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Supervisory coordination without centralized capital regulation*

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We study the interaction between the capital regulation and supervision of multinational banks when the latter is centralized. Both, stricter regulation and stricter supervision have positive international externalities in that they reduce the intra-bank cost of cross-subsidizing failing subsidiaries abroad. We show that stricter, centralized supervision leads to more lenient capital regulation at the national level. We identify the cases in which the too lenient regulation overcompensates the global welfare gain of stricter supervision. In these cases, moving towards a supervisory union reduces global welfare.

Keywords: banking supervision, capital regulation, multinational banks

JEL Codes: F36, G21, G28, H87

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1 Introduction

The global financial crisis of 2007 – 2009 has highlighted the need for more rigorous, internationally coordinated bank capital regulation and supervision. In particular, the crisis showed the danger of forbearance at the national level and towards internationally active banks. To address this issue, the EU ratified legislation towards a bank supervisory union in 2013: the Single Supervisory Mechanism (SSM). In conjunction with the Single Resolution Mechanism (SRM), the SSM assumes the ultimate supervisory authority over all eurozone banks (EU, 2013b). Moreover, large, systemically relevant and internationally active banks are under its direct supervision. Early assessments of this centralized mechanism find it to have increased the effectiveness and rigor of supervision, particularly for the case of internationally active banks (Schoenmaker and Véron, 2016). This is supported by event study evidence in Loipersberger (2018), who shows that centralized supervision has positive effects on bank valuation.

In regards to more rigorous capital regulation, the EU legally implemented the Basel III accords in 2013 (EU, 2013a). Unlike the SSM and SRM, the updated capital regulatory framework distinctly allows for national discretion in the implementation of policy standards. For instance, EU member states have room for forbearance concerning the computation of bank capital ratios (Gropp et al., 2021b). This is evidenced by the significant cross-country heterogeneity in effective capital ratios calculated by the ECB in their 2014 stress tests of systemically important banks[1]. As such, the EU currently represents a regulatory regime which combines centralized supervision with capital regulation that is at least partly decentralized. The question we address in this paper is whether centralized supervision is efficient in this environment.

We present a model where capital regulatory decisions at the national level interact with decentralized or centralized supervisory decisions. In the model, the national banking sectors are composed of local subsidiaries of multinational banks. The subsidiaries are

[1] As discussed by Fratianni and Pattison (2015), national regulators stated average Tier 1 common capital ratios up to 2.9 % higher than those calculated by the ECB.

heterogeneous with respect to their exogenously given investment success probability. The distribution of success probabilities is independent in the two countries, such that one subsidiary of a multinational bank may be successful and its foreign affiliate may fail. In such a case, the successful subsidiary assumes the failure cost of and cross-subsidizes its failing counterpart abroad. As documented by Fiechter et al. (2011), the default of a subsidiary imposes high reputational costs on the multinational bank, such that the bank stands to gain from cross-subsidization. In our model, negative international spillovers of subsidiary failures thus arise through the affiliate network of multinational banks.

The capital regulatory and supervisory decisions are taken sequentially. In the second stage, either the national or central regulators set the supervisory standards in the form of resolution thresholds. These thresholds indicate the minimum success probability required of a bank subsidiary to be allowed to continue and realize its investment outcome. A higher resolution threshold implies a lower share of failing bank subsidiaries. We follow Beck et al. (2013) and Beck et al. (2016) in this modeling approach. Our model includes an additional first stage, in which the national regulators non-cooperatively set capital regulatory standards in the form of minimum capital ratios. A higher capital requirement limits the lending volume and thereby the loss given a subsidiary failure. In this decision, the national regulators anticipate the share of bank failures as determined by the supervisory standards of the second stage.

We compare the regulatory decision making and global welfare under a regime of no policy coordination with a regime of centralized supervision but decentralized capital regulation. Absent policy coordination, national regulators fail to account for the international spillovers of both stricter supervision and stricter capital regulation. Stricter supervision in one country decreases the share of local bank subsidiaries which fail and require cross-subsidization by their successful foreign counterparts. This reduction in the cost of intra-bank subsidization is not considered by the national regulators such that the nationally set supervisory standards are too lenient from a global welfare perspective. Stricter capital requirements similarly reduce the cost of cross-subsidization given an affiliate failure abroad. As such, the capital regulatory standards, too, are too lenient

in a non-cooperative setting compared to the supranational optimum.

Moving towards a regime of stricter, centralized supervision while keeping capital regulation decentralized affects the incentives for setting national capital regulation. Stricter supervision reduces the share of failing bank subsidiaries. Consequently, limiting the intra-bank cost of subsidiary failure through strict capital requirements becomes less important. As such, the national governments set even more lenient capital requirements under centralized supervision than in the case of no policy coordination. This has a negative externality on the other country. We show that this negative welfare effect of laxer capital requirements can lead to an overall welfare loss from the supervisory reform. This is the case, when the cost of reimbursing bank creditors through public funds is large compared to the rents from successful investment.

Our analysis connects the existing literature on supervisory and capital regulatory coordination across countries. With regards to supervisory coordination, Beck et al. (2013) and Beck et al. (2016) analyze the effects of various modes of bank activity abroad on centralized and decentralized supervisory decisions. For the case of multinational banking, Calzolari et al. (2019) study the welfare effects of centralizing supervision under an endogenous choice of bank organizational form. Colliard (2020) considers an endogeneous choice of bank quality disclosure to the centralized or decentralized regulator. In a related strand of literature, Repullo (2018), Carletti et al. (2020) and others examine the issue of non-optimal information sharing between a central supervisory authority and national regulators. These papers do not however consider an additional capital regulatory decision as we do.

With regards to capital regulatory coordination, Dell'Ariccia and Marquez (2006) assess the effects of a centralization of capital requirements when bank capital is mobile. Haufler and Maier (2019) extend this analysis by accounting for a heterogeneous quality of the international banks which is private knowledge. Kara (2016) in contrast, studies the optimal capital regulation of domestic banks in the presence of global, systemic risk. The papers do not consider a supervisory decision.

