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Abstract

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JEL Classification: N/A

Keywords: Regulatory competition, General Equilibrium, Capital requirements, bank levy, bank resolution

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Regulatory Competition in Banking: A General Equilibrium Approach*

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Abstract

We study competition between governments with regard to capital requirements, bank levies and resolution regimes in a general equilibrium setting. In a two-country model, households can invest both domestically and abroad, with banks acting as intermediaries between households and risky technologies. When competing governments set banking regulation, the mechanism at work is driven by the trade-off between accentuating benefits over costs stemming from banking activities, on the one hand, and enhancing banks' competitiveness, on the other hand. Whether or not regulatory competition yields the efficient allocation of resources and risks crucially depends on whether governments compete with one, two or three policy tools.

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JEL Classification: D53; E44; G21; G28; H73

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1 Introduction

In an environment of internationally integrated financial markets, banking regulation affects the allocation of resources among jurisdictions on the globe. That naturally gives rise to competition among national governments who aim to maximize their benefits and minimize their costs from banking activities. In this paper, we study how competing governments behave when they set banking regulation—in terms of capital requirements, bank levies and resolution regimes—with the goal to maximize the welfare of households that reside within their jurisdiction. Adopting a general equilibrium approach, and comparing the outcome that arises under regulatory competition against a supranational solution, we shed light upon the impact of regulatory competition in banking on the level of risk-taking and, therefore, on the allocation of resources and risks, and ultimately on social welfare.

In particular, we develop a two-country two-period general equilibrium model with households, technologies, banks and a government in each country. Households in each country invest an initial endowment of capital in the first period and consume in the second period. The initial endowment is converted into a consumption good by means of two different technologies that are available in both countries: a free-of-risk technology (FT), and a risky technology (RT) in which the returns depend on the macroeconomic conditions. Capital is mobile. RT can only be financed by bank loans. That is, banks, which finance their operations by raising deposits and equity from both residents and foreigners, act as intermediaries between households and risky technologies.

Governments set banking regulation in the form of capital requirements, bank levies and resolution regimes. Capital requirements, set by national governments in the form of minimum equity-to-debt ratios, must comply themselves with an exogenous *floor* level of capital regulation that can be interpreted as complying with internationally agreed minimum standards in the spirit of the Basel III framework. Bank levies can be understood in the spirit of the proposal of the International Monetary Fund (2010), in the aftermath of the 2007-2009 financial crisis, regarding ex-ante bank contributions. The bank resolution regime determines whether failed banks will be bailed out, which also implies that deposits are guaranteed, or not.

A government's decisions on banking regulation only apply to banks that operate within this government's jurisdiction. That said, potential deposit guarantees stemming from the bank resolution regime are provided to all depositors, irrespec-

tive of where they reside. We also assume that once regulation is decided, this regulation is implemented with consistency. That reflects the focus of our paper on the impact of regulatory competition on the *design* of banking regulation (ex ante), as opposed to its *implementation* (ex post). Thus, at a conceptual level, our paper complements the book of Rochet (2008), where political interference in banking regulation assumes the form of time inconsistency problems. Our paper is also complementary to Gersbach et al. (2015), who provide a general equilibrium rationale for imposing capital requirements in a single country. Drawing on the model of Gersbach et al. (2015), we study the outcome when countries compete with regard to banking regulation.

Following the tradition that can be traced back to Pigou (1920), we consider government intervention as a means towards social welfare maximization. Yet, national governments aim at maximizing social welfare only within their jurisdiction. Whether governments' intervention under regulatory competition maximizes the aggregate welfare across jurisdictions is *a priori* unclear. In fact, that is the core question of this paper.

In our model, when competing governments set banking regulation, the mechanism at work is driven by the trade-off between accentuating benefits over costs from banking, on the one hand, and enhancing banks' competitiveness, on the other hand. Benefits take the form of revenues from bank levies. Costs refer to bail-out expenditures. Banks' competitiveness depends on the effect of policy tools on bank returns, which in turn depend on revenues, costs and capital structure of banks: Bank levies depress bank revenues; a bail-out provision decreases bank costs by making deposits a risk-free asset; and capital requirements raise the bank equity-to-deposits ratio. This mechanism precludes both too strict and too lax banking regulation in equilibrium. As will be shown, a rather lax decision regarding one tool of banking regulation is counteracted by a rather strict decision with respect to another tool of banking regulation. Hence, the equilibrium policy mix of banking regulation reflects a balance with regard to the aforementioned trade-off.

In the most general case, when issuance of equity is costly, we establish two main results. First, regulatory competition yields a suboptimal allocation of resources when governments compete only over the dimension of capital requirements, with bank levies and resolution regimes being exogenously fixed such that bail-out costs exceed revenues from levies. Second, regulatory competition yields the efficient allocation of resources if there are policy tools available to competing governments that can counteract costs stemming from banks. In the case of governments com-

peting with regard to all three policy tools, they economize on equity issuance costs by setting capital requirements equal to the *floor* level, and then choose between two approaches: Either they depress bank costs—in the form of returns on deposits—by promising to bail out failed banks at the expense of simultaneously reducing bank revenues by imposing levies, or they leave bank costs undistorted by adopting a bail-in provision, also leaving bank revenues intact via zero levies. Both approaches offset bail-out costs, if any, and result in the same level of banks' competitiveness in terms of bank returns.

We subsequently discuss our results in four respects. First, we highlight the dual role of equity as a means for reducing risk-taking and absorbing losses. Second, we extend our analysis with regard to households' risk-aversion and show that the results are robust. Third, we consider the impact of banking crisis repercussions—besides mere bail-out costs—on the decisions of competing governments. Finally, institutional implications of our results are discussed in view of the EU institutional architecture, which is characterized by the co-existence of national and supranational competences.

Important insights into regulatory competition in banking regulation have further been obtained by Buck and Schliephake (2013) who show that when banks are allowed to finance projects abroad, the optimal policy mix—in the form of capital requirements and supervisory effort—cannot be reached and the capital standards reduce to the minimum, if the quality of domestic supervisors is unobservable. Acharya (2003) studies the competition between regulators with respect to capital requirements and closure policy. In an infinite horizon model, Acharya (2003) shows that under harmonized capital requirements, national regulators, who aim at maximizing the continuation value of all bank claims, reduce their regulatory standards with respect to closure policies. Reduced regulatory standards set by national regulators have been found by Dell'Ariccia and Marquez (2006) as well. In their model, aiming to maximize the weighted sum of the probability that banks do not fail and banks' profits, the national regulators have incentives to support their banks' competitiveness by setting lower capital standards.

Morrison and White (2009) also contribute to the literature on competition with regard to banking regulation in the form of assignment of banking licenses to banks that are either sound or unsound. Regulators aim to maximize the expected volume of funds deposited at sound banks, and bankers benefit if they are licensed by a regulator of better reputation because of the resulting depositors' confidence. In this setting, Morrison and White (2009) find that competition benefits the country

with a stricter licensing process by attracting the high quality banks. Finally, Boyer and Kempf (2016) show that regulatory competition yields an inefficient outcome. In a setting where competing regulators, facing informational asymmetries with regard to banks' efficiency levels, aim to control banks' riskiness and size, the inefficient outcome arises as the result of regulators' inability to exercise discretion in regulating banks of different efficiency levels.

Our contribution to the literature is threefold. First, we complement previous models by considering welfare-maximization within each jurisdiction as the mere objective of competing governments. Incentives for competing governments to attract banking activities into their jurisdiction may or may not arise endogenously, depending on whether that contributes to national social welfare. Second, our general equilibrium approach allows a thorough understanding of the effects of banking regulation—composed of three policy tools—on equilibrium returns and risk-taking levels, and ultimately, on the allocation of resources among competing countries. Third, showing that whether regulatory competition yields the efficient allocation of resources, or not, crucially depends on the policy tools available to competing governments, we contribute to the broader literature of regulatory competition that does not necessarily focus on banking regulation. Our results lie between the seminal work of Tiebout (1956), who shows that tax policy by local governments can be efficient, and the literature exploring the downside of such forms of competition (see, for example, Sinn (1997)).

The rest of the paper is organized as follows. In Section 2, we present the setup of the model and the competitive equilibrium with exogenous banking regulation is characterized. In Section 3, we endogenize competing governments' decisions on banking regulation. Against the benchmark results of Section 3, in Section 4, we study regulatory competition when issuance of equity is costly. A discussion on important aspects of our paper is offered in Section 5, and we conclude in Section 6. Proofs are given in the Appendix.

2 Model Setup and Competitive Equilibrium

We consider a two-country two-period model ($t = 1, 2$) with entrepreneurs, households, bankers and a government in each country. At $t = 1$, there is a single non-storable and non-consumable endowment, which can be transformed into a consumption good in period $t = 2$ by two different technologies, namely, a technology that is free-of-risk (FT) and a risky technology (RT). There is a total

endowment W ($W > 0$) of the investment good in each country. Thus, the global endowment equals $2W$.

Perfect competition prevails in all markets, and therefore, all agents are price-takers (contract-takers). A generic country is denoted by the subscript j ($j = 1, 2$) or k ($k = 1, 2$) with $j \neq k$ if both labels are used concurrently. Moreover, all agents are risk-neutral.[1] The following assumption will facilitate the characterization of equilibrium in case of an agent's indifference between domestic and foreign assets.[2]

Assumption 1. *If the expected returns on domestic assets are at least equal to the expected returns on foreign assets available to an agent, then this agent strictly prefers the former.*

2.1 Entrepreneurs

The technologies are operated by representative entrepreneurs that stand for a continuum of entrepreneurs who behave competitively.

Free-of-risk Technology (FT)
An investment of the amount of k_F^j in FT in Country j at $t = 1$ yields $f(k_F^j)$ of the consumption good in period $t = 2$. The production function $f(\cdot)$, that is the same in both countries, satisfies $f'(\cdot) > 0$, $f''(\cdot) < 0$, and the Inada conditions $\lim_{k_F^j \to 0} f'(k_F^j) = +\infty$ and $f'(W) = 0$.

There are no financial frictions associated with operating FT. Hence, FT in Country j can be financed by issuing risk-free bonds, B_F^j, directly to households. In order for the bond market to clear, $B_F^j = k_F^j$. These bonds are repaid in period $t = 2$ with R_F^j per unit of invested capital. Thus, the profits of the representative entrepreneur in FT in Country j are $\Pi_F^j(k_F^j) = f(k_F^j) - R_F^j k_F^j$. From the first-order condition (henceforth, FOC), we obtain:

$$R_F^j = f'\left(k_F^j\right). \tag{1}$$

We call R_F^j the *"FT returns in Country j"*. Because of capital mobility, the FT returns in the two countries need to be equal. Otherwise, and because of the Inada conditions, the returns in FT would be either infinite or zero. Thus, $R_F^j = R_F^k =: R_F$ and $k_F^j = k_F^k =: k_F$.

[1] In Section 5, we discuss our results with respect to households' risk-aversion.

[2] The assumption is justified by small fixed costs incurred by agents investing abroad, e.g. translations, travels. These costs can be neglected, but break ties in case of indifference.

Risky Technology (RT)

The output in RT is uncertain. In particular, there are two states of the world that are realized at the beginning of $t = 2$: the *good state* occurs with probability σ $(0 < \sigma < 1)$ and the *bad state* occurs with probability $1 - \sigma$. An investment of one unit of investment good in RT in Country j in period $t = 1$ returns $\overline{R}$ and $\underline{R}$ units of consumption good in period $t = 2$ in the good state and the bad state of the world, respectively, with $0 < \underline{R} < \overline{R}$.[3] Therefore, the expected returns of investing one unit of the investment good in RT read as follows:

$$\mathbb{E}[\widetilde{R}] = \sigma\overline{R} + (1 - \sigma)\underline{R}. \tag{2}$$

The amount of capital invested in RT in Country j is denoted by k_R^j.

2.2 Banks

A friction in RT determines the role of banks. In particular, we assume that entrepreneurs running RT are prone to moral hazard featuring the following characteristic:[4] Entrepreneurs cannot pledge repayment to investors since, for instance, they may simply take the output of investments and run. Hence, RT entrepreneurs can only be funded via banks that have access to a monitoring technology to enforce repayment obligations.[5] For the sake of simplicity, we assume that banks can completely alleviate moral hazard of RT entrepreneurs and that monitoring costs are zero.[6] That is, banks, acting as financial intermediaries between households and RT entrepreneurs, perceive RT as a risky investment whose returns will be detailed below.

