. All values are denoted in percentage deviations from the benchmark steady state.

D Macroprudential Policy

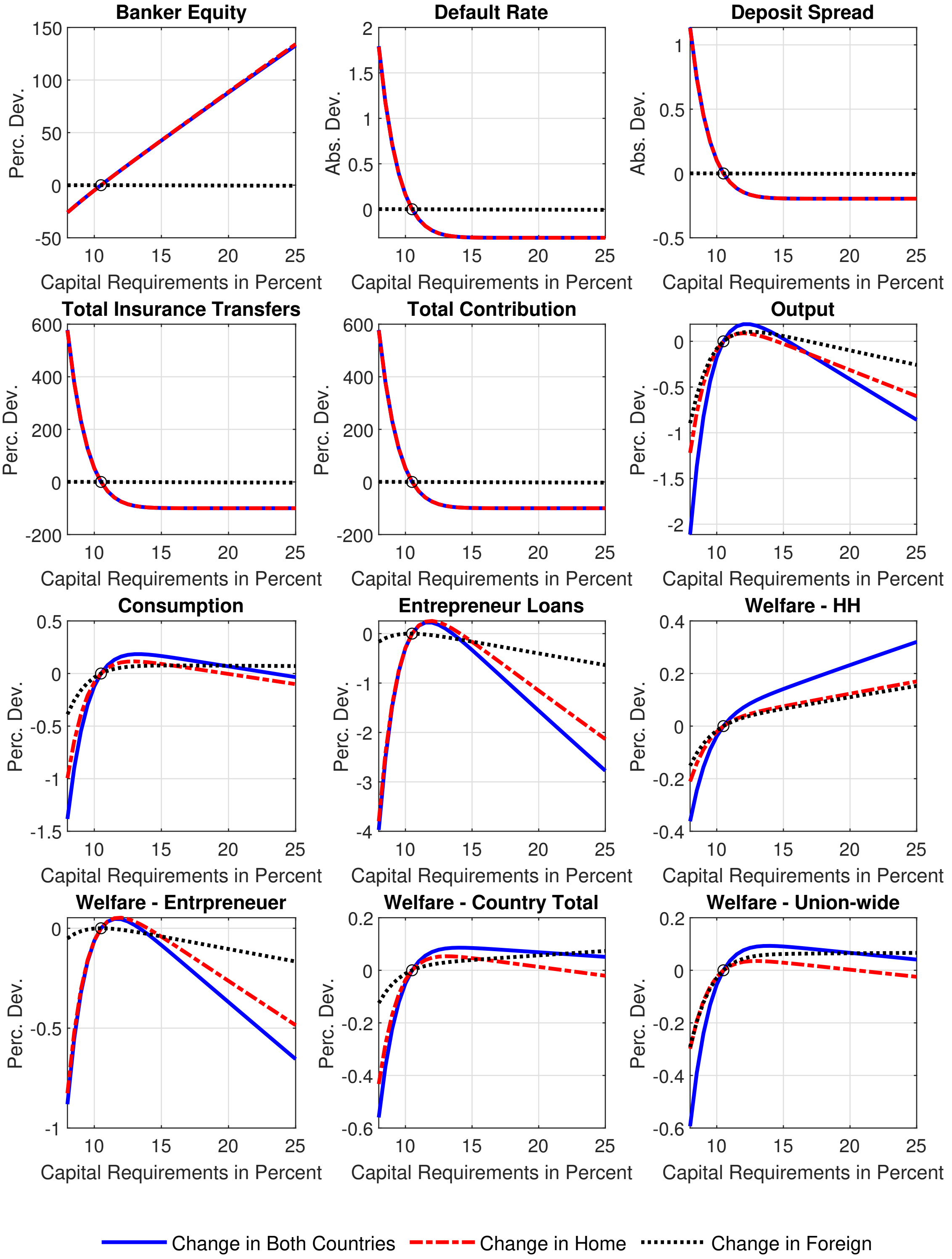
We demonstrate in section 6.4 that for bank capital ratios below 12 percent, EDIS can only foster risk-sharing across countries and induce moral hazard in the long run when country-specific contributions to EDIS are not weighted by countries' expected default costs. In this appendix, we visualize additional evidence for this finding. We do so by discussing the long-run properties of different capital requirements in our two-country setting. Since expected default costs decline with the bank capital ratio, the risk weight that neutralizes moral hazard is a function of the capital requirement as we depict in figure 9. Under our baseline calibration with a capital ratio of 10.5 percent, the implied steady-state risk weight is 32 percent for the home country and 68 percent for the foreign economy. The home country's risk weight increases with lower domestic capital requirements or with higher capital requirements in the foreign country which makes the foreign banking system safer in relative terms.