Our paper is most closely related to the small strand of literature that studies the interaction of the two regulatory policy instruments. Acharya (2003) and Buck and Schliephake (2013) both study the welfare implications of centralized capital regulation in the presence of nationally set supervision. International spillovers of regulation arise through the competition of cross-border banks in national lending markets. In contrast, our paper considers the centralization of supervisory standards in the context of multinational banking. There, international spillovers arise within the subsidiary network of the multinational banks.

Finally, we contribute to the broader literature on the interaction between policy instruments. This has been studied in an international context for capital regulation and deposit insurance (Lóránth and Morrison, 2007), supervision and deposit insurance (Hardy and Nieto, 2011) and supervision and ex-post bailouts (Haufler, 2021).

The remainder of this paper proceeds as follows. Section 2 introduces the theoretical framework of banking supervision and capital regulation in the context of multinational banking. Section 3 compares the choice of supervisory and capital regulatory standard under a national and a centralized regime of supervision. Section 4 analyzes the welfare effects of moving towards a centralized supervisory regime given this interaction. Section 5 concludes.

2 Banking supervision and capital regulation in a two-country region

We model the interaction between two national governments in the capital regulation and supervision of multinational bank subsidiaries. In particular, we consider a two-country region $i \in \{A, B\}$, where the national governments (henceforth 'regulators') set supervisory and capital regulatory standards for the bank subsidiaries active under their jurisdiction. The regulators set the supervisory standard in the form of a resolution threshold λ_i. The resolution threshold indicates the minimum success probability for

bank investments. The investment success probabilities of bank subsidiaries in country i, Λ_i, are heterogenous and exogenously given. If a subsidiary's success probability is discovered to be below the threshold value $\Lambda_i < \lambda_i$, all of the subsidiary's investments are terminated rather than allowed to continue. We follow Beck et al. (2013) and Beck et al. (2016) in this modeling approach. Our model extends their analysis in that the regulators additionally set a capital regulatory standard. The standard takes the form of a minimum capital ratio k_i. We compare a regime of no coordination with one of supranational supervision, where the choice of the capital regulatory standard remains decentralized. We analyze the case of symmetric countries.

Our model has two stages. In stage one, the national regulators non-cooperatively choose the minimum capital ratio k_i for all bank subsidiaries active under their jurisdiction. The subsidiaries then make risky investments. In the second stage, the regulators discover the heterogeneous success probabilities Λ_i of the subsidiaries' investments. Then, either a central, supranational regulator or the national regulators choose the resolution thresholds λ_i and resolve all bank subsidiaries with a success probability below the threshold $\Lambda_i < \lambda_i$. The continuing subsidiaries move on to have their investments succeed or fail. We solve the model by backward induction.

2.1 Multinational banks

The two-country region houses a continuum of perfectly competitive multinational banks. The multinational banks operate via national subsidiaries in countries $i \in \{A, B\}$ which offer credit to producing firms[2]. The subsidiaries finance their lending in part via equity capital and in part by raising deposits.

In both countries, the bank subsidiaries are owned by domestic capitalists. In this, we assume a multinational bank to be an international merger of formerly domestic units where the national subsidiaries retain their previous, fully domestic ownership structure. International mergers take place for instance as a means of expanding service to domestic

[2]In the EU, approximately 70 % of the multinational lending of the past ten years was intermediated by subsidiaries rather than branches (source: BIS Statistics Warehouse, own calculations).

customers going abroad (Gulamhussen et al., 2016). The capitalists provide a fixed, aggregate amount of capital E to the domestic bank subsidiaries. They receive all residual profits from their operation[3].

Each subsidiary has access to an unlimited amount of domestically raised deposits. Depositing with a bank is risk free in both countries due to national, full-coverage deposit insurance schemes. This reflects the current practice in most developed and developing countries, which have implemented either an explicit or implicit deposit insurance scheme (Barth et al., 2013). We therefore assume deposits to be priced at the risk-free interest rate δ as determined by international capital markets. Without loss of generality, we assume $\delta = 0$. Deposits have seniority over equity capital financing. This ensures that the national deposit insurance schemes only have to reimburse local depositors if the banks' overall profits are smaller than the sum of deposits.

By extending credit to the private sector, the bank subsidiaries face a risk of borrower default. The subsidiaries can mitigate this credit risk by exerting effort in monitoring their borrowers. The cost of monitoring differs exogenously across bank subsidiaries. This can for instance depend on the organizational form of their lending operation, where a greater hierachial distance between the loan officer and borrower increases the monitoring cost (Stein, 2002). We assume the (inverse) monitoring cost to be distributed such that the optimal monitoring effort Λ_i of subsidiaries in each country is distributed uniformly $\Lambda_i \sim \mathcal{U}(0,1)$. By exerting a greater monitoring effort, the subsidiaries increase the success probability of their borrowers' production[4]. In particular, we assume the monitoring effort and borrower success probability to have a one-to-one relationship, such that a monitoring effort Λ_i yields a success probability of production of $\Lambda_i \sim \mathcal{U}(0,1)$. If production is not successful, the borrowers default on their bank loan. We assume the investment outcomes of a given bank subsidiary to be perfectly correlated. This implies that all firms receiving financing from a particular subsidiary face the same probability of success, reflecting the

[3]We assume that the capitalists' outside option yields a return lower than these profits for all units of E.

[4]One rationale for this relationship is that stricter bank monitoring reduces an entrepreneur's moral hazard problem, inducing him to exert a greater managerial effort (Holmstrom and Tirole, 1997).

degree of oversight and support they receive [5].

While credit risks are assumed to be perfectly correlated within each national bank subsidiary, risks have a zero correlation between countries. This can be justified by the existence of rigorous national regulation, which helps to ring fence local subsidiaries from foreign credit risk (Anginer et al., 2017). A strong reliance on local deposit financing further minimizes the correlation of credit risks between countries. This is the case for multinational commercial banks in developed economies, which we model. In consequence, each bank faces a non-zero probability of subsidiary i succeeding and j failing and vice versa.