Specifically, we consider a continuum of identical banks that are operated by bank managers who only play a passive role, i.e., we assume there is no conflict of interest between bank managers and shareholders. Since banks are identical and perfectly competitive, we consider a representative bank in each country. The bank in Country j can be financed by deposits, D^j, and equity, E^j.[7] D^j is the sum of

[3]Our results hold regardless of whether the realization of the state of the world is perfectly correlated across countries, or not. That is the case because all decisions of agents and governments are made before the state of the world is revealed, based on expected terms.

[4]RT can be interpreted as newly-established firms, as opposed to well-established FT firms.

[5]Such monitoring activities take, for instance, the form of cash flow inspections, regular business monitoring and collateralization, see the seminal paper of Diamond (1984) on financial intermediaries as delegated monitors.

[6]Neglecting monitoring costs merely simplifies the formal presentation. Adding monitoring costs m $(m > 0)$ per unit of loan does not affect the results.

[7]As a result of the assumption of no conflict of interest between bank managers and share-

deposits from households of Country j (D^{jj}) and from households of Country k (D^{jk}). E^j is composed of equity from households of Country j (E^{jj}) and from households of Country k (E^{jk}). That is, $D^j = D^{jj} + D^{jk}$ and $E^j = E^{jj} + E^{jk}$. Capital structure of the bank in Country j is depicted by the equity-to-debt ratio,

$$\Theta^j = \frac{E^{jj}+E^{jk}}{D^{jj}+D^{jk}} = \frac{E^j}{D^j} \ .$$

We assume the existence of a legal requirement for a strictly positive amount of equity for banks to be licensed.[8] That is, the case of $E^j = 0$ automatically implies the absence of a banking sector in Country j. The dummy variable b^j indicates the existence or the absence of a banking sector in Country j, as follows:

$$b^j = \begin{cases} 0 & \text{if there is no banking sector in Country j;} \\ 1 & \text{if there is a banking sector in Country j.} \end{cases}$$

Banks in Country j invest the amount of raised funds in the form of deposits, D^j, and equity, E^j, in RT loans, denoted by L^j_R. Namely, bank assets are equal to $L^j_R \equiv D^j + E^j$ with state-contingent returns $\overline{R}^j_R$ and $\underline{R}^j_R$ per unit of loan in the good state and the bad state of the world, respectively. Thus, expected returns for investing one unit of capital in L^j_R in Country j are $\mathbb{E}[R^j_R] = \sigma\overline{R}^j_R + (1-\sigma)\underline{R}^j_R$. In order for the loan market to clear, $L^j_R = k^j_R$.

The representative entrepreneur in RT in Country j aims at maximizing his expected profits that are $\mathbb{E}[\Pi^j_R] = \sigma\overline{\Pi}^j_R + (1-\sigma)\underline{\Pi}^j_R$, where $\overline{\Pi}^j_R$ and $\underline{\Pi}^j_R$ are the RT profits in the good state and the bad state of the world, satisfying $\overline{\Pi}^j_R = k^j_R \cdot (\overline{R} - \overline{R}^j_R)$ and $\underline{\Pi}^j_R = k^j_R \cdot (\underline{R} - \underline{R}^j_R)$, respectively.

Because of the linear production function in RT, the entrepreneur would demand an infinite (zero) amount of capital in case of strictly positive (negative) profits. That, however, cannot be satisfied because it would result in either $k_F = 0$ or $k_F = W$, which in turn would yield either infinite or zero FT returns. Hence, $\mathbb{E}[\Pi^j_R] = 0$ in equilibrium, implying both

$$\overline{R}^j_R = \overline{R}; \tag{3}$$

$$\underline{R}^j_R = \underline{R} \tag{4}$$

and consequently, $\mathbb{E}[R^j_R] = \mathbb{E}[\widetilde{R}]$. Hence, the returns on loans to risky projects in

holders, there is no need for inside equity. E^j refers to outside equity.

[8] This requirement is a common practice. For example, Article 12 of Directive 2013/36/EU requires an initial capital that is not less than EUR 5 million in order for a bank to be licensed.

the two countries are identical.

We now provide further details on the liability-side of bank balance-sheets. Deposits are senior to equity. In particular, banks of Country j promise in period $t = 1$ to repay their depositors with R_D^j per unit of deposit in period $t = 2$. Whether depositors receive the entire amount of promised returns depends on bank profits in period $t = 2$. $\mathbb{E}[R_D^j]$ denotes the expected returns on deposits from Country j's banks. If bank profits—namely, bank revenues net of returns on deposits—are positive, they are distributed among shareholders. We assume limited liability of shareholders.

Banks do not default as long as they are able to fulfill their repayment obligations to their depositors. That requires non-negative profits, even if the bad state of the world occurs. That is, $(D^j + E^j) \cdot \underline{R} - D^j \cdot R_D^j \geq 0$.[9] This non-defaulting condition can also be expressed as follows:

$$\Theta^j \geq \bar{\Theta}^j, \tag{5}$$

where

$$\bar{\Theta}^j = \frac{R_D^j - \underline{R}}{\underline{R}}. \tag{6}$$

We call $\bar{\Theta}^j$ the *"resilience threshold in Country j"* because banks with equity-to-debt ratio above this threshold withstand the bad state of the world. A bank with capital structure satisfying (5) is *resilient*. Otherwise, it is *fragile*.

Banks' problem is solved in two steps. In the first step, banks aim to raise an initial amount of equity, and obtain an amount say E^j, in order to be licensed and start operating. Whether banks can do this, or not, depends on households' expectations. If $\mathbb{E}[R_E^j] = \mathbb{E}[R_E^k]$, then banks of both countries can raise equity. Otherwise, the expected returns on equity offered by the representative banks in the two countries are different, say $\mathbb{E}[R_E^j] > \mathbb{E}[R_E^k]$. In that case, the representative bank in Country k cannot raise equity and therefore, it is not licensed and cannot operate. That means $b^j = 1$ and $b^k = 0$. In the second step, the initial shareholders appoint a bank manager who is acting on their behalf. The bank manager decides on the capital structure of his bank, Θ^j, subject to a regulatory constraint which will be introduced below, aiming to maximize the expected returns on equity,

[9] In equilibrium, it turns out that banks stay afloat if the good state of the world is materialized in period $t = 2$, irrespective of their capital structure.

$\mathbb{E}[R_E^j]$, which read as follows:

$$\mathbb{E}[R_E^j] = \sigma \cdot \overline{R}_E^j + (1-\sigma) \cdot \underline{R}_E^j, \tag{7}$$

where

$$\overline{R}_E^j = \left(L_R^j \cdot \overline{R} - D^j \cdot R_D^j\right) / E^j \tag{8}$$

$$\underline{R}_E^j = \max\left\{\left(L_R^j \cdot \underline{R} - D^j \cdot R_D^j\right) / E^j, 0\right\}. \tag{9}$$

We note that returns on equity cannot fall below zero because of limited liability of bank shareholders.

The following assumption will break ties in case of managers' indifference between deposits and equity:

Assumption 2. *If the expected returns are independent of Θ^j in an interval, say $[\Theta_{\text{low}}^j, \Theta_{\text{high}}^j]$, then the bank manager chooses $\Theta^j = \Theta_{\text{low}}^j$.*

That can be justified by (arbitrarily) small, but positive, equity issuance costs. Indeed, Assumption 2 becomes redundant in Section 4 where cost of equity issuance is formally modeled.

2.3 Households

We assume that in each country resides a continuum of households. In period $t = 1$, all households are endowed with the same amount of capital and non-tradable property rights to FT and RT that operate in their home countries. Thus, we consider a representative household in each country, endowed with initial capital W. The household in Country j invests its endowment W in period $t = 1$ by choosing a portfolio composed of six assets: B_F^j, B_F^k, D^{jj}, D^{kj}, E^{jj} and E^{kj}.

In period $t = 2$, the household in Country j consumes $\overline{c}^j$ and $\underline{c}^j$ in the good state and the bad state of the world, respectively. Household's expected utility, which is denoted by $\mathbb{E}[U^j]$, reads as follows:

$$\mathbb{E}[U^j] = \sigma \cdot \overline{c}^j + (1-\sigma) \cdot \underline{c}^j. \tag{10}$$

Since household's expected utility depends linearly on the assets' expected returns, the representative household in Country j invests in the asset with the highest

expected return.[10] If multiple assets are associated with the highest expected returns, the representative household is indifferent among those assets. Because in equilibrium FT capital in both countries, and deposits and equity in at least one country need to be strictly positive, we obtain:

Lemma 1.

$$R^* = \begin{cases} R_F^j = R_F^k = \mathbb{E}[R_D^j] = \mathbb{E}[R_D^k] = \mathbb{E}[R_E^j] = \mathbb{E}[R_E^k] & \textit{if } b^j = b^k = 1; \\ R_F^j = R_F^k = \mathbb{E}[R_D^j] = \mathbb{E}[R_E^j] & \textit{if } b^j = 1 \textit{ and } b^k = 0. \end{cases}$$

We henceforth call R^* the *"equilibrium returns"*.

2.4 Government

The government in each country decides on three policy tools: capital requirements, bank levies and bank resolution. Government decisions take place at the beginning of period $t = 1$. We assume that these decisions are implemented with consistency. We describe these policy tools in turn.

Capital Requirements

Capital requirements in Country j, denoted by Θ^j_{reg}, take the form of a minimum equity-to-debt ratio that banks in Country j need to achieve in order to be allowed to operate in Country j. Formally, capital requirements are described as follows:

$$\Theta^j \geq \Theta^j_{\text{reg}} \geq \vartheta, \tag{11}$$

where ϑ ($\vartheta > 0$) is an exogenous *floor* capital regulation which reflects internationally given minimum standards the country has agreed to.[11] That also satisfies the legal requirement for a strictly positive amount of equity in order for a bank to be founded (see also Footnote 8).

Bank Levies

Governments can impose a levy on the revenues of banks operating within their jurisdiction.[12] In particular, banks are required to contribute the fraction τ^j of

[10] Households' consumption, and therefore expected utility, also depends on revenues from bank levies and potential bail-out costs that are introduced in Subsection 2.4. However, the representative household cannot affect these aggregate variables, thus making investment decisions only based on assets' expected returns.

[11] For instance, ϑ can be interpreted in the spirit of capital regulation set by the Basel Committee on Banking Supervision (BCBS) the Charter of which states that *"BCBS standards constitute minimum requirements and BCBS members may decide to go beyond them."*

[12] Such a levy has been discussed in the aftermath of the 2007-2009 financial crisis in a proposal

their revenues to the government of Country j.[13] Thus, Country j's government receives $\overline{\Phi}^j = \tau^j \cdot L_R^j \cdot \overline{R}$ and $\underline{\Phi}^j = \tau^j \cdot L_R^j \cdot \underline{R}$ in the bad state and the good state of the world, respectively. These revenues may be used to finance bank bail-outs, as will be described below. If there are no bail-out costs, revenues from levies are distributed to, and consumed by, households. The expected revenues of the government in Country j read as follows:

$$\mathbb{E}[\Phi^j] = \tau^j \cdot L_R^j \cdot \mathbb{E}[\widetilde{R}]. \tag{12}$$

Bank Resolution

The government in Country j chooses the bank resolution regime by deciding whether failed banks will be bailed out or bailed in. The bank resolution regime is characterized according to

$$P^j = \begin{cases} 0 & \text{if failed banks in Country } j \text{ are bailed out;} \\ 1 & \text{if failed banks in Country } j \text{ are bailed in.} \end{cases}$$

If $P^j = 0$, then deposits in Country j are guaranteed irrespective of depositors' residence, and $\mathbb{E}[R_D^j] = R_D^j$. In that case, bail-out costs, denoted by T^j, amount to the promised returns on deposits net of the liquidation value of the bank, and materialize if banks are fragile. In the case of bail-in, i.e., $P^j = 1$, then, if banks fail, depositors share the liquidation value of the bank and the bail-out expenditures are zero, i.e., $T^j(P^j = 1) = 0$. That is,

$$T^j = \begin{cases} \max\left\{\left(D^j \cdot R_D^j - (D^j + E^j) \cdot \underline{R}\right), 0\right\} & \text{if } P^j = 0; \\ 0 & \text{if } P^j = 1. \end{cases} \tag{13}$$

The expected bail-out costs are denoted by $\mathbb{E}[T^j]$. Because in equilibrium banks do not fail in the good state of the world, expected bail-out costs are given by:

$$\mathbb{E}[T^j] = (1 - \sigma) \cdot T^j. \tag{14}$$

Bailout costs can be financed by revenues from bank levies. If bail-out costs exceed these revenues, the government covers the difference by imposing a lump sum taxation on households. Each government is only responsible for bailing out banks

of the International Monetary Fund (2010). Ex ante bank contributions as required by Regulation (EU) No 806/2014 move also in the same direction.