In figures 17 and 18, we show the long-run steady-state values for a selection of macroeconomic and financial conditions after changes in the capital ratio both for the home country and the foreign country. Three observations become apparent.

First, increasing the capital requirement in a given country significantly reduces the number of defaulting banks in the same country. For capital ratios of about 12 percent (14 percent), the default rate in the home (foreign) country is close to zero. When reducing the number of bank defaults, the required insurance transfers also approach zero. The latter explains why the differences between EDIS and national deposit insurances, visualized in figures 10 and 11, become negligible for capital ratios above 12 percent and 14 percent, respectively. With bank defaults being close to zero, there is no need for the existence of any deposit insurance. However, as we show below close-to-zero bank defaults come with the cost of lower economic activity and welfare.

Second, the effects of higher capital requirements on real economic activity, intermediated loans, and welfare are hump-shaped. In both countries, real economic activity, loans, and especially borrower welfare improved when capital requirements increase up to a certain threshold between $12 - 15$ percent. The hump-shaped pattern is a result of two distinct channels: (i) an increase in capital requirements decreases bank defaults and thereby reduces the high costs such defaults imply for the economy, but (ii) at the same time, higher capital ratios and thus higher levels of bank equity limit bank leverage positions and eventually intermediated loans, dampening economic activity. Up to capital ratios of $12 - 15$ percent, the first channel

Figure 17: Steady-State Changes in Home for Changes in Capital Requirements when the EDIS is active