In such a case, the successful subsidiary in i cross-subsidizes its failing foreign counterpart in j. As documented by Fiechter et al. (2011), the default of a subsidiary imposes high reputational costs on the multinational bank as a whole. In consequence, multinational banks stand to gain from cross-subsidizing the creditors of failing subsidiaries. This behavior has been observed during past, localized crises such as the European sovereign debt crisis. For instance, Bofondi et al. (2018) show that multinational banks operating in Italy reduced their local credit supply less during the crisis than domestic Italian banks did.

2.2 Firms and consumers

We consider prospective borrowers in each local lending market $i \in \{A, B\}$ to be individual entrepreneurs or small firms without any existing capital. Each firm has access to a production technology which produces one unit of a homogeneous consumption good X_i for each unit of bank credit L_i. The firms face a demand for the consumption good from local consumers. A representative consumer in country i has a quasi-linear utility function $u_i(X_i, Z_i) = \bar{R}X_i - X_i^2/2 + Z_i$, with Z_i being auxiliary consumption, the numeraire good. This gives rise to a demand function for the consumer good of $X_i(p_i) = \bar{R} - p_i$ at a given consumer price p_i. Each unit of lending L_i used in the production of the consumer

[5] Perfect correlation of credit risks is a common assumption in the capital regulation literature, see e.g. Dell'Ariccia and Marquez (2006) or Boyd and De Nicolo (2005).

good bears a cost to the borrowing firm equal to the credit interest rate R_i. Assuming the free entry of firms and zero auxiliary production cost, the zero profit condition holds and the unit cost of credit is passed on fully to the consumers $p_i = R_i$. Then, the demand for the consumption good is reflected in the firms' demand for credit $D_i(R_i) = \bar{R} - R_i$. The aggregate credit supply L_i to each lending market is determined by the fixed amount of bank capital E provided by the domestic capitalists as well as the minimum capital ratio k_i, such that $L_i = E/k_i$. This leads to a market clearing credit interest rate of

$$R_i = \bar{R} - \frac{E}{k_i}. \tag{1}$$

Due to perfect competition among the borrowing firms, all rents from the sale of the consumption good are passed on to the consumers. With the inverse demand for the consumption good $p_i(X_i)$ and the equilibrium production volume $X_i = L_i = E/k_i$, the equilibrium consumer surplus in the case of successful production is given by

$$CS_i = \frac{E^2}{2k_i^2}. \tag{2}$$

The equilibrium consumer surplus per unit lending is given by $cs_i = E/2k_i$.

2.3 Regulators

The regulators sequentially set standards for the capital regulation and supervision of the bank subsidiaries under their jurisdiction. In stage one, the national regulators non-cooperatively set the capital standard in the form of a minimum capital ratio k_i. We argue that a non-cooperative, national regime of capital regulation is plausible. National governments have retained significant discretion in the implementation of the Basel III accords and the Capital Requirements Regulation (CRR) of the EU (Gropp et al., 2021b). This is evidenced by the heterogeneity in effective capital ratios computed by the ECB

in the 2014 stress tests of systemically important banks[6].

In stage two, either a central, supranational regulator or the national regulators choose the supervisory standard. The standard is based on a signal they receive about the success probabilities Λ_i of the bank subsidiaries' investments. We can for instance interpret this signal as a subsidiary's performance in a stress test. The regulators then set a resolution threshold λ_i and resolve all bank subsidiaries whose investment success probability Λ_i is lower than the threshold value $\Lambda_i \in (0, \lambda_i]$. Since the investment success probabilities are distributed uniformly $\Lambda_i \sim \mathcal{U}(0,1)$, this amounts to a share λ_i of subsidiaries being resolved rather than allowed to continue. We interpret a bank resolution as a government led, early liquidation of its investments. Following Beck et al. (2013) and Beck et al. (2016) and without loss of generality, we assume that the initial investments are recovered in full by the government. This is the case when the market price for liquidated bank assets is sufficiently high (Acharya et al., 2011).

The share $1-\lambda_i$ of subsidiaries which have a success probability greater than the threshold value $\Lambda_i \in (\lambda_i, 1)$ are allowed to continue on to realize the outcome of their investment. Given the uniform distribution of success probabilities, the continuing $1-\lambda_i$ subsidiaries have an average success probability of $\frac{1+\lambda_i}{2}$. As such, a share $\frac{1+\lambda_i}{2}$ succeed in their investment and a share $1-\frac{1+\lambda_i}{2} = \frac{1-\lambda_i}{2}$ fail. Multiplication with the share of continuing subsidiaries $1-\lambda_i$ yields the ex-ante share of investment success and failure, $\frac{1-\lambda_i^2}{2}$ and $\frac{(1-\lambda_i)^2}{2}$, respectively.

Of the $\frac{1-\lambda_i^2}{2}$ successful subsidiaries in i, a share $\frac{(1-\lambda_j)^2}{2}$ is affiliated with a failing subsidiary in j. In such a case, the successful subsidiary in i cross-subsidizes its failing foreign counterpart due to reputational concerns. The cross-subsidization entails a unit cost per unit lending in j to the successful subsidiary in i. We assume that the profitability of successful investment is large enough to do so, i.e. $(R_i - 1)\frac{E}{k_i} - \frac{E}{k_j} > 0$.

A share $\frac{(1-\lambda_i)^2}{2}$ of subsidiaries in i fail. Of these, a share $\frac{1-\lambda_j^2}{2}$ is affiliated with a successful subsidiary in j and receives an intra-bank cross-subsidy. Conversely, a share

[6]As discussed by Fratianni and Pattison (2015), national regulators stated an average Tier 1 common equity ratio up to 2.9 % higher compared to the calculations of the ECB.