[13] Bank levy on bank revenues in period $t = 2$ is equivalent to bank levy on bank balance-sheet in period $t = 1$ with revenues being invested in RT, or to taxation on RT output in period $t = 2$.

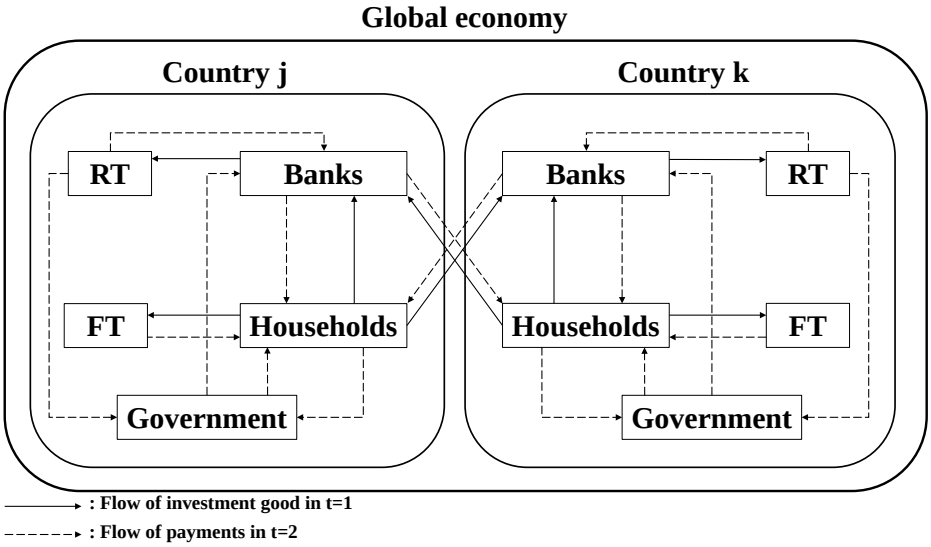

Figure 1: Model Setup

that operate in its own jurisdiction and can only impose taxation on households that reside within its jurisdiction.

Definition 1. *Banking regulation in Country j is fully described by capital requirements, Θ^j_{reg}, bank levies, τ^j, and bank resolution regime, P^j.*

A supranational authority will be denoted with the subscript s. For example, $P^s = 0$ implies that a supranational authority requires by both countries to implement a bail-out clause, i.e., $P^j = P^s = 0$ with $j = 1, 2$.

The setup of the model is graphically presented in Figure 1. Note that, in principle, households and banks can invest across borders in FT and RT, respectively. However, because of Lemma 1 and Assumption 1, households only invest in domestic FT in equilibrium; since returns on loans are identical in the two countries, Assumption 1 induces only domestic loans.

2.5 Equilibrium Returns

From Lemma 1, we know that banks in Country j operate only if they can offer returns that are at least equal to the returns offered by banks in Country k. We call the expected returns that can be offered by banks in Country j the *"equilibrium returns in Country j"*, which are denoted with R^{j*}. From Lemma 1, and because

in equilibrium banks managers will choose $\Theta^j = \Theta^j_{\text{reg}}$,[14] we obtain:

Lemma 2.

$$R^* = \max\{R^{j*}, R^{k*}\}$$

where

$$R^{j*}(\Theta^j_{\text{reg}}, \tau^j, P^j) = \begin{cases} (1-\tau^j) \cdot \frac{1+\Theta^j_{\text{reg}}}{\sigma+\Theta^j_{\text{reg}}} \cdot \sigma\overline{R} & \forall \Theta^j_{\text{reg}} \in \left(0, \bar{\Theta}^j\right) \ \textit{and} \ P^j = 0; \\ (1-\tau^j) \cdot \mathbb{E}[\widetilde{R}] & \forall \Theta^j_{\text{reg}} \in \left[\bar{\Theta}^j, +\infty\right) \ \textit{and} \ P^j = 0, \ \textit{or} \\ & \forall \Theta^j_{\text{reg}} \in (0, +\infty) \ \textit{and} \ P^j = 1. \end{cases}$$

The first expression of Lemma 2 is the result of households' decision to invest in the asset with the highest expected return, as it is also reflected in Lemma 1. Lemma 2 reveals the impact of the policy tools on equilibrium returns, and therefore, on the level of risk-taking and the allocation of resources. Specifically, policy tools affect risk-taking by affecting the returns banks can offer. The higher the returns, the more funds banks attract, and the more capital is invested in risky technologies. From (7)–(9), we observe that bank returns depend on three components: bank revenues, bank costs and capital structure, i.e., the relationship between equity and deposits. We discuss the impact of policy tools on these components in turn.

Bank levies eat away bank revenues. Therefore, the higher the bank levies, the lower the bank revenues and, consequently, the lower the returns banks may offer, which ultimately implies lower risky investments.

The bank resolution regime may affect bank costs. In particular, a bail-out provision makes deposits a risk-free asset, therefore, reducing their returns. In that sense, a bail-out provision can be understood as a subsidy on bank costs that distorts returns on deposits. In contrast, a bail-in provision implies that depositors may also bear losses in case of a bank default. This risk is reflected in deposit returns, thus increasing bank costs and reducing the equilibrium returns.

The effect of capital requirements needs to be understood in light of the effect of bank resolution. In particular, the subsidy of bail-out remains irrelevant as long as the equity-to-debt ratio of banks is high enough to render them resilient. If, however, banks are fragile, i.e., $\Theta^j_{\text{reg}} < \bar{\Theta}^j$, the subsidy of bail-out on bank costs becomes relevant. Indeed, dividing (13) by D^j, one can observe that the lower the

[14] This property is proven by showing that $\partial\mathbb{E}[R^j_E]/\partial E^j = -\sigma D^j \left((1-\tau^j)\overline{R} - R^{j*}\right)/{E^j}^2 < 0$ and $\partial\mathbb{E}[R^j_E]/\partial D^j = \sigma\left((1-\tau^j)\overline{R} - R^{j*}\right)/E^j > 0$ for all capital structures that render banks fragile, as well as by combining Assumption 2 and $\partial\mathbb{E}[R^j_E]/\partial E^j = \partial\mathbb{E}[R^j_E]/\partial D^j = 0$ for all capital structures that render banks resilient.

equity-to-debt ratio, the higher the subsidy in the form of bail-out costs becomes.

Because $\partial R^{j*}/\partial \Theta^j_{\text{reg}} < 0 \ \forall \Theta^j_{\text{reg}} < \bar{\Theta}^j$ and $P^j = 0$, $\partial R^{j*}/\partial \Theta^j_{\text{reg}} = 0 \ \forall \Theta^j_{\text{reg}} \geq \bar{\Theta}^j$, $\partial R^{j*}/\partial \tau^j < 0 \ \forall \Theta^j_{\text{reg}}$, and observing that $R^{j*}(\bar{\Theta}^j, \tau^j; P^j = 0) = R^{j*}(\Theta^j_{\text{reg}}, \tau^j; P^j = 1)$, we can summarize the effects of policy tools on equilibrium returns as follows:

Corollary 1. *Equilibrium returns in Country j are, ceteris paribus,*

(i) strictly decreasing in capital requirements if banks are fragile, and independent of capital requirements if banks are resilient;

(ii) strictly decreasing in bank levies;

(iii) lower under a bail-in regime ($P^j = 1$) as compared to a bail-out regime ($P^j = 0$) if banks are fragile, and independent of bank resolution regime if banks are resilient.

2.6 Competitive Equilibrium

In a competitive equilibrium with exogenous banking regulation, equilibrium returns R^* are such that households in Country j maximize their expected utility, entrepreneurs in Country j maximize their profits, bank managers in Country j maximize expected returns on equity, and all markets clear, namely,[15]

$$\left(k^j_F + E^j + D^j + k^k_F + E^k + D^k\right) - (W + W) = 0; \tag{15}$$

$$\left(\overline{c}^j + \overline{c}^k\right) - \left(f(k^j_F) + k^j_R \cdot \overline{R} + f(k^k_F) + k^k_R \cdot \overline{R}\right) = 0; \tag{16}$$

$$\left(\underline{c}^j + \underline{c}^k\right) - \left(f(k^j_F) + k^j_R \cdot \underline{R} + f(k^k_F) + k^k_R \cdot \underline{R}\right) = 0. \tag{17}$$

Proposition 1. *For any given banking regulation $(\hat{\Theta}^j_{\text{reg}}, \hat{\tau}^j, \hat{P}^j)$ with $j = 1, 2$ there exists a unique competitive equilibrium with the expected utility of households given by:*

$$\mathbb{E}[U^j] = R^* \cdot W + \Pi_F + b^j \cdot \left(\mathbb{E}[\Phi^j] - \mathbb{E}[T^j]\right), \tag{18}$$

where

$$b^j = \begin{cases} 0 & \text{if } R^{j*} < R^{k*}; \\ 1 & \text{if } R^{j*} \geq R^{k*}. \end{cases} \tag{19}$$

The proof of Proposition 1 is given in the Appendix. Proposition 1 highlights the channel through which banking regulation affects the allocation of the investment

[15] As shown in Subsection 2.1, bond and loan markets clear by construction.

good between the two countries and the consequent impact on households' welfare. In particular, we note that countries do not differ from each other with respect to the returns on capital, R^*W, and FT profits, $\Pi_F(R^*)$, with $R^* = \max\{R^{j*}, R^{k*}\}$ as given by Lemma 2. But differences in banking regulation can differentiate countries with regard to revenues from bank levies and bail-out expenditures. Namely, a country that adopts a laxer approach towards banking regulation can be more attractive to banking activities,[16] enjoying thus high revenues but also suffering from large bail-out expenditures should its banks fail.

3 Endogenous Regulatory Competition

We now investigate the equilibrium that arises when banking regulation is endogenously determined by competing governments. We first investigate the one-dimensional problem when governments only compete with regard to capital requirements, with bank levies and bank resolution being exogenously given. We then endogenize bank levies, and finally, we study the three-dimensional problem when all three policy tools are endogenously determined.

3.1 One-dimensional Regulatory Competition

Considering that bank levies and bank resolution are given exogenously, regulatory competition only takes place with regard to capital requirements in this subsection. Such a situation may arise because capital regulation is conferred upon an independent authority with the sole mandate of setting capital requirements. This authority perceives other policy tools as given. Bank levies and bank resolution regime may be set by another domestic authority, or even by a supranational body.[17] For the sake of simplicity, we assume that a supranational authority imposes

$$\tau^s = 0 \text{ and } P^s = 0.$$

[16] This result is in line with Houston et el. (2012), who show that international capital flows are directed to markets with laxer regulation. In the same spirit, Ongena et al. (2013) show that stricter regulation in one country yields a shift of the risky activities to the country with laxer regulation, while Karolyi and Taboada (2015) show that regulatory arbitrage takes place with regard to cross-border bank acquisitions as well.

[17] That can be understood in the spirit of Regulation (EU) No 806/2014 that, indeed, establishes a supranational mechanism that collects bank contributions and decides on bank resolution at the EU level.

That is, neither country collects revenues from bank levies, while the distortion of bail-out is present in both. Since $\overline{\Phi}^j = \underline{\Phi}^j = 0$ for $j = 1, 2$, the problem faced by the national government in Country j is the following:

$$\max_{\Theta^j_{\text{reg}}} \left\{ \mathbb{E}[U^j] = R^* \cdot W + \Pi_F - \mathbb{E}[T^j] \right\}. \tag{20}$$

Banks will operate in the country with the higher equilibrium returns. From Proposition 1 and Corollary 1, we readily conclude that banks operate in both countries if $\Theta^j \geq \bar{\Theta}^j$ or $\Theta^j = \Theta^k$, whereas banks operate only in Country j if $\Theta^j < \Theta^k$ with $\Theta^j < \bar{\Theta}^j$. A direct result of this is that the resilience threshold is identical in the two countries, i.e., $\bar{\Theta}^j = \bar{\Theta}^k =: \bar{\Theta}$.