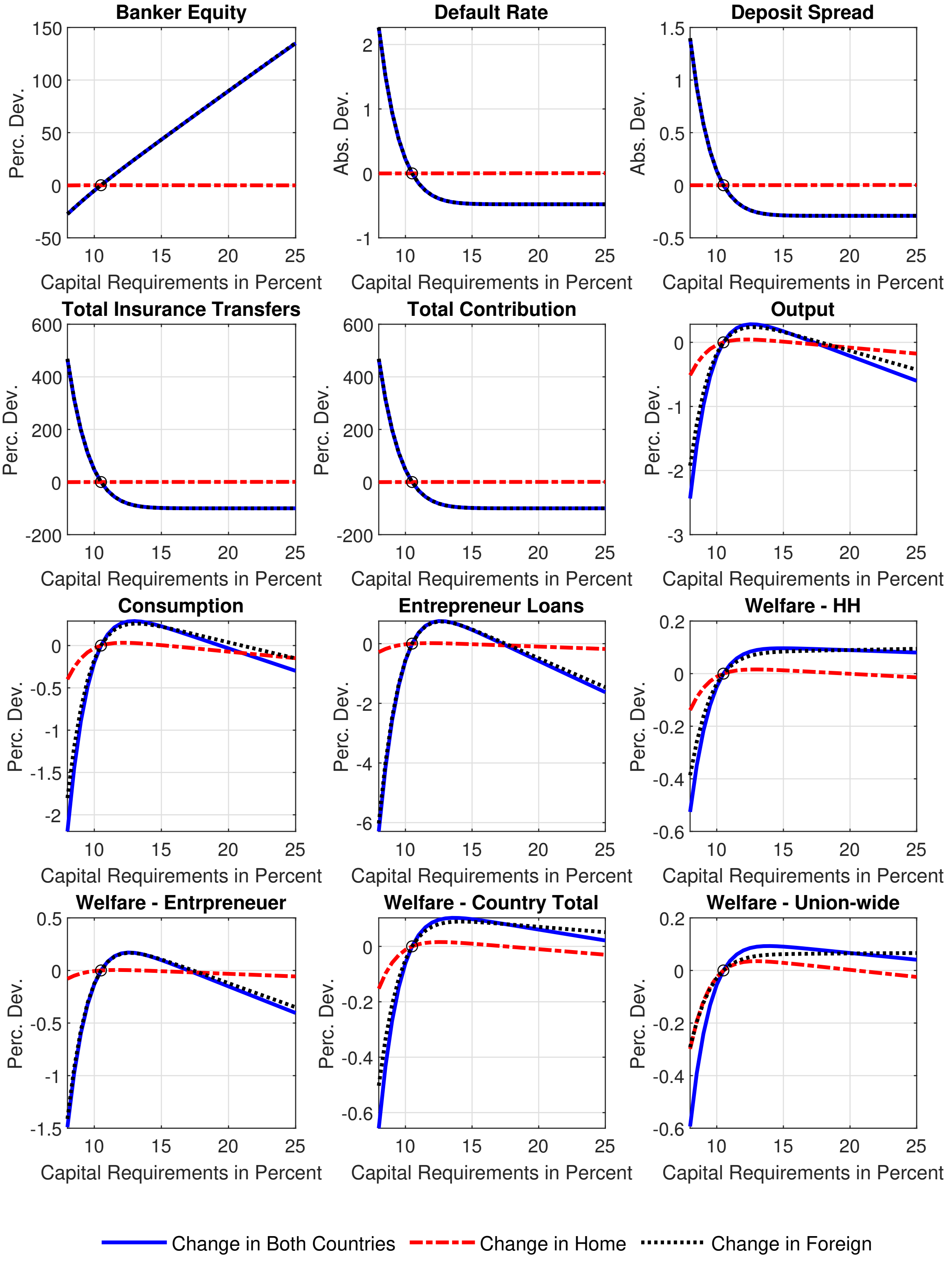


Note: Steady-state levels of selected variables of the home economy after changing the capital requirement value in either the home country (red dashed line), the foreign country (black dotted line) or in both countries simultaneously (blue solid line). Circle markers represent benchmark steady-state calibration. Deposit insurance is provided only by EDIS. Reported values are in levels.

dominates and for larger values the second channel is more important. Our overall findings on the level of optimal long-term capital ratios are in line with similar studies such as Mendicino et al. (2018).

Third, increasing capital requirements in the foreign countries has expansionary effects on the home country, at least when the capital ratio remains below the optimal foreign value of around 14 percent. However, this finding does not hold in reverse. Lowering the bank default rates in the riskier foreign country via higher capital requirements results in a equalization of home and foreign default rates. Bankers in the home country that are invested with share $(1 - \zeta_t^{n,h})$ in the foreign banking system yield in total a higher expected net return on bank equity. The higher overall equity return of bankers in home causes eventually domestic real activity and loans to increase and domestic bank default rates to marginally decline. When increasing instead capital ratios in the home economy, the differences between home and foreign bank default rates increase. Eventually foreign bankers' total equity return decline and depresses the foreign economy.

Figure 18: Steady-State Changes in Foreign for Changes in Capital Requirements when the EDIS is active