$1 - \frac{1-\lambda_j^2}{2} = \frac{1+\lambda_j^2}{2}$ is affiliated with a subsidiary in j that does not succeed and thereby cannot provide support. These $\frac{(1-\lambda_i)^2}{2}\frac{(1+\lambda_j^2)}{2}$ subsidiaries in i must consequently default on their equity capital and deposits. In such cases, the national deposit insurance scheme is triggered. Government i steps in and reimburses the domestic depositors of the defaulting subsidiaries at the expense of the taxpayer. Each unit of public funds raised to reimburse the depositors incurs a cost of c. We assume the cost of public funds to be larger than one, $c > 1$. This captures the distortions associated with collecting public funds through taxes.

To keep our welfare analysis simple, we assume the consumers as described in section 2.2 to also hold the domestic bank capital in i. Then, all rents in the economy are allocated to the consumer-capitalists, such that domestic welfare can be represented by the utility of a representative consumer-capitalist. The components of utility affected by regulatory policy are the domestic bank profits, the consumer surplus in market X_i and the tax payments into the deposit insurance fund.

We therefore express national welfare in country i, WF_i, as an unweighted sum of domestic bank profits and the consumer surplus CS_i minus the tax payments:

$$WF_i = \frac{E}{k_i}\left(\frac{1-\lambda_i^2}{2}\left[R_i - 1 + cs_i\right] - \frac{(1-\lambda_i)^2}{2}\frac{(1+\lambda_j^2)}{2}\left[k_i + c(1-k_i)\right]\right) - \frac{E}{k_j}\frac{(1-\lambda_i^2)}{2}\frac{(1-\lambda_j)^2}{2}. \tag{3}$$

The first term of equation (3) describes the profits and consumer surplus from successful investment and production. A share $\frac{1-\lambda_i^2}{2}$ of bank subsidiaries in i succeed, earning a profit per unit lending of $R_i - 1$, with the market clearing credit interest rate $R_i = \bar{R} - E/k_i$. Due to the domestic ownership of the subsidiaries in i, all profits from domestic lending remain in i. The successful production and sale of the consumption good further lead to a consumer surplus of $cs_i = E/2k_i$ per unit of lending. The second term describes the costs from the deposit insurance scheme. A share $\frac{(1-\lambda_i)^2}{2}\frac{1+\lambda_j^2}{2}$ of subsidiaries in i fails and does not receive support through the affiliate network. These subsidiaries default

on their domestic equity capital and deposits. The depositors are reimbursed through the national deposit insurance scheme in i at a unit cost of public funds of $c > 1$. The capital holders bear the residual loss. The third term of the domestic welfare function describes the cost from cross-subsidization of failing affiliates in j. This occurs for a share $\frac{1-\lambda_i^2}{2}\frac{(1-\lambda_j)^2}{2}$ of domestic subsidiaries.

3 Optimal capital regulation under different supervisory regimes

3.1 Second stage: Choice of supervisory standard

In the second stage, the regulators choose the supervisory standard in the form of an optimal resolution threshold λ_i. The resolution threshold is set either centrally, by a supranational authority or unilaterally by the national regulators. We compare the optimal resolution threshold under a non-cooperative national regime of supervision λ_N and a supranational regime λ_G.

Under a non-cooperative national regime of supervision, each country considers only the domestic costs and benefits in its choice of resolution threshold. Therefore, we derive the first order condition for the nationally optimal resolution threshold as the derivative of the national welfare function (3) with respect to λ_i:

$$\frac{\partial WF_i}{\partial \lambda_i} = \frac{E}{k_i}\left(-\lambda_i\left[R_i - 1 + cs_i\right] + (1-\lambda_i)\frac{1+\lambda_j^2}{2}\left[k_i + c(1-k_i)\right]\right) + \frac{E}{k_j}\lambda_i\frac{(1-\lambda_j)^2}{2} = 0. \tag{4}$$

The negative first term of equation (4) represents the domestic cost from stricter supervision. A higher resolution threshold λ_i reduces the share of successful bank subsidiaries in i. Fewer successful subsidiaries in turn imply lower aggregate profits in the banking sector and a lower consumer surplus from successful production. The domestic benefits from stricter supervision are twofold. The second term represents the reduction in the share of defaulting subsidiaries in i, $\frac{(1-\lambda_i)^2}{2}\frac{1+\lambda_j^2}{2}$, associated with an increase in the do-

mestic resolution threshold. Fewer defaults in turn entail lower losses to domestic capital holders as well as tax payers in the form of a lower cost of reimbursing depositors. The third term reflects the reduction in the cross-subsidization of failing foreign affiliates. A reduced share of successful subsidiaries in i implies that fewer domestic affiliates provide intra-bank support. The reduction in the cost of the deposit insurance is especially pronounced for a large unit cost of public funds c. In consequence, the nationally optimal resolution threshold λ_N will be high whenever the cost of public funds is high and low if the rents from successful investment are high. Due to the cross-subsidization between bank affiliates, the choice of resolution threshold in country i affects the welfare in country j. We consequently expect the optimal supervisory standard in the supranational regime λ_G to differ from that under national supervision λ_N.

In the supranational regime, the central supervisory authority maximizes the sum of welfare levels of the two countries $WF = WF_i + WF_j$, with $i \neq j$. In order to compare the optimal supervisory standards under the two regimes, we evaluate the effect of marginally stricter supervision in i on WF at the nationally optimal resolution threshold $\lambda_i = \lambda_N$:

$$\begin{aligned} \left.\frac{\partial WF}{\partial \lambda_i}\right|_{\lambda_i=\lambda_N} &= \left.\frac{\partial WF_j}{\partial \lambda_i}\right|_{\lambda_i=\lambda_N} \\ &= \frac{E}{k_i}(1-\lambda_i)\frac{1-\lambda_j^2}{2} - \frac{E}{k_j}\lambda_i\frac{(1-\lambda_j)^2}{2}\left[k_j + c(1-k_j)\right]. \end{aligned} \tag{5}$$

A resolution threshold $\lambda_i = \lambda_N$ maximizes the welfare of country i. At this point, the derivative of domestic welfare WF_i is zero. At the same time, a higher resolution threshold has non-zero international externalities on country j. As represented by the first term of equation (5), a higher resolution threshold decreases the share of failing bank subsidiaries in i. This decreases the cost of cross-subsidization to their successful affiliates in j which implies a positive effect on country j's welfare. At the same time, a higher resolution threshold λ_i reduces the share of successful bank subsidiaries in i

that can support their failing counterparts in j. Consequently, a higher share of failing subsidiaries in j must default on their capital and deposits. The associated losses to capital holders and taxpayers imply a negative effect on the welfare of country j. Each unit of public funds raised to reimburse the $1-k_j$ depositors incurs a cost of $c > 1$.