If $b^j = b^k = 1$, countries' welfare does not differ. If $b^j = 1$ and $b^k = 0$, we know from Proposition 1 that countries' welfare differs with regard to the expected bail-out costs. It becomes clear that countries can be strictly better off by avoiding to host banking activities, and thus, shifting the potential costs to the other country. Taking also into account that, due to Corollary 1, the equilibrium returns do not depend on capital requirements if $\Theta^j \geq \bar{\Theta}$, we conclude that Country j reacts to the decision of Country k on Θ^k_{reg} according to the following:

$$\Theta^j_{\text{reg}} \begin{cases} > \Theta^k_{\text{reg}} & \text{if } \Theta^k_{\text{reg}} \in \left(0, \bar{\Theta}\right); \\ \geq \bar{\Theta} & \text{if } \Theta^k_{\text{reg}} \in [\bar{\Theta}, +\infty). \end{cases} \tag{21}$$

Since governments have incentives to deviate upwards if bail-out costs are positive, whereas they are indifferent if bail-out costs are zero, we obtain:

Proposition 2. *Let $\vartheta < \bar{\Theta}$. Then, there exists a continuum of equilibria where Country j sets $\Theta^j_{\text{reg}} \geq \bar{\Theta}$.*

Because $\partial\mathbb{E}[U^s]/\partial\Theta^s_{\text{reg}} < 0$ for all $\Theta^s_{\text{reg}} < \bar{\Theta}$, whereas $\partial\mathbb{E}[U^s]/\partial\Theta^s_{\text{reg}} = 0$ for all $\Theta^s_{\text{reg}} \geq \bar{\Theta}$, where

$$\mathbb{E}[U^s] = R^* \cdot 2W + \sum_j \left(\Pi^j_F - \mathbb{E}[T^j]\right), \tag{22}$$

a supranational authority would also set $\Theta^s_{\text{reg}} \geq \bar{\Theta}$.

3.2 Two-dimensional Regulatory Competition

We now study regulatory competition with regard to capital requirements and bank levies, assuming that a supranational authority imposes

$$P^s = 1 \ .$$

Since we know from Proposition 1 that households' expected utility in countries with different banking regulations only differ with respect to the expected revenues from bank levies, $\mathbb{E}[\Phi^j]$, and expected bail-out expenditures, $\mathbb{E}[T^j]$, we are particularly interested in the impact of different points of the two-dimensional policy space defined by Θ^j_{reg} and τ^j on $\mathbb{E}[\Phi^j]$ and $\mathbb{E}[T^j]$. We call the difference between these two variables the *"net expected revenues"* and by substituting for $\mathbb{E}[\Phi^j]$ and $\mathbb{E}[T^j]$ from (12) and (14), respectively, we obtain:

$$\mathbb{E}[\Phi^j] - \mathbb{E}[T^j] = k^j_R \cdot \phi^j(\Theta^j_{\text{reg}}, \tau^j), \tag{23}$$

where

$$k^j_R = \beta^j(W - k_F); \tag{24}$$

$$\phi^j = \begin{cases} \frac{1+\Theta^j_{\text{reg}}}{\sigma+\Theta^j_{\text{reg}}} \cdot \sigma\overline{R}\tau^j - (1-\sigma) \cdot \left(\frac{\sigma\overline{R}}{\sigma+\Theta^j_{\text{reg}}} - \underline{R}\right) & \forall \Theta^j \in \left(0, \bar{\Theta}\right); \\ \tau^j \cdot \mathbb{E}[\widetilde{R}] & \forall \Theta^j \in \left[\bar{\Theta}, +\infty\right); \end{cases} \tag{25}$$

$$\beta^j = \begin{cases} 0 & \text{if } R^{j*} < R^{k*}; \\ 1 & \text{if } R^{j*} = R^{k*}; \\ 2 & \text{if } R^{j*} > R^{k*}. \end{cases} \tag{26}$$

We observe that $\mathbb{E}[\Phi^j] - \mathbb{E}[T^j] = 0$ if and only if the following holds:

$$\tau^j = \bar{\tau}(\Theta^j_{\text{reg}}), \tag{27}$$

where

$$\bar{\tau}(\Theta^j_{\text{reg}}) = \max\left\{\frac{1-\sigma}{1+\Theta^j_{\text{reg}}} \cdot \left(1 - \frac{\underline{R}(\sigma + \Theta^j_{\text{reg}})}{\sigma\overline{R}}\right), 0\right\}. \tag{28}$$

Note that $\bar{\tau}(\Theta^j_{\text{reg}})$ is a continuous and decreasing function in Θ^j_{reg} in the interval $\left(0, \bar{\Theta}\right)$, while $\bar{\tau}(\Theta^j_{\text{reg}}) = 0$ for all $\Theta^j_{\text{reg}} \geq \bar{\Theta}$. Moreover, from Lemma 2, we obtain:

$$R^{j*}(\Theta^j_{\text{reg}}; \tau^j = \bar{\tau}(\Theta^j_{\text{reg}}), P^j = 0) = \mathbb{E}[\tilde{R}] \qquad \forall \Theta^j_{\text{reg}}. \tag{29}$$

Finally, because $\mathbb{E}[\Phi^j] - \mathbb{E}[T^j] > 0$ for all $\tau^j > \bar{\tau}$ and $\mathbb{E}[\Phi^j] - \mathbb{E}[T^j] < 0$ for all $\tau^j < \bar{\tau}$, we call $\bar{\tau}$ the *"policy space dichotomy"*. An illustration of the policy space dichotomy for a certain specification[18] is shown in Figure 2.

[18] $f(k_F) = 2\sqrt{k_F} - k_F$, $W = 1$, $\underline{R} = 0.5$, $\overline{R} = 2$, and $\vartheta = 0.05$.

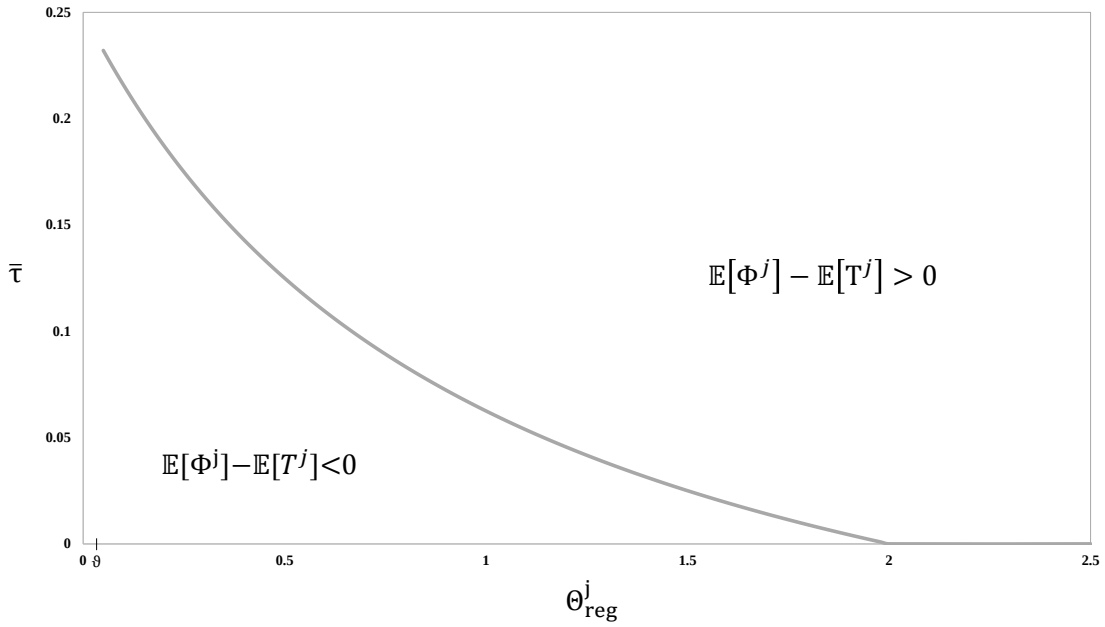

Figure 2: Policy space dichotomy, $\bar{\tau}$, with $P^j = 0$

We now turn our focus to the problem faced by the national government in Country j, which reads as follows:

$$\max_{(\Theta^j_{\text{reg}},\tau^j)} \left\{\mathbb{E}[U^j] = R^* \cdot W + \Pi_F + \mathbb{E}[\Phi^j] - \mathbb{E}[T^j]\right\}. \tag{30}$$

We know from the preceding analysis of the two-dimensional policy space that in this case, different banking regulations can result in negative, zero, or positive net expected revenues. Because governments are better off by shifting abroad banking activities as long as their policy mix of banking regulation lies in the subspace of negative net expected revenues, and by attracting banking activities as long as their policy mix lies in the subspace of positive net expected revenues, we obtain:

Lemma 3. *There cannot be equilibrium with* $\mathbb{E}[\Phi^j] - \mathbb{E}[T^j] \neq 0$.

The proof of Lemma 3 is given in the Appendix. Lemma 3 sheds light upon the incentives of competing governments. Governments have incentives to avoid hosting banks by adopting a stricter approach towards regulation, whereas they have incentives to attract banks by decreasing their capital requirements and bank levies in the case of strictly positive net expected revenues.

Drawing on Lemma 3, and showing that there is no welfare-increasing deviation from the policy space dichotomy, we establish:

Proposition 3. *Let $P^j = 0$. There exists a continuum of equilibria where Country j sets $\tau^j = \bar{\tau}(\Theta^j_{\text{reg}})$ for all $\Theta^j_{\text{reg}} \in (0, +\infty)$, with $j = 1, 2$.*

The proof of Proposition 3 is given in the Appendix. The intuition runs as follows. Provisioned on the level of capital requirements, the government insures itself by imposing bank levies such that potential bail-out expenditures are covered by revenues. Regulatory competition prevents governments from setting levies at levels that would yield positive net expected revenues because that would harm their attractiveness to revenues-generating banking activities.

If now a supranational government sets capital requirements and bank levies, maximizing welfare across jurisdictions, it solves the following problem:

$$\max_{(\tau^s, \Theta^s_{\text{reg}})} \left\{ \mathbb{E}[U^s] = R^* \cdot 2W + \sum_j \left(\Pi^j_F + \mathbb{E}[\Phi^j] - \mathbb{E}[T^j] \right) \right\}. \tag{31}$$

From FOC with respect to τ^s, we obtain that a supranational government sets

$$\tau^s = \bar{\tau} = \max \left\{ \frac{1-\sigma}{1+\Theta^s_{\text{reg}}} \left(1 - \frac{\underline{R}(\sigma + \Theta^s_{\text{reg}})}{\sigma \overline{R}} \right), 0 \right\}. \tag{32}$$

Because $\partial \mathbb{E}[U^s](\tau^s = \bar{\tau}) / \partial \Theta^s_{\text{reg}} = 0$, we conclude that a supranational authority would choose among the same continuum from which national governments choose in equilibrium. Note that although the socially optimal outcome can be achieved either with $b^j = b^k = 1$, or with $b^j = 1$ and $b^k = 0$, Assumption 1 selects the equilibrium with banks operating in both countries.

3.3 Three-dimensional Regulatory Competition

We now endogenize all three policy tools of banking regulation. The problem faced by the national government in Country j is the following:

$$\max_{(\Theta^j_{\text{reg}}, \tau^j, P^j)} \left\{ \mathbb{E}[U^j] = R^* \cdot W + \Pi_F + \mathbb{E}[\Phi^j] - \mathbb{E}[T^j] \right\}. \tag{33}$$

For the analysis below it is important to recall from (13) that bail-out costs are zero under a bail-in provision. Namely, $\mathbb{E}[T^j](P^j = 1) = 0$. Furthermore,

$$R^{j*}(\Theta^j_{\text{reg}}; \tau^j = \bar{\tau}(\Theta^j_{\text{reg}}), P^j = 0) = R^{j*}(\Theta^j_{\text{reg}}; \tau^j = 0, P^j = 1) = \mathbb{E}[\tilde{R}]. \tag{34}$$

Thus, in order for the same equilibrium returns to arise—irrespective of the resolution regime—bank levies under a bail-in provision need to be lower as compared to bank levies accompanied by a bail-out provision. That is the case because a bail-in provision increases bank costs, since deposits bear risk for which depositors need to be compensated with higher returns. In (34), the increase in bank costs—due to bail-in—is compensated with an increase in bank revenues—due to zero bank levies.

Following the reasoning of Lemma 3, we obtain that there cannot be an equilibrium with $P^j = 1$ and $\tau^j > 0$. Specifically, two cases may occur. First, if the other country also adopts a bail-in provision, then competition forces countries to decrease bank levies in order to become more competitive, thus attracting banking activities and the corresponding revenues from bank levies. Incentives to deviate cease when revenues are zero, i.e., for $\tau^j = 0$. Second, if one country adopts a bail-in clause and the other country adopts a bail-out clause, regulatory competition would force the former towards $\tau^j = 0$ and the latter towards $\tau^j = \bar{\tau}$, thus equilibrium returns in both countries satisfying (34).