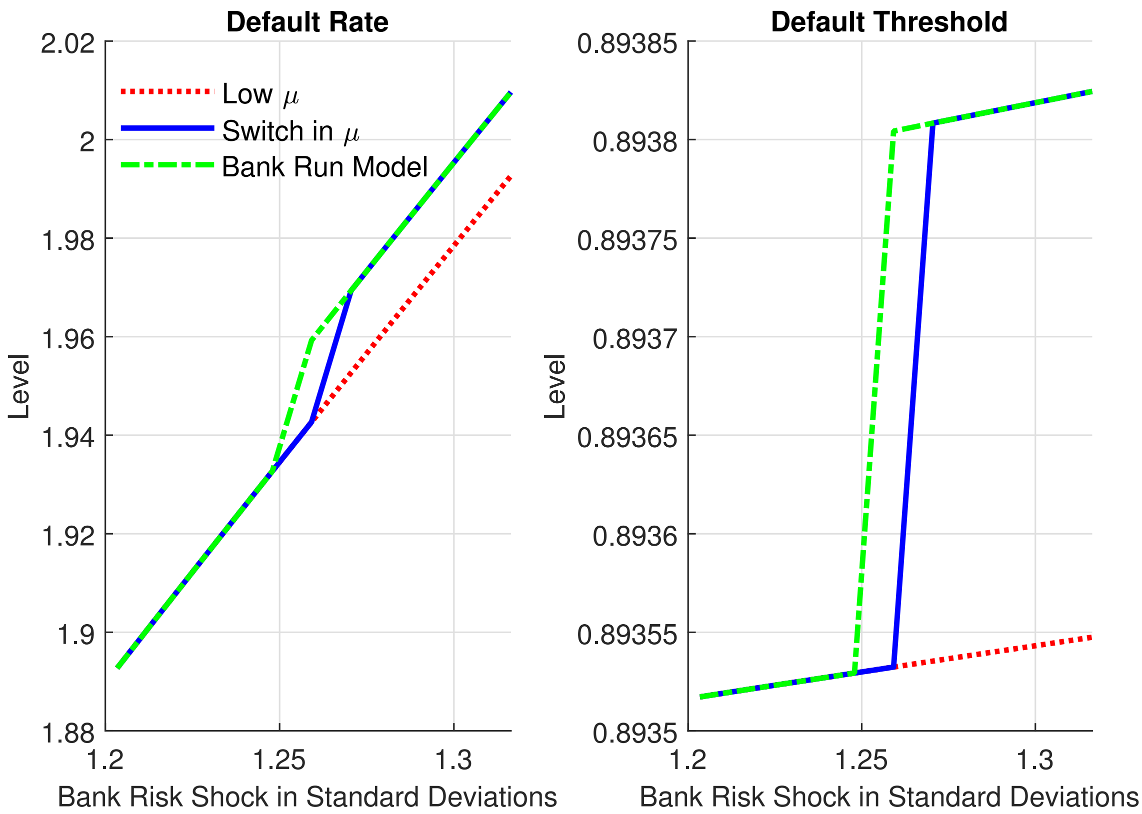
Note: Steady-state levels of selected variables of the foreign economy after changing the capital requirement value in either the home country (red dashed line), the foreign country (black dotted line) or in both countries simultaneously (blue solid line). Circle markers represent benchmark steady-state calibration. Deposit insurances are provided only by EDIS. Reported values are in levels.

E Bank Runs

As discussed in section 6.5, our bank-run framework features an “in-between” region in which sunspot shocks can trigger a bank run. To discuss the characteristics of that region more thoroughly, we visualize the region of self-fulfilling bank runs, given by the difference between the solid blue and the dotted green lines in figure 19. Our calibration implies that bank runs can occur for aggregate bank risk shocks with values between 10 and 11 percent. Whenever the shock falls in this region, it has the potential to trigger a self-fulfilling bank run. Households wrongly believe that bank asset returns are lower[54], and thus the default threshold and realized bank defaults are higher than their fundamental values. The non-fundamental economy would behave as in the high-distress state (green dotted line), even though fundamentals are still in line with a low-distress state (blue solid line). Thus, a bank run may be set in motion according to the self-fulfilling dynamics related to $\overline{\omega}^{*,c}_{t+1}$, defined in equation 58 in section 6.5.

[54]The lower anticipated return is driven by the perception of higher monitoring costs resulting from the sunspot shock.

Figure 19: Bank-Run Feasibility Region



Note: Area between the dotted green and blue solid line defining the "in-between" state in which a run equilibrium is possible. Response of quarterly default rates and thresholds to adverse bank risk shock for a variety of shock sizes one period after shock realization (occurrence of regime-switch).