The sign of the international externality (5) is determined by the tax cost per unit of deposit insurance $c(1-k)$. If the cost is small, the positive spillover of fewer instances of intra-bank cross-subsidization dominates the negative spillover of more frequent defaults. The reimbursement cost is small, either if the share of deposit financing in j, $1-k_j$, is small or if the unit cost of public funds c is close to its lower bound of $c = 1$. In the symmetric national optimum $\lambda_i = \lambda_j = \lambda_N$ and $k_i = k_j = k_N$, equation (5) reduces to the sufficient condition for a positive externality

$$c < 1 + \frac{1}{1-k_N}. \tag{6}$$

Condition (6) is more likely to be met when national capital regulation is strict and the required ratio of equity capital k_N is high. We argue that this is the case for all countries implementing the Basel III accords. While cross-country heterogeneity exists in the implementation of the accords, they offer a binding lower bound for prudential capital regulation (BIS, 2010). In such a setting, the international externality of stricter supervision, as given by equation (5), is likely to be positive.

We use our analysis of the international spillovers to compare the optimal resolution threshold under the decentralized supervisory regime λ_N with the centralized one λ_G. In appendix A, we show that there is indeed an internal solution for the centrally optimal resolution threshold λ_G and that this threshold satisfies the sufficient condition for a welfare maximum. Given the result of a positive externality of stricter supervision, the resolution threshold is higher in the supranational compared to the national optimum $\lambda_G > \lambda_N$. We summarize our findings in the following lemma.

Lemma 1 *If the tax cost of deposit insurance is sufficiently small, such that condition*

(6) holds, the international externality of stricter supervision is positive. Consequently, supervision is stricter in the supranational optimum than in the national optimum $\lambda_G > \lambda_N$.

Lemma 1 receives support from assessments of the Single Supervisory Mechanism (SSM) and the Single Resolution Mechanism (SRM) instated in the EU (EU, 2013a). Schoenmaker and Véron (2016) for instance, find the centralized mechanisms to have increased the rigor and timeliness of supervision, particularly for internationally active banks. Further, empirical studies of other contexts show that local supervisors are more lenient than centralized ones (Agarwal et al., 2014).

3.2 First stage: Choice of capital regulatory standard

In the first stage, the national regulators non-cooperatively choose the optimal capital ratio k_i applicable to all bank subsidiaries under their respective jurisdiction. We apply the second stage results for the resolution thresholds in the decentralized optimum $\lambda_i = \lambda_j = \lambda_N$ or centralized optimum $\lambda_i = \lambda_j = \lambda_G$. Maximizing the domestic welfare function of country i as given by equation (3), the first order condition for the nationally optimal capital ratio is given by

$$\frac{\partial WF_i}{\partial k_i} = \frac{E}{k_i^2}\left[-\frac{(1-\lambda^2)}{2}(\bar{R} - \frac{E}{k_i} - 1) + \frac{(1-\lambda)^2}{2}\frac{1+\lambda^2}{2}c\right] = 0. \tag{7}$$

The negative first term of equation (7) represents the cost from stricter capital regulation. A higher capital requirement reduces the aggregate credit supply $L_i = E/k_i$. A lower credit supply in turn reduces bank profits and the consumer surplus from successful investment. The simultaneous increase in the revenue per unit of successful investment $\partial R_i/\partial k_i = \partial(\bar{R} - E/k_i)/\partial k_i > 0$ is not large enough to change the negative sign of this effect. The positive second term represents the benefits from stricter capital regulation. An increase in the required capital ratio decreases the share and volume of deposit financing and thereby the cost to taxpayers of reimbursing depositors of defaulting subsidiaries.

This reduction in the cost of depositor reimbursements is especially pronounced for a large unit cost of public funds c. Both, the cost and the benefits from stricter capital regulation decrease in absolute value with an increase in the resolution threshold λ.

Solving the first order condition (7) for k_i, we find the nationally optimal capital ratio

$$k_N(\lambda) = \frac{E(1-\lambda^2)}{(1-\lambda^2)(\bar{R}-1) - (1-\lambda)^2(1+\lambda^2)\frac{c}{2}}. \tag{8}$$

In its choice of capital ratio, the national regulator trades off the credit interest rate and cost of deposit insurance with the credit volume. As such, the numerator of equation (8) describes the increase in the equilibrium credit interest rate associated with a marginal increase in the capital ratio. The first term of the denominator reflects the reduction in the credit volume while the second one describes the decrease in the cost of deposit insurance payments. Equation (8) describes an internal solution $k \in (0,1)$ if the cost of the deposit insurance scheme is not too large, such that the condition $(1-\lambda^2)(\bar{R}-E-1) > (1-\lambda)^2(1+\lambda^2)\frac{c}{2}$ holds. At a threshold value $\lambda = 0$ for instance, the condition would take the form $\bar{R} - E - 1 > \frac{c}{2}$.