The above suggest that equilibria under a three-dimensional regulatory competition need to satisfy $\tau^j = 0$ and $P^j = 1$, or $\tau^j = \bar{\tau}(\Theta^j_{\text{reg}})$ and $P^j = 0$. Since we also know from (34) that differences with regard to capital requirements will not affect the equilibrium returns, we know that Country j reacts to Country k's decisions as follows:

$$
\begin{aligned}
&P^j = 0 \text{ and } \tau^j < \tau^k, \text{ or } P^j = 1 \text{ and } \tau^j > 0 && \text{if } P^k = 0 \text{ and } \tau^k > \bar{\tau} \\
&P^j = 0 \text{ and } \tau^j = \tau^k, \text{ or } P^j = 1 \text{ and } \tau^j = 0 && \text{if } P^k = 0 \text{ and } \tau^k = \bar{\tau} \\
&P^j = 0 \text{ and } \tau^j > \tau^k, \text{ or } P^j = 1 \text{ and } \tau^j \geq 0 && \text{if } P^k = 0 \text{ and } \tau^k < \bar{\tau} \\
&P^j = 0 \text{ and } \tau^j > \bar{\tau}, \text{ or } P^j = 1 \text{ and } \tau^j < \tau^k && \text{if } P^k = 1 \text{ and } \tau^k > 0 \\
&P^j = 0 \text{ and } \tau^j = \bar{\tau}, \text{ or } P^j = 1 \text{ and } \tau^j = \tau^k && \text{if } P^k = 1 \text{ and } \tau^k = 0.
\end{aligned}
$$

Finally, we know from the proof of Proposition 3 that deviations from $\tau^j = \bar{\tau}$ while $P^j = 0$ cannot increase welfare. Combining now Corollary 1 and (34), we readily obtain that deviations from $\tau^j = 0$ while $P^j = 1$ also cannot increase welfare because the deviating country will be unable to attract banking activities. We hence establish:

Proposition 4. *There exists a continuum of equilibria when Country j sets either $(\tau^j, P^j) = (\bar{\tau}(\Theta_{\text{reg}}), 0)$ or $(\tau^j, P^j) = (0, 1)$ for any Θ^j_{reg}.*

Overall, the countries choose between two approaches: Either they offer safety to depositors by promising to bail out failed banks at the expense of reducing returns due to bank levies, or they renounce bank levies at the expense of pushing the risk of bail-in to depositors if banks fail. Both approaches yield identical equilibrium returns. Since the equilibria under three-dimensional regulatory competition includes the equilibria under two-dimensional regulatory competition, which replicates the allocation of resources under a supranational solution, it is straightforward that three-dimensional regulatory competition also yields the efficient allocation of resources.

4 Regulatory Competition with Costly Equity

The preceding analysis has been done under the assumption that issuance of equity and deposits is costless. That simplified the analysis and allowed us to establish a benchmark set of results against which results from a more detailed model can be compared. Indeed, since not only banks' financing is costly, but even more importantly, the cost among different assets vary, we capture in this section the empirical observation that the issuance of equity is costlier than raising deposits. Specifically, we generalize the model of the preceding sections assuming that equity is issued at cost δ per unit of issued equity ($0 < \delta < \underline{R}$).

That impacts the equilibrium returns that are now denoted by R^*_δ as opposed to equilibrium returns with zero equity issuance cost R^* that are described by Lemma 2. R^*_δ read according to the following:

Lemma 4.

$$R^*_\delta = \max\{R^{j*}_\delta, R^{k*}_\delta\},$$

where

$$R^{j*}_\delta(\Theta^j_{\text{reg}}, \tau^j, P^j) = \begin{cases} (1-\tau^j)\cdot\frac{1+(1-\delta)\Theta^j_{\text{reg}}}{\sigma+\Theta^j_{\text{reg}}}\cdot\sigma\overline{R} & \forall\Theta^j_{\text{reg}} \in \left(0, \bar{\Theta}^j\right) \ \textit{and}\ P^j = 0 \\ (1-\tau^j)\cdot\frac{1+(1-\delta)\Theta^j_{\text{reg}}}{1+\Theta^j_{\text{reg}}}\cdot\mathbb{E}[\widetilde{R}] & \begin{array}{l}\forall\Theta^j_{\text{reg}} \in \left[\bar{\Theta}^j, +\infty\right) \ \textit{and}\ P^j = 0, \ \textit{or} \\ \forall\Theta^j_{\text{reg}} \in (0, +\infty) \ \textit{and}\ P^j = 1.\end{array} \end{cases}$$

That is, as opposed to R^*, R^*_δ depends on banks' capital structure, regardless of whether banks are resilient or fragile, i.e., for all $\Theta^j_{\text{reg}} \in (0, +\infty)$. As a direct result of this, Assumption 2 becomes redundant and in equilibrium banks choose $\Theta^j = \Theta^j_{\text{reg}}$ for all Θ^j_{reg} since expected returns on equity are decreasing in equity and increasing in deposits regardless of whether banks are fragile or resilient.

Against the benchmark results of Section 3, we show that when equity is costly, regulatory competition may or may not yield the efficient allocation of resources, depending on the policy tools that are available to governments. Specifically, it is shown that regulatory competition is inefficient when governments compete only with regard to capital requirements while bank levies and bank resolution are exogenously fixed at supranational level. However, once governments compete with regard to two or three policy tools, regulatory competition can yield the efficient allocation even when equity is costly.

4.1 Inefficient Regulatory Competition

We begin with the one-dimensional regulatory competition with costly equity that results in a suboptimal allocation of resources. As in Subsection 3.1, we assume that a supranational authority imposes $\tau^s = 0$ and $P^s = 0$, which means that there are no revenues from bank levies, while bail-out costs are positive if banks fail. As in Subsection 3.1, $\bar{\Theta}^j_{\text{reg}} = \bar{\Theta}^k_{\text{reg}} := \bar{\Theta}$, and because, taking Proposition 1 and Lemma 4 into account, we know that banks operate in the country with the lowest level of capital requirements. Namely,

$$\Theta = \min\left\{\Theta^j_{\text{reg}}, \Theta^k_{\text{reg}}\right\}. \tag{35}$$

The problem faced by the national government in Country j is the following:

$$\max_{\Theta^j_{\text{reg}}} \left\{\mathbb{E}[U^j] = R^*_\delta \cdot W + \Pi_F - \mathbb{E}[T^j]\right\}. \tag{36}$$

Because $\partial\mathbb{E}[U^j]/\partial\Theta^j_{\text{reg}} < 0$ for all $\Theta^j_{\text{reg}} \in \left[\bar{\Theta}^j, +\infty\right)$, we conclude that if $\vartheta \geq \bar{\Theta}$, then in equilibrium, the government in Country j sets $\Theta^j_{\text{reg}} = \vartheta$ and the government in Country k sets $\Theta^k_{\text{reg}} \geq \vartheta$. We thus turn our focus to the most general case where $\vartheta < \bar{\Theta}$. From (35) and (36) we know that $\mathbb{E}[T^j(\Theta; \Theta^j_{\text{reg}} < \Theta^k_{\text{reg}})] > 0$ and $\mathbb{E}[T^j(\Theta; \Theta^j_{\text{reg}} > \Theta^k_{\text{reg}})] = 0$ for all $\Theta \in \left(0, \bar{\Theta}\right)$. Thus, we obtain:

$$\mathbb{E}[U^j\left(\Theta; \Theta^j_{\text{reg}} < \Theta^k_{\text{reg}}\right)] < \mathbb{E}[U^j\left(\Theta; \Theta^j_{\text{reg}} > \Theta^k_{\text{reg}}\right)] \qquad \forall \Theta \in \left(0, \bar{\Theta}\right). \tag{37}$$

We call $\mathbb{E}[U^j\left(\Theta; \Theta^j_{\text{reg}} < \Theta^k_{\text{reg}}\right)]$ the *"Underlying Welfare in Country j"* (UW^j), highlighting the fact that the expected utility of households in Country j can

never be smaller than

$$UW^j = R^*_\delta \cdot (W - k_F) + f(k_F) - k^j_R \cdot (1-\sigma) \cdot \left(\frac{\sigma \overline{R}}{\sigma + \Theta} - \underline{R} \right) \tag{38}$$

with $\Theta = \Theta^j_{\text{reg}} < \Theta^k_{\text{reg}}$. In that case, $R^*_\delta = R^{j*}_\delta > R^{k*}_\delta$ and $k^j_R = 2(W - k_F) - \delta E^j$. We call $\mathbb{E}[U^j\left(\Theta; \Theta^j_{\text{reg}} > \Theta^k_{\text{reg}}\right)]$ the *"Free-riding Welfare in Country j"* (FW^j), highlighting the fact that if $\Theta^j_{\text{reg}} > \Theta^k_{\text{reg}}$, then households in Country j can enjoy the benefits of higher returns—due to capital mobility—without bearing any bail-out costs, since there is no banking sector in Country j, i.e., $\mathbb{E}[T^j] = 0$. Thus,

$$FW^j(\Theta) = UW^k(\Theta) + \mathbb{E}[T^k(\Theta)] \qquad \forall \Theta \in \left(0, \bar{\Theta}\right) \tag{39}$$

with $\Theta = \Theta^k_{\text{reg}} < \Theta^j_{\text{reg}}$.[19]

In order to solve the problem of Country j's government, we need to know its best response to any given Θ^k_{reg}. In particular, Country j's government can choose among three types of reaction: (i) to set $\Theta^j_{\text{reg}} < \Theta^k_{\text{reg}}$, achieving $\mathbb{E}[U^j(\Theta)] = UW^j(\Theta)$ with $\Theta = \Theta^j_{\text{reg}}$; (ii) to set $\Theta^j_{\text{reg}} > \Theta^k_{\text{reg}}$, achieving $\mathbb{E}[U^j(\Theta)] = FW^j(\Theta)$ with $\Theta = \Theta^k_{\text{reg}}$; or (iii) to set $\Theta^j_{\text{reg}} = \Theta^k_{\text{reg}}$, achieving $\mathbb{E}[U^j(\Theta)] \in (UW^j(\Theta), FW^j(\Theta))$ with $\Theta = \Theta^j_{\text{reg}}$. Because of the symmetry of the model, the best responses of the two countries are identical, and therefore, in equilibrium, if the capital requirements of at least one country lie in $(0, \bar{\Theta})$, then the capital requirements of the two countries cannot be identical. Otherwise, because of (37), there would always be incentives for governments to increase their capital requirements. Furthermore, calculating $\partial UW^j / \partial \Theta$, we obtain:

Lemma 5. *There exists a sufficiently small, but strictly positive δ with $\partial UW^j / \partial \Theta > 0$ for all $\Theta \in (0, \bar{\Theta})$.*

The proof of Lemma 5 is given in the Appendix. For the sake of simplicity, we focus on the case of an increasing UW^j in Θ for all $\Theta \in \left(0, \bar{\Theta}\right)$, which occurs for small δ according to Lemma 5. In that case, because of the monotonicity of UW^j and (39), we know that there is no $\dot{\Theta} \in \left(0, \bar{\Theta}\right)$ such that

$$UW^j(\Theta'; \Theta' \in (0, \dot{\Theta})) \geq FW^j(\Theta''; \Theta'' \in (\dot{\Theta}, \bar{\Theta})). \tag{40}$$

Namely, competing governments have incentives to avoid bail-out expenditures.

[19] Any reference to UW^j always implies that $\Theta^j_{\text{reg}} < \Theta^k_{\text{reg}}$, i.e., $\Theta = \Theta^j_{\text{reg}}$ whereas any reference to FW^j always implies that $\Theta^j_{\text{reg}} > \Theta^k_{\text{reg}}$, i.e., $\Theta = \Theta^k_{\text{reg}}$.

Therefore, Country j reacts to the decision of Country k on Θ^k_{reg} according to

$$\Theta^j_{\text{reg}} \begin{cases} > \Theta^k_{\text{reg}} & \text{if } \Theta^k_{\text{reg}} \in \left(0, \bar{\Theta}\right); \\ = \bar{\Theta} & \text{if } \Theta^k_{\text{reg}} \in \left(\bar{\Theta}, +\infty\right); \\ \geq \bar{\Theta} & \text{if } \Theta^k_{\text{reg}} = \bar{\Theta}. \end{cases} \tag{41}$$

Thus, we obtain:

Proposition 5. *Let $\vartheta < \bar{\Theta}$ and equity issuance cost δ be sufficiently small with $\partial UW^j/\partial\Theta > 0$ $\forall\Theta \in \left(0, \bar{\Theta}\right)$. Then, there exists a continuum of equilibria where one country, say Country j, sets $\Theta^j_{\text{reg}} = \bar{\Theta}$ and Country k sets $\Theta^k_{\text{reg}} \geq \bar{\Theta}$.*

Note that there is no deviation from $\bar{\Theta}$ that increases the expected utility. In particular, assuming Country j chooses $\bar{\Theta}$, then if Country k chooses $\Theta^k_{\text{reg}} > \bar{\Theta}$, we obtain $R^{j*} > R^{k*}$, $b^j = 1$ and $b^k = 0$. Therefore, $\mathbb{E}[U^k] = \mathbb{E}[U^j]$. If Country k chooses $\Theta^k_{\text{reg}} < \bar{\Theta}$, we obtain $R^{j*} < R^{k*}$, $b^j = 0$ and $b^k = 1$. Therefore, and because $\partial UW^j/\partial\Theta > 0$ for all $\Theta \in \left(0, \bar{\Theta}\right)$, we obtain $\mathbb{E}[U^k\left(\Theta = \Theta^k_{\text{reg}}; \Theta^k_{\text{reg}} < \bar{\Theta}\right)] < \mathbb{E}[U^k\left(\Theta = \Theta^k_{\text{reg}}; \Theta^k_{\text{reg}} = \bar{\Theta}\right)]$.