Taking the derivative of equation (8) by λ, we find the effect of an increase in the resolution threshold on the nationally optimal capital ratio to be

$$\frac{dk_N}{d\lambda} = -\frac{Ec(1-\lambda)^2\left[1-\lambda+\lambda^2+\lambda^3\right]}{\left[(1-\lambda^2)(\bar{R}-1) - (1-\lambda)^2(1+\lambda^2)\frac{c}{2}\right]^2} < 0. \tag{9}$$

For all threshold values $\lambda \in (0,1)$, a higher resolution threshold leads to a lower non-cooperatively set capital ratio in the first stage. An increase in the resolution threshold decreases the share of successful investments and thereby the negative effect of stricter capital regulation in reducing the credit volume. In this, a higher resolution threshold reduces the cost of stricter capital regulation as given in (7). This effect is partially offset, as a lower share of successful investment also decreases the benefit from a higher credit

interest rate $R_i = \bar{R} - E/k_i$. At the same time, a higher resolution threshold decreases the share of subsidiary defaults and thereby the benefits from stricter capital regulation. These benefits take the form of a lower cost of reimbursing depositors. At the nationally optimal capital ratio k_N, the reduction in the benefits dominates the overall effect and the capital ratio declines. For a large cost of public funds c, the capital ratio is particularly sensitive to changes in the resolution threshold.

As summarized in Lemma 1, the resolution threshold λ set in the second stage is larger under supranational compared to national supervision $\lambda_G > \lambda_N$. Hence, in stage one, the national regulators optimally set a lower capital ratio under a supranational supervisory regime compared to a national one $k_N(\lambda_G) < k_N(\lambda_N)$. We summarize this finding in the following proposition.

Proposition 1 *A supranational supervisory regime with stricter supervision than the national regime $\lambda_G > \lambda_N$ implies a lower non-cooperatively set capital standard, $k_N(\lambda_G) < k_N(\lambda_N)$.*

Proposition 1 states that national capital regulation can be more lenient in a supervisory union, as is currently in place in the EU, compared to a setting of no policy coordination. This result shows a potentially harmful side effect of tighter banking supervision in a supervisory union (Enria, 2019). The national regulators anticipate a stricter supervisory standard to be set by a central supervisor in the second stage. In this, they anticipate their domestic benefit from strict capital regulation to decline relative to the domestic cost. Given the national regulators' leeway in implementing and enforcing capital standards, they consequently set more lenient capital requirements so as to account for the reduced relative benefit of strict capital regulation. Proposition 1 receives support from empirical studies such as Gropp et al. (2021a). As the evidence suggests, stricter requirements of a centralized regulator lead to laxer capital regulatory standards at the national level. This domestic regulatory leniency can arise due to various national political and economic motives.

Externality of national capital regulation We analyze the international externality of stricter capital regulation at the national optimum. This prepares our study of the welfare effects of a small supervisory reform as discussed in section 4. We do so by evaluating the effect of marginally stricter capital regulation in i on global welfare $WF = WF_i + WF_j$ at the nationally optimal capital ratio $k_i = k_N$:

$$\left.\frac{\partial WF}{\partial k_i}\right|_{k_i=k_N} = \left.\frac{\partial WF_j}{\partial k_i}\right|_{k_i=k_N} = \frac{E}{k_i^2}\frac{(1-\lambda_j)^2}{2}\frac{1-\lambda_i^2}{2}. \tag{10}$$

A capital ratio $k_i = k_N$ maximizes welfare of country i such that the derivative of WF_i is zero at this point. The international externality of a higher capital ratio k_i on country j is unambiguously positive. An increase in k_i reduces the lending volume $L_i = E/k_i$ in i. This implies a reduction in the cost to bank subsidiaries in j of cross-subsidizing their failing counterparts in i. We further show in appendix B that an internal solution for the supranationally optimal capital ratio k_G exists if the cost of the deposit insurance is not too large and that k_G satisfies the sufficient condition for a welfare maximum. Given this result, we can infer that the capital ratio is higher in the supranational compared to the national optimum $k_G > k_N$. We summarize this finding in the following lemma.

Lemma 2 *The international externality of stricter capital regulation is positive. Consequently, capital regulation is stricter in the supranational optimum than in the national optimum $k_G > k_N$.*

Lemma 2 is consistent with previous findings of the capital regulatory literature. A positive externality of capital regulation usually arises whenever a higher domestic capital ratio decreases the cost from bank failure abroad (Kara, 2016). This is the case in our analysis.

4 Welfare effects of a global supervisory regime

We assess the welfare implications of moving towards a supervisory union for the example of a small supervisory reform. We represent the reform as a marginal increase in the resolution threshold λ starting in the equilibrium where both the supervisory and the capital regulatory standard are set at the nationally optimal levels $\lambda_i = \lambda_j = \lambda_N$ and $k_i = k_j = k_N$. The overall effect of such a reform on the welfare of country i is given by

$$\left.\frac{dWF_i}{d\lambda}\right|_{\lambda=\lambda_N} = \left.\frac{\partial WF_i}{\partial \lambda_j}\right|_{\lambda_j=\lambda_N} + \left.\frac{\partial WF_i}{\partial k_j}\right|_{k_j=k_N} \cdot \frac{dk_j}{d\lambda}. \tag{11}$$

An intervention threshold $\lambda_i = \lambda_N$ and capital ratio $k_i = k_N$ maximize the welfare of country i. Thereby, the first order derivatives of WF_i by λ_i and k_i are zero at this point. The remaining terms describe the international externalities on country i of stricter supervision in country j, working through changes in both λ_j and k_j.

Stricter supervision in j has positive and negative effects on welfare in i. On the one hand, the direct effect of an increased resolution threshold λ_j on WF_i is positive under the condition of lemma 1. The increased resolution threshold in j decreases the share of failing bank subsidiaries in j which require cross-subsidization by their successful counterparts in i. At the same time, stricter supervision implies a lower non-cooperatively set capital ratio k_j, $dk_j(\lambda)/d\lambda < 0$. More lenient capital regulation in j in turn has a negative spillover effect on welfare in i. A lower capital requirement in j increases the local lending volume $L_j = E/k_j$ and thereby the expected cost of cross-subsidization to bank affiliates in i.

In consequence, the overall welfare effect of moving towards a supranational supervisory regime, as given by equation (11), can be negative. This is the case, when the positive direct effect of stricter supervision is overcompensated by the negative indirect effect of more lenient, nationally set capital regulation. Appendix C derives the following sufficient

condition for a welfare loss:

$$c(1-\lambda_N) > (1+\lambda_N)\left[(1+\lambda_N)(\bar{R}-1) - \lambda_N E\right]. \tag{12}$$

Condition (12) can be interpreted as follows. The supervisory reform implies a welfare loss if the expected cost of depositor reimbursements is large relative to the expected rents from successful investment. The expected cost of depositor reimbursements is driven by the unit cost of public funds c. A larger cost of public funds affects the reform's welfare impact in two ways. Stricter supervision in one country increases the share of defaulting subsidiaries in the other country which must be reimbursed by the taxpayer at a cost c. Thus, for a large cost parameter, the direct, positive externality of stricter supervision (5) is small. At the same time, stricter supervision decreases the share of defaulting domestic subsidiaries and thereby the benefit from setting stricter, national capital regulation. For a large cost of public funds, this domestic benefit is especially sensitive to changes in supervision. Therefore, the reduction in regulatory capital standards caused by tighter supervision is larger the larger c is, see equation (9). This in turn implies a large negative international spillover effect of more lenient capital regulation (10). Our marginal analysis holds for both countries i and j due to symmetry.

The sufficient condition (12) is more likely to be fullfilled for small values of the nationally set intervention threshold λ_N. At a threshold value $\lambda_N = 0$ for instance, the condition would take the form $c > \bar{R} - 1$. A small threshold implies a high share of bank subsidiaries which are allowed to realize their investments. For a small threshold, global welfare consequently reacts strongly to changes in the nationally set capital ratio k_N and thereby the lending volume $L_N = E/k_N$. In particular, the negative indirect welfare effect of more lenient capital regulation becomes large for small values of λ_N. Accordingly, a small supervisory reform is more likely to be welfare decreasing, if it starts from a lenient nationally set supervisory standard. We summarize this result in the following proposition.

Proposition 2 *A reform towards a centralized supervisory regime can be welfare de-*

creasing, if the costs of public funds c are large, relative to the interest rate R_i and if the supervisory standard λ_N is sufficiently low in the initial decentralized equilibrium.

Proposition 2 has an important implication for supervisory unions such as the EU where capital regulation is at least partly decentralized. Moving towards centralized supervision, the welfare loss from more lenient national capital regulation can overcompensate the welfare gain from stricter supervision. As such, the overall welfare effect of centralized supervision depends critically on the degree of national discretion in the setting of capital standards.

5 Conclusion

In this paper, we model the interaction between bank capital regulation and supervision in a supervisory union like the one currently in place in the EU. We consider the context of multinational banking. Both, stricter capital regulation and stricter supervision have positive international spillovers in that they reduce the intra-bank cost of cross-subsidizing failing bank subsidiaries abroad. As such, national regulators set too lenient capital regulatory and supervisory standards from a global welfare perspective. We show that stricter, centralized supervision incentivizes even more lenient capital regulation at the national level. Stricter supervision reduces the share of subsidiary defaults and thereby the domestic welfare gain from stricter capital regulation. We further show that the negative spillovers of laxer national capital regulation can overcompensate the global welfare gain of stricter supervision. Then, moving towards a supervisory union without capital regulatory coordination reduces global welfare. This is the case when the cost of public funds is sufficiently large relative to the profitability of successful investments. Our results suggest that the efficiency of a supervisory union critically depends on the consistent definition and implementation of capital standards across member states.

Our model can be extended to analyze additional aspects of supervisory unions. One such question is the role of heterogeneity in the costs of public funds between member states. Modeling heterogeneous costs allows for additional insight into which countries

are most likely to benefit or loose from a supervisory union.

A Supranational supervisory standard: sufficient condition

We show that there is indeed an internal solution for the resolution threshold λ_G which maximizes global welfare. To this end, we show that the second order derivative of the global welfare function WF by λ_i is negative, indicating a maximum

$$\begin{aligned}\left.\frac{\partial^2 WF}{\partial \lambda_i^2}\right|_{\lambda_i=\lambda_G} = &-\frac{E}{k_i}\left[\bar{R}-\frac{E}{2k_i}-1+k_i+c(1-k_i)+\frac{1-\lambda_j^2}{2}(1-c)(1-k_i)\right] \\ &+\frac{E}{k_j}\left[\frac{(1-\lambda_j)^2}{2}(1-c)(1-k_j)\right].\end{aligned}$$

With $\lambda_i = \lambda_j = \lambda$ and $k_i = k_j = k$ this reduces to

$$\left.\frac{\partial^2 WF}{\partial \lambda_i^2}\right|_{\lambda_i=\lambda_G} = -\frac{E}{k}\left[\bar{R}-\frac{E}{2k}-1+k+c(1-k)+\lambda(1-\lambda)(1-c)(1-k)\right]. \quad \text{(A.1)}$$

Under the assumption that profits from a successful investment are positive and large enough to cross-subsidize a failing foreign subsidiary $\bar{R}-\frac{E}{k}-1>1$, equation (A.1) is negative for all $\lambda \in (0,1)$.