If now a supranational authority sets capital requirements, it would solve the following:

$$\max_{\Theta^s_{\text{reg}}} \left\{ \mathbb{E}[U^s] = R^*_\delta \cdot 2W + \sum_j \left(\Pi^j_F - \mathbb{E}[T^j]\right) \right\}. \tag{42}$$

From FOC we obtain that if $\vartheta \geq \bar{\Theta}$, the supranational government sets $\Theta^s_{\text{reg}} = \vartheta$, whereas if $\vartheta < \bar{\Theta}$, the supranational government sets Θ^s_{reg} such that $\Theta^s_{\text{reg}} < \bar{\Theta}$. Namely, the outcome under regulatory competition deviates from the supranational solution. That happens because the supranational government economizes on equity issuance cost—by setting laxer capital regulation—at a global scale, whereas national governments perceive economies on equity issuance cost only at a national scale. At the same time, national governments bear the cost of bailing out failed banks at a global scale because of the free-riding incentives that arise in the absence of revenues. In other words, the pressure on national governments to avoid a banking crisis (relative to the temptation to economize on equity issuance cost) is strictly greater than the respective pressure on a supranational authority. Thus, national governments set stricter capital regulation, as compared to the supranational government, and hence, regulatory competition does not yield the maximum expected utility across jurisdictions.

The same policy outcomes, and incentives for avoiding banking activities, would arise for any exogenously given combination of bank levies and resolution regimes

that yields less revenues from levies than bail-out costs. If however bank levies and resolution regimes are set at supranational level such that revenues exceed costs, then competing governments aim at attracting banking activities and incentives resemble the ones described below.

4.2 Efficient Regulatory Competition

We now show that two- and three-dimensional regulatory competition can yield the efficient allocation of resources even with costly equity. We focus on the most general case where competing governments have all three policy tools at their disposal.

The mechanism leading to Proposition 4 is still at work with regard to bank levies. However, with (34) being transformed into

$$\begin{aligned} R_\delta^{j*}(\Theta_{\text{reg}}^j; \tau^j = \bar{\tau}, P^j = 0) &= R_\delta^{j*}(\Theta_{\text{reg}}^j; \tau^j = 0, P^j = 1) \\ &= \frac{1 + (1-\delta)\Theta_{\text{reg}}^j}{1 + \Theta_{\text{reg}}^j} \cdot \mathbb{E}[\tilde{R}], \end{aligned} \tag{43}$$

competing governments' decisions on capital requirements matter for the competitiveness of banks. Specifically, because $\partial R_\delta^{j*}(\Theta_{\text{reg}}^j; \tau^j = \bar{\tau}, P^j = 0)/\partial\Theta_{\text{reg}}^j = \partial R_\delta^{j*}(\Theta_{\text{reg}}^j; \tau^j = 0, P^j = 1)/\partial\Theta_{\text{reg}}^j < 0$, governments set capital requirements at the *floor* level, i.e., $\Theta_{\text{reg}}^j = \vartheta$, to allow their banks to economize on equity issuance costs. A country that deviates upwards from the *floor* capital regulation becomes unable to attract banking activities. Then, in line with the mechanism described in Subsection 3.3, countries choose either $\tau^j = \bar{\tau}$ and $P^j = 0$, or $\tau^j = 0$ and $P^j = 1$, in order for bail-out costs to be canceled out. We thus obtain:

Proposition 6. *In equilibrium, Country j sets either $\left(\Theta_{\text{reg}}^j, \tau^j, P^j\right) = (\vartheta, \bar{\tau}(\vartheta), 0)$ or $\left(\Theta_{\text{reg}}^j, \tau^j, P^j\right) = (\vartheta, 0, 1)$, with $j = 1, 2$.*

That is, there exist four possible equilibria with two equilibria corresponding to situations with both countries choosing the same banking regulation, and two equilibria corresponding to situations with the two countries choosing banking regulation that differs with regard to bank levies and resolution regime. Because of (43), all possible equilibria result in the same equilibrium returns. An illustration of the possible equilibria Country j may choose for a certain specification[20] is shown in Figure 3.

[20] $f(k_F) = 2\sqrt{k_F} - k_F$, $W = 1$, $\underline{R} = 0.5$, $\overline{R} = 2$, and $\vartheta = 0.05$.

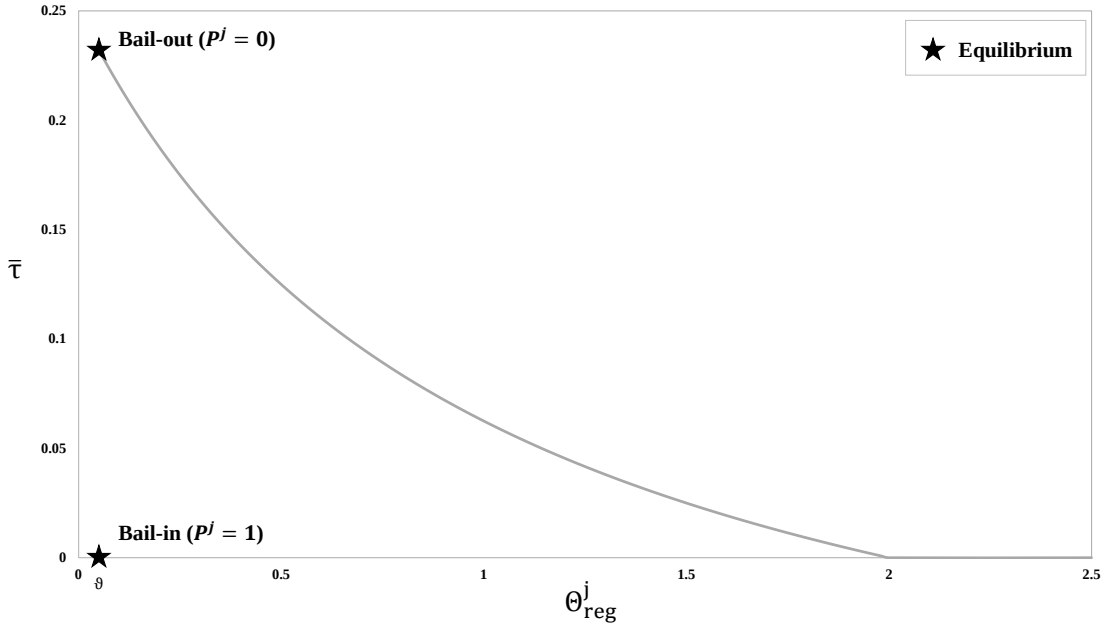

Figure 3: Possible equilibrium banking regulation $\left(\Theta^j_{\text{reg}}, \tau^j, P^j\right)$ with $j = 1, 2$

To sum up, once the playing field with regard to capital requirements is even, i.e., $\Theta^j_{\text{reg}} = \Theta^k_{\text{reg}} = \vartheta$, the countries choose between two approaches: Either they depress bank costs—in the form of returns on deposits—by promising to bail out failed banks at the expense of also reducing bank revenues by imposing bank levies, or they let bank costs undistorted by adopting a bail-in provision leaving also bank revenues intact via zero levies. The cost of a banking crisis, if any, is offset in both approaches; either by raising revenues or by avoiding bail-out costs. Both approaches yield the socially optimally level of equilibrium returns and thus risk-taking, resulting in the same allocation of resources if a supranational authority was to set banking regulation maximizing welfare across jurisdictions. In that sense, our results deviate from the predominant narrative according to which governments engage in a *"race-to-the-bottom"* under the fear of regulatory arbitrage, moving in the direction suggested by Karolyi and Taboada (2015), who present evidences showing that a benign form of regulatory arbitrage is also possible. In our model, the concern of regulatory arbitrage is indeed revealed in the form of countries' incentives to attract revenues-generating banking activities. However, these incentives are constrained by their need to contain costs stemming from banking so that they do not exceed revenues.

5 Discussion

In this section we discuss four important aspects of our paper. We first explain the intuition on the role of equity in our model. Second, we discuss our results with regard to households' risk-aversion. We then discuss a scenario when a banking crisis generates costs besides mere bail-out expenditures, and we finally offer a discussion on institutional implications of our results.

5.1 Role of Equity

In the absence of moral hazard associated with bank managers, equity plays no role in terms of correcting principal-agent distortions. Reflecting the focus of our paper on the impact of regulatory competition on the allocation of resources, equity serves two purposes from a regulatory perspective: impacting returns and being a means for absorbing losses. Both affect the level of risk-taking and therefore the allocation of resources through general equilibrium effects. We discuss the two purposes in turn.

Bank profits are proportionally distributed to shareholders. That means the higher the equity, the more shares among which profits are distributed, and therefore, the lower these returns are. In turn, that means banks are less able to attract funds which implies more funds are left to be invested directly by households in free-of-risk bonds. That is, the higher the level of equity, the lower the level of risk-taking.

Turning to the second purpose, it is important to recall from Subsection 2.5 that a bail-out clause can be interpreted as a subsidy on bank costs that distorts returns on deposits. This distortion remains irrelevant if banks are resilient, but it boosts bank profits if banks are fragile. Banks are resilient if the equity-to-debt ratio is high enough. Otherwise, banks are fragile and the distortion of bail-out takes effect. In fact, the lower the equity, the higher the subsidy in the form of bail-out expenditures, and therefore, the higher the deviation of the equilibrium returns—and of risk-taking—from the socially optimal level.

5.2 Risk-averse Households

Throughout the analysis we assumed that households are risk-neutral. That allowed us to explicitly express equilibrium returns with regard to policy tools, thus illustrating the general equilibrium effects of regulatory competition in banking.

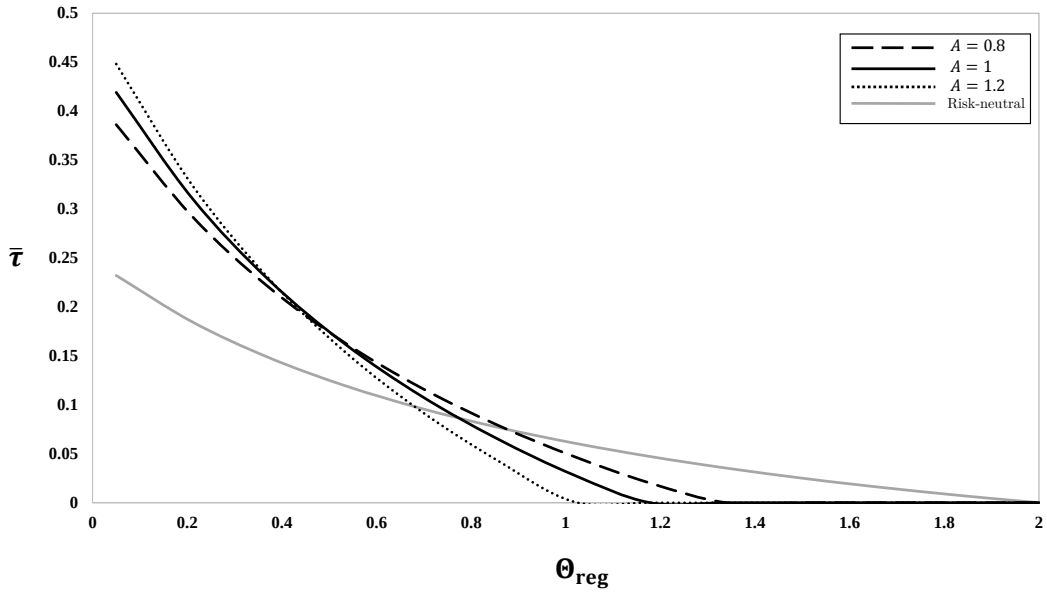

Figure 4: Policy space dichotomy, $\bar{\tau}$, with $P^j = 0$ for different risk-aversion levels

Nevertheless, this assumption corresponds to a special case. It is therefore important to discuss our results in light of the more general, and probably empirically more relevant, case of risk-averse households. We explain below that the mechanism we described with risk-neutral households is still at work when households are risk-averse. Household risk-aversion, however, results in quantitative changes in terms of the level of bank levies for any given level of capital requirements.