We now show that the limit cases $\lambda_i \to 0$ and $\lambda_i \to 1$ do not satisfy the first order condition for maximal global welfare and can thereby not be optimal:

$$\left.\frac{\partial WF(\lambda_i)}{\partial \lambda_i}\right|_{\lambda_i=0} = \frac{E}{k_i}\left[k_i + c(1-k_i)\underbrace{\left(1-\frac{1-\lambda_j^2}{2}\right)}_{>0}+\frac{1-\lambda_j^2}{2}(1-k_i)\right] > 0 \quad \text{(A.2)}$$

$$\left.\frac{\partial WF(\lambda_i)}{\partial \lambda_i}\right|_{\lambda_i=1} = -\frac{E}{k_i}\left[\bar{R}-\frac{E}{2k_i}-1\right]+\frac{E}{k_j}\underbrace{\left[\frac{(1-\lambda_j)^2}{2}(1-c)(1-k_i)\right]}_{<1}. \quad \text{(A.3)}$$

With $k_i = k_j = k$ and $c > 0$, expression (A.3) reduces to the sufficient condition

$$\left.\frac{\partial WF(\lambda_i)}{\partial \lambda_i}\right|_{\lambda_i=1} < -\frac{E}{k}\underbrace{\left[\bar{R} - \frac{E}{2k} - 1 - 1\right]}_{>0}, \tag{A.4}$$

which is smaller than zero for all $\lambda \in (0,1)$ due to the assumption of sufficiently large profits from lending. Hence, $0 < \lambda_G < 1$. □

B Supranational capital standard: sufficient condition

We show that any internal solution for the capital ratio in supranational optimum k_G represents a maximum of global welfare. To this end, we show that for any solution $k_G \in (0,1)$, the second order derivative of the global welfare function $WF = WF_i + WF_j$ by k_i is negative, indicating a maximum.

Maximizing the global welfare function, the first order condition for the supranationally optimal capital ratio k_G is given by

$$k_G(\lambda) = \frac{E(1-\lambda^2)}{(1-\lambda^2)(\bar{R}-1) - \frac{(1-\lambda)^2}{2}\left[(1+\lambda^2)c + 1 - \lambda^2\right]}, \tag{A.5}$$

with $\lambda = \lambda_i = \lambda_j$. Equation (A.5) describes an internal solution $k_G \in (0,1)$ if the cost of the deposit insurance scheme and intra-bank cross-subsidization is not too large compared to the rents from successful investment, such that the condition $(1-\lambda^2)(\bar{R} - E - 1) > \frac{(1-\lambda)^2}{2}\left[(1+\lambda^2)c + 1 - \lambda^2\right]$ holds.

The second order derivative of WF with respect to k_i is given by

$$\left.\frac{\partial^2 WF}{\partial k_i^2}\right|_{k_i=k_G} = \frac{2E}{k_i^3}\left(\frac{1-\lambda^2}{2}\left[\bar{R} - \frac{3E}{2k_i} - 1\right] - \frac{1-\lambda^2}{4}\left[(1+\lambda^2)c + 1 - \lambda^2\right]\right).$$

It takes a negative value, if the expression in the round brackets is negative. We insert the first order condition $k_G(\lambda)$ given by equation (A.5). The expression in the brackets takes a negative value if the following condition holds:

$$(1-\lambda^2)(\bar{R}-1) - \frac{(1-\lambda)^2}{2}\left[(1+\lambda^2)c + 1 - \lambda^2\right] > 0. \tag{A.6}$$

Given the restriction to internal solutions, this reduces to the sufficient condition

$$(1-\lambda^2)E > 0 \tag{A.7}$$

which holds for all $\lambda \in (0,1)$. Hence, any internal solution $k_G \in (0,1)$ for the supranational capital standard must represent a maximum. □

C Derivation of condition (12)

We prove that if sufficient condition (12) holds, moving towards a global supervisory regime decreases the welfare of country i. To this end, we analyze the welfare impact of a small supervisory reform, as given by equation (11). In a first step, we insert the expressions for the international externalities of stricter supervision and capital regulation on country i, (5) and (10), into the welfare analysis. Starting at the national optimum $\lambda_i = \lambda_j = \lambda_N$ and $k_i = k_j = k_N$, this leads to a condition for a welfare loss $\frac{dWF_i}{d\lambda} < 0$

$$\begin{aligned} 0 \; > & (1-\lambda_N)\frac{1-\lambda_N^2}{2} - \lambda_N \frac{(1-\lambda_N)^2}{2}\left[k_N + c(1-k_N)\right] \\ & + \frac{1}{k_N}\frac{(1-\lambda_N)^2}{2}\frac{1-\lambda_N^2}{2}\frac{dk_N}{d\lambda}. \end{aligned} \tag{A.8}$$

Into this inequality, we insert expressions (8) and (9) for the national regulators' choice of capital ratio $k_N(\lambda)$ and its dependence on λ, $dk_N/d\lambda$:

$$
\begin{aligned}
0 \;>\; & c\lambda(1-\lambda)\left[\frac{c}{2}(1-\lambda)^2(1+\lambda^2)-(1-\lambda^2)(\bar{R}-E-1)\right] \\
& +\; (1-\lambda^2)\left[(1-\lambda^2)(\bar{R}-1)-\lambda(1-\lambda)E\right] \\
& -\; c(1-\lambda)\left[(1-\lambda)(1-\lambda^4)-\lambda(1-\lambda)^2\right].
\end{aligned}
\tag{A.9}
$$

Under the condition for an interior solution $k_N \in (0,1)$ of the nationally set capital requirement, $(1-\lambda^2)(\bar{R}-E-1) > (1-\lambda)^2(1+\lambda^2)\frac{c}{2}$, the first line of inequality (A.9) must be negative for all values of $\lambda \in (0,1)$. Replacing the first line by zero leads to the sufficient condition

$$
\begin{aligned}
0 \;>\; & (1-\lambda^2)\left[(1-\lambda^2)(\bar{R}-1)-\lambda(1-\lambda)E\right] && \text{(A.10)} \\
& -\; c(1-\lambda)^2\left[(1-\lambda^4)-\lambda(1-\lambda)\right] \\
\Leftarrow \quad 0 \;>\; & (1+\lambda)\left[(1+\lambda)(\bar{R}-1)-\lambda E\right]-c(1-\lambda). && \text{(A.11)}
\end{aligned}
$$

The sufficient condition (A.11) is more likely to be fulfilled for small values of λ. At $\lambda = 0$ it takes the form $c > \bar{R}-1$.

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