The trade-off between accentuating benefits over costs stemming from banking activities, on the one hand, and enhancing banks' competitiveness, on the other hand, drives the mechanism at work when competing governments set banking regulation. This mechanism is robust with regard to households' risk-aversion. That is, competing governments' aspiration for raising revenues and retaining bail-out costs is limited by the need for enhancing banks' competitiveness in order to attract, and indeed benefit from revenues-generating banking activities.

Yet, because risk-averse households need to smooth consumption depending on their risk-aversion levels, benefits need to overcompensate costs as compared to the scenario with risk-neutral households. That results in quantitative changes that are illustrated in Figure 4 for the case of regulatory competition with regard to capital requirements and bank levies—with a bail-out provision being exogenously

imposed—for a given specification.[21]

Note that, due to general equilibrium effects, higher risk-aversion does not necessarily mean higher bank levies for all levels of capital requirements. Specifically, the optimal level of bank levies depends on the interaction of the effects of capital requirements and risk-aversion on equilibrium returns. The capital requirement effect refers to higher returns for lower capital requirements when accompanied with a bail-out provision. Risk-aversion effect refers to depressed returns at higher risk-aversion levels due to higher risk premia required by risk-averse households.

For low levels of capital requirements, their effect dominates the risk-aversion effect. That boosts risk-taking and bail-out costs due to higher returns, therefore, necessitating higher bank levies for higher levels of risk-aversion in order for households to optimally smooth their consumption according to their risk-averse levels. As capital requirements increase, their effect fades and the risk-aversion effect reduces returns, decreasing risk-taking and bail-out costs and therefore, requiring lower revenues from bank levies to compensate for bail-out costs.

5.3 Banking Crisis Repercussions

Our analysis shows that if there are tools that can counteract potential bail-out costs, governments may choose capital requirements low enough such that banks fail if the bad state of the world occurs. These results are obtained under the assumption of no adverse repercussions of a banking crisis on the economy, besides mere costs for bailing out banks' debt-holders.

The financial crisis of 2007-2009 showed, however, that banking crisis repercussions may spill over to the production sectors of the economy. One way to model such repercussions is to consider that an investment of one unit in RT in period $t = 1$ returns $\overline{R}$, $\underline{R}$ and $(1-\kappa)\underline{R}$ with $\kappa \geq 0$ in the good state of the world, the bad state of the world with resilient banks and the bad state of the world with fragile

[21] $f(k_F) = 2\sqrt{k_F} - k_F$, $W = 1$, $\underline{R} = 0.5$, $\overline{R} = 2$, and $\vartheta = 0.05$, and expected utility

$$\mathbb{E}[U^j] = \begin{cases} 1 - \sigma \cdot e^{-A \cdot \overline{c}^j} - (1-\sigma) \cdot e^{-A \cdot \underline{c}^j} & \text{if } A \neq 0; \\ \sigma \cdot \overline{c}^j + (1-\sigma) \cdot \underline{c}^j & \text{if } A = 0, \end{cases}$$

where A is the risk-aversion parameter. In that case, households invest such that

$$\overline{c}^j - \underline{c}^j = \frac{1}{A} \cdot \ln\left(\frac{\sigma}{1-\sigma} \cdot \frac{\overline{R}_E^j - R^{j*}}{R^{j*} - \underline{R}_E^j}\right).$$

banks, respectively.[22]

In this scenario it can be shown that the policy space dichotomy is adjusted upwards, namely, higher bank levies are required as compared to the case with $k = 0$ for any given level of capital requirements that renders bank fragile. Hence, if $\kappa \geq \frac{\mathbb{E}[\widetilde{R}]}{(1-\sigma)\underline{R}}$, competing governments when maximizing their jurisdictions' welfare, should optimally choose to sacrifice equity issuance costs in order to render their banks resilient. One might then attribute the observation that capital requirements have not been adequate to eliminate banking crises so far either to a miscalculation of banking crisis costs, or to other mechanisms that generate benefits for policy-makers and alleviate concerns of crisis repercussions (e.g. lobbying, higher re-election chances due to short-term boost of economic performance).

5.4 Institutional Implications

In view of the EU institutional architecture, in which national and supranational competences co-exist, we now discuss institutional implications of our results. Drawing on the current debate as to whether a deposit insurance scheme shall be managed at the EU level, we first outline the basic arguments for and against such a supranational solution, and then relate our results to this debate.

The basic argument for a European Deposit Insurance Scheme points out that such an institutional development would complement the Single Supervisory Mechanism and the Single Resolution Mechanism that are already in place, thus completing the banking union. That in turn will level the playing field, facilitating banking activities across borders, diversifying the financial system within the EU and thus enhancing its resilience. Concerns against this solution stress that introduction of risk-sharing tools (i.e., sharing the risk of compensating depositors of failed banks) shall go hand in hand with improvements with regard to risk-reduction tools (i.e., reduction of non-performing loans and breaking the link between banks and sovereigns).[23]

In our paper, we do not specifically model a deposits insurance scheme, although bank levies could be interpreted as insurance premia paid by banks in order to have access to deposit insurance. Even so, banking regulation is composed of many more than three dimensions. That is, we cannot claim that our results point to a definite answer to the question at hand. Yet, since we do model tools of

[22] The preceding analysis corresponds then to the special case of $\kappa = 0$.

[23] A detailed elaboration on the debate can be found in the Communication of the European Commission COM (2017) 592 on completing the banking union.

banking regulation at national and supranational level, we can at least contribute to this debate at a more conceptual level. Specifically, in the scenario when bank levies and bank resolution are fixed at supranational level and competition between governments takes place with regard to capital requirements—a risk-reduction tool—an inefficient allocation of resources arises. That is, when certain tools are fixed at supranational level, whereas others are managed at national level, a suboptimal equilibrium might occur. Given that the co-existence of national and supranational competences is a genuine characteristic of the EU, proposals for shifting certain aspects of banking regulation to the supranational level need to pay special attention as to whether the incentives that will arise due to regulatory competition with regard to other aspects of banking regulation move in the right direction, or not.

6 Conclusions

We studied the interaction among tools of banking regulation—in the form of capital requirements, bank levies and bank resolution—at national and supranational level. We explicitly expressed the effect of these policy tools on equilibrium returns and therefore, on the level of risk-taking, the allocation of resources, and ultimately, on social welfare. Drawing on this general equilibrium approach, we showed that the trade-off between accentuating benefits over costs stemming from banking activities, on the one hand, and enhancing banks' competitiveness, on the other hand, drives the mechanism at work when competing governments set banking regulation. That is, competing governments' aspiration for raising revenues and retaining bail-out costs is limited by incentives for enhancing banks' competitiveness.

In the most general case, when issuance of equity is costly, we established two main results. First, an inefficient allocation of resources occurs when bank levies and resolution regime are fixed at supranational level with regulatory competition taking place with regard to capital requirements. Second, when policy tools that can generate benefits counteracting costs stemming from banking activities are available to governments, i.e., when competition takes place among all three policy tools, the efficient allocation of resources occurs. In that case, competing governments choose between two approaches: Either they offer safety to depositors by promising to bail out failed banks at the expense of reducing returns by bank levies, or they renounce bank levies at the expense of pushing the risk of bail-in

to depositors if banks fail. Both approaches result in the same level of banks' international competitiveness in terms of the level of returns banks promise aiming to attract funds.

Appendix

Proof of Lemma 3

We prove Lemma 3 in two steps. In Step 1 we prove that there is no equilibrium with $\mathbb{E}[\Phi^j] - \mathbb{E}[T^j] < 0$. In Step 2 we prove that there is no equilibrium with $\mathbb{E}[\Phi^j] - \mathbb{E}[T^j] > 0$.

Step 1:
Assume that $\Theta^j_{\text{reg}} \geq \Theta^k_{\text{reg}}$ and $\tau^j \geq \tau^k$ with at least one strict inequality and $\tau^k < \bar{\tau}$. Note that since $\bar{\tau} = 0 \ \forall \Theta^k \geq \bar{\Theta}$, Step 1 only considers $\Theta^k_{\text{reg}} \in (0, \bar{\Theta})$.

Because of Corollary 1, and taking Proposition 1 into consideration, we know that $R^* = R^{k*} > R^{j*}$. Therefore, the capital from both countries, net of FT allocations, is invested in Country k, i.e., $k_F = f'^{-1}(R^*)$, $b^k = 1$, $b^j = 0$, $k^k_R = 2(W - k_F)$ and $k^j_R = 0$, and thus, $\mathbb{E}[\Phi^k] - \mathbb{E}[T^k] = k^k_R \cdot \phi^k$ and $\mathbb{E}[\Phi^j] - \mathbb{E}[T^j] = 0$. Furthermore,

$$\mathbb{E}[U^j] = R^*(W - k_F) + f(k_F) \tag{44}$$

$$\mathbb{E}[U^k] = R^*(W - k_F) + f(k_F) + \mathbb{E}[\Phi^k] - \mathbb{E}[T^k]. \tag{45}$$

Since $\tau^k < \bar{\tau}$, we know that $\mathbb{E}[\Phi^k] - \mathbb{E}[T^k] < 0$ which implies $\mathbb{E}[U^j] > \mathbb{E}[U^k]$.

Since $R^* \frac{\partial k_F}{\partial \tau^k}$ is canceled out by $\frac{\partial f(k_F)}{\partial k_F} \cdot \frac{\partial k_F}{\partial \tau^k}$ because $R^* \equiv \frac{\partial f(k_F)}{\partial k_F}$, we obtain

$$\begin{aligned} \frac{\partial \mathbb{E}[U^k]}{\partial \tau^k} = &- \frac{1 + \Theta^k}{\sigma + \Theta^k} \cdot \sigma \overline{R} \cdot (W - k_F) \\ &+ \frac{1 + \Theta^k}{\sigma + \Theta^k} \cdot \sigma \overline{R} \cdot (2(W - k_F)) \\ &+ \frac{\partial k^k_R}{\partial \tau^k} \cdot \phi^k. \end{aligned} \tag{46}$$

The three lines on the right hand side of (46) are denoted by *Term 1*, *Term 2* and *Term 3*, respectively.

Term 2, which is positive, dominates *Term 1* because $2(W - k_F) - \delta E^k > W - k_F$. Further, $\phi^k < 0$ for all $\tau^k < \bar{\tau}$ and ϕ^k becomes zero at $\tau^k = \bar{\tau}$. Taking into account that $\partial R^* / \partial \tau^k < 0$, and because of the Inada conditions in FT, we know that $\partial k_F / \partial \tau^k > 0$. Because

$$k^k_R = \tfrac{1 + (1-\delta)\Theta^k}{1 + \Theta^k} 2 \left(W - f'^{-1}(R^*)\right),$$

and taking into account that $\frac{\partial R^*}{\partial \tau^k} < 0$ and $f'' < 0$, we conclude that *Term 3* is

positive for all $\tau^k \leq \bar{\tau}$. We conclude thus,

$$\frac{\partial \mathbb{E}[U^k]}{\partial \tau^k} > 0 \qquad \forall \tau^k \leq \bar{\tau}. \tag{47}$$

That is, government in Country k can be strictly better off by increasing bank levies. Note that (47) holds even if $R^{j*} = R^{k*}$ because *Term 1* would cancel out *Term 2*, while *Term 3* is positive.

That is, as long as net expected revenues are strictly negative, competing governments have incentives to deviate.

Step 2:
Assume that $\Theta^j_{\text{reg}} \geq \Theta^k_{\text{reg}}$ and $\tau^j \geq \tau^k$ with at least one strict inequality if $\Theta^k_{\text{reg}} \in (0, \bar{\Theta})$, and with $\tau^j > \tau^k$ if $\Theta^k_{\text{reg}} \in [\bar{\Theta}, +\infty)$, and let $\tau^k > \bar{\tau}$.

Because of Corollary 1, and taking Proposition 1 into consideration, we know that $R^* = R^{k*} > R^{j*}$. Therefore, the capital from both countries, net of FT allocations, is invested in Country k, i.e., $k_F = f'^{-1}(R^*)$, $b^k = 1$, $b^j = 0$, $k^k_R = 2(W - k_F)$ and $k^j_R = 0$, and thus, $\mathbb{E}[\Phi^k] - \mathbb{E}[T^k] = k^k_R \cdot \phi^k$ and $\mathbb{E}[\Phi^j] - \mathbb{E}[T^j] = 0$. Furthermore,

$$\mathbb{E}[U^j] = R^*(W - k_F) + f(k_F) \tag{48}$$
$$\mathbb{E}[U^k] = R^*(W - k_F) + f(k_F) + \mathbb{E}[\Phi^k] - \mathbb{E}[T^k]. \tag{49}$$

Since $\tau > \bar{\tau}$, we know that $\mathbb{E}[\Phi^k] - \mathbb{E}[T^k] > 0$ which implies $\mathbb{E}[U^j] < \mathbb{E}[U^k]$.

Country j can then be strictly better off by setting $\Theta^j_{\text{reg}} = \Theta^{k-}_{\text{reg}}$ and $\tau^j = \tau^{k-}$ while $\tau^j > \bar{\tau}$, with Θ^{k-} and τ^{k-} denoting capital requirements and bank levy marginally smaller than Θ^k and τ^k. Now, because of Corollary 1, and taking Proposition 1 into consideration, we know that $R^* = R^{j*} > R^{k*}$. Therefore, the capital from both countries, net of FT allocations, is invested in Country j, i.e., $k_F = f'^{-1}(\dot{R}^*)$, $b^j = 1$, $b^k = 0$, $k^j_R = 2(W - k_F)$ and $k^k_R = 0$, and thus, $\mathbb{E}[\Phi^j] - \mathbb{E}[T^j] = k^j_R \cdot \phi^j$ and $\mathbb{E}[\Phi^k] - \mathbb{E}[T^k] = 0$. Furthermore,

$$\mathbb{E}[U^j] = R^*(W - k_F) + f(k_F) + \mathbb{E}[\Phi^j] - \mathbb{E}[T^j] \tag{50}$$
$$\mathbb{E}[U^k] = R^*(W - k_F) + f(k_F). \tag{51}$$

Note that, in contrast with the drastic increase of k^j_R from 0 to $2(W - k_F)$, the continuous functions of the net expected revenues, the equilibrium returns and FT allocation, as well as the function ϕ^j, as given by (25), only marginally change because of the marginal reduction of capital requirements and tax policy. That

implies $\mathbb{E}[U^j] > \mathbb{E}[U^k]$.

That is, as long as net expected revenues are strictly positive, competing governments have incentives to deviate.

Steps 1 and 2 establish Lemma 3. □

Proof of Lemma 5

$$\begin{aligned}\frac{\partial}{\partial\Theta}(UW^j) = & -(1-\sigma)\frac{\partial k_R^j}{\partial\Theta}\cdot\left(\frac{\sigma\overline{R}}{\sigma+\Theta}-\underline{R}\right)\Bigg\}\ \textit{Term 1} \\ & +\ k_R^j\cdot(1-\sigma)\cdot\frac{\sigma\overline{R}}{(\sigma+\Theta)^2}\Bigg\}\ \textit{Term 2} \\ & -\ (W-k_F)\cdot(1-(1-\delta)\sigma)\cdot\frac{\sigma\overline{R}}{(\sigma+\Theta)^2}\Bigg\}\ \textit{Term 3}\end{aligned} \tag{52}$$

with $k_R^j = 2(W-k_F)-\delta E^j$. *Term 1* is always positive, decreasing in Θ and becomes zero for $\Theta = \bar{\Theta}$. *Term 2* is also positive. *Term 3* is always negative. Noting that $k_R^j = 2(W-k_F)-\delta E^j > (W-k_F)$, we infer that for small δ, *Term 2* dominates *Term 3* in the interval $\left(0,\bar{\Theta}\right)$. □

Proof of Proposition 1

It is straightforward to show that risk-neutral households invest in the asset with the highest expected returns. Because of households' investment decision, $R^* = \max\{R^{j*}, R^{k*}\}$ where R^{j*} is given by Lemma 2. From that, and because of Assumption 1, we also obtain:

$$b^j = \begin{cases} 0 & \text{if } R^{j*} < R^{k*} \\ 1 & \text{if } R^{j*} \geq R^{k*}. \end{cases} \tag{53}$$

Furthermore, banks choose $\Theta^j = \Theta^j_{\text{reg}}$, FT entrepreneurs in Country j demand $k_F = f'^{-1}(R^*)$ and RT entrepreneurs in Country j can raise funds equal to $k_R^j = \beta^j\cdot(W-k_F)$ with

$$\beta^j = \begin{cases} 0 & \text{if } R^{j*} < R^{k*} \\ 1 & \text{if } R^{j*} = R^{k*} \\ 2 & \text{if } R^{j*} > R^{k*}. \end{cases} \tag{54}$$

It remains to show that all markets clear.

Asset Market Clearing

The asset market clears according to (15) by taking into account that $k_F = f'^{-1}(R^*)$, $\frac{E^j}{D^j} = \Theta^j_{\text{reg}}$ and $\frac{E^k}{D^k} = \Theta^k_{\text{reg}}$. In case $\tau^j = \tau^k$, $\Theta^j_{\text{reg}} = \Theta^k_{\text{reg}}$ and $b^j = b^k$, we know that $E^j = E^k$ and $D^j = D^k$ because of Assumption 1 and Lemma 1.

Consumption Good Market Clearing in Good State

We need to show that

$$\overline{c}^j + \overline{c}^k = f(k_F) + f(k_F) + (k^j_R + k^k_R)\overline{R}. \tag{55}$$

Households in Country j in the good state of the world consume the returns on their investments in D^j, B^j_F and E^j, profits from FT and RT and revenues from bank levies. Taking (3) into account, we know that $\overline{\Pi}_R = 0$, and because $B^j_F = k_F$, we write:

$$\begin{aligned}\overline{c}^j + \overline{c}^k =& D^j R^j_D + B^j_F R^j_F + E^j \frac{(1-\tau^j)(E^j + D^j)\overline{R} - D^j R^j_D}{E^j} \\ &+ f(k_F) - k_F R^j_F + \tau^j (E^j + D^j)\overline{R} \\ &+ D^k R^k_D + B^k_F R^k_F + E^k \frac{(1-\tau^k)(E^k + D^k)\overline{R} - D^k R^k_D}{E^k} \\ &+ f(k_F) - k_F R^k_F + \tau^k (E^k + D^k)\overline{R}.\end{aligned} \tag{56}$$

From (56), and because $k^j_R = E^j + D^j$, we establish equality (55).

Consumption Good Market Clearing in Bad State

We need to show that

$$\underline{c}^j + \underline{c}^k = f(k_F) + f(k_F) + (k^j_R + k^k_R)\underline{R}. \tag{57}$$

Households in Country j in the good state of the world consume the returns on their investments in D^j, B^j_F and E^j, profits from FT and RT and revenues from bank levies, net of any bail-out costs. Taking (4) into account, we know that

$\overline{\Pi}_R = 0$, and because $B_F^j = k_F$, we write:

$$
\begin{aligned}
\underline{c}^j + \underline{c}^k =& (1 - X^j P^j) D^j R_D^j + X^j P^j D^j \frac{(1-\tau^j)(E^j + D^j)\underline{R} - D^j R_D^j}{D^j} \\
&+ B_F^j R_F^j + (1 - X^j) E^j \frac{(1-\tau^j)(E^j + D^j)\underline{R} - D^j R_D^j}{E^j} \\
&+ f(k_F) - k_F R_F^j + \tau^j (E^j + D^j)\underline{R} \\
&- X^j (1 - P^j) \cdot \left(D^j \cdot R_D - \left(D^j + E^j\right) \cdot (1-\tau^j)\underline{R}\right) \\
&+ (1 - X^k P^k) D^k R_D^k + X^k P^k D^k \frac{(1-\tau^k)(E^k + D^k)\underline{R} - D^k R_D^k}{D^k} \\
&+ B_F^k R_F^k + (1 - X^k) E^k \frac{(1-\tau^k)(E^k + D^k)\underline{R} - D^k R_D^k}{E^k} \\
&+ f(k_F) - k_F R_F^k + \tau^k (E^k + D^k)\underline{R} \\
&- X^k (1 - P^k) \cdot \left(D^k \cdot R_D - \left(D^k + E^k\right) \cdot (1-\tau^k)\underline{R}\right),
\end{aligned}
\tag{58}
$$

where $X^j = 1$ if banks are fragile, and $X^j = 0$ otherwise. That means, if $X^j = 1$ and $P^j = 0$, then equity holders receive zero returns and depositors are bailed out; if $X^j = 1$ and $P^j = 1$, then equity holders receive zero returns, bank revenues are distributed among depositors and bail-out cost is zero; and if $X^j = 0$, then bank revenues are distributed among equity holders, depositors receive all promised returns and bail-out cost is zero. From (58), and because $k_R^j = E^j + D^j$, we establish equality (57) for all X^j and P^j.

We now establish uniqueness. For any given banking regulation $(\hat{\Theta}_{\text{reg}}^j, \hat{\tau}^j, \hat{P}^j)$, the equilibrium returns in Country j, R^{j*}, are uniquely determined according to Lemma 2. If $R^{j*} < R^{k*}$, then according to Lemma 2 and (53), $R^* = R^{k*}$, $b^j = 0$ and $b^k = 1$, which yields the following allocation of resources: $k_F^j = k_F^k =: k_F = f'^{-1}(R^*)$, $k_R^j = 0$ and $k_R^k = 2 \cdot (W - k_F)$. If $R^{j*} = R^{k*}$, then according to Lemma 2 and (53), $R^* = R^{j*} = R^{k*}$ and $b^j = b^k = 1$, which yields the following allocation of resources: $k_F^j = k_F^k = k_F =: f'^{-1}(R^*)$ and $k_R^j = k_R^k = W - k_F$. □

Proof of Proposition 3

We prove Proposition 3 in three steps.

Step 1:

Lemma 3 precludes an equilibrium with $\mathbb{E}[\Phi^j] - \mathbb{E}[T^j] \neq 0$. Equivalently, Lemma 3 precludes an equilibrium with $\tau^j \neq \bar{\tau}(\Theta_{\text{reg}}^j)$.

Step 2:

Because of (29), we know that deviations along the policy-space dichotomy do not result in changes with regard to the allocation of capital between countries.

Step 3:

We now show that there is no welfare-increasing deviation above or below the policy-space dichotomy.

Assume $\tau^j = \bar{\tau}(\Theta^j_{\text{reg}})$ and $\tau^k = \bar{\tau}(\Theta^k_{\text{reg}})$. Taking (29) into account, we know that $R^* = R^{j*} = R^{k*}$ with $\mathbb{E}[\Phi^j] - \mathbb{E}[T^j] = \mathbb{E}[\Phi^k] - \mathbb{E}[T^k] = 0$. Thus,

$$\mathbb{E}[U^j] = R^*(W - k_F) + f(k_F) \tag{59}$$

$$\mathbb{E}[U^k] = R^*(W - k_F) + f(k_F). \tag{60}$$

Upwards Deviation

Assume now that $\tau^j = \bar{\tau}(\Theta^j_{\text{reg}})$, whereas $\tau^k > \bar{\tau}(\Theta^k_{\text{reg}})$. From Corollary 1, and taking (29) into account, we know that $R^* = R^{j*} > R^{k*}$. Therefore, $b^j = 1$ and $b^k = 0$. Expected revenues from bank levies in Country j are zero because $\tau^j = \bar{\tau}$, while expected revenues from bank levies in Country k are also zero because there are no banks. Thus, households expected utilities in the two countries as given by (59) and (60) remain intact.

That is, an upwards deviation from policy-space dichotomy yields no welfare increase.

Downwards Deviation

Assume now that $\tau^j = \bar{\tau}(\Theta^j_{\text{reg}})$, and $\tau^k < \bar{\tau}(\Theta^k_{\text{reg}})$. Two cases may exist:

- Case 1:
  If this deviation yields $R^* = R^{j*} > R^{k*}$, then $b^j = 1$ and $b^k = 0$. Expected revenues from bank levies in Country j are zero because $\tau^j = \bar{\tau}$, while expected revenues from bank levies in Country k are also zero because there are no banks. Thus, households expected utilities in the two countries as given by (59) and (60) remain intact.

- Case 2:
  If this deviation yields $R^* = R^{k*} > R^{j*}$, then $b^j = 0$ and $b^k = 1$. Then, (60) becomes

  $$\mathbb{E}[U^k] = R^*(W - k_F) + f(k_F) + \mathbb{E}[\Phi^j] - \mathbb{E}[T^j]. \tag{61}$$

  Since we know that (46) is negative for all $\tau^k \leq \bar{\tau}$, we conclude that Country

k's downwards deviation reduced the welfare of its households.

That is, a downwards deviation from policy-space dichotomy yields either no welfare increase or welfare decrease.

Steps 1–3 establish Proposition 3. □

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