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# Regulatory competition in credit markets with capital standards as signals

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## Abstract

This paper studies regulatory competition in the banking sector in a model where banks are heterogeneous and taxpayers come up for the losses of failing banks. Capital requirements force the weakest banks to exit the market. This gives rise to a signalling effect of capital standards, as borrowing firms anticipate the higher average quality of banks in a more strictly regulated country. In this model, regulatory competition in capital standards may lead to a ‘race to the top’ for two different reasons. First, if the signalling effect is sufficiently strong, the overall demand for loans from the high-quality banks of the regulating country rises, even though the number of active banks in this country is reduced. Second, if governments are heavily concerned about the tax revenue losses arising from bank failures, strict capital requirements are imposed to improve the pool quality of the domestic banking sector and reduce the risk to taxpayers.

**Keywords:** regulatory competition, capital requirements, bank heterogeneity

**JEL Classification:** G21, G18, F36, H73

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# 1 Introduction

The regulation of banks, and in particular the setting of capital adequacy standards, is arguably one of the most important policy issues in the aftermath of the financial crisis. In many countries, large, commercial banks needed to be recapitalized with public funds in recent years. In several countries, such as Ireland or Iceland, the public bailout was so massive that it threatened the entire state of public finances. The new Basel III capital standards, which foresee the ratio of core capital to rise to 7 percent of the banks' outstanding loans until 2019, are therefore widely believed to represent a critical step forward in ensuring more resilient banking sectors around the world.<sup>1</sup> At the same time, the higher capital standards are also expected to lead to a consolidation of banking sectors, with smaller or weaker banks having to exit the market.

The financial sectors of many countries have grown dramatically in recent decades and represent an important source of value added, highly paid jobs, and - in good times - tax revenue.<sup>2</sup> Therefore, an important concern in policy discussions is that the national setting of higher capital adequacy standards will not distort international competition between the banking sectors of different countries, and maintain a 'level playing field'.

Interestingly, however, it is by no means clear whether individual countries, which may be tempted to pursue 'beggar-thy-neighbor' policies, have an incentive to set their national capital standards above or below that of neighboring jurisdictions. On the one hand is the conventional concern that maintaining low adequacy rules reduces the cost of doing business for domestic banks, thus securing an 'unfair' advantage in the international competition for bank customers. As an example, several critical voices were raised in the United States during 2011 against the new Basel rules, and the implementation of these rules was eventually delayed. This raised concerns among

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<sup>1</sup>Thus Mervyn King, then Governor of the Bank of England, noted in October 2010 that "the broad answer to the problem [of finding adequate regulatory tools] is likely to be remarkably simple. Banks should be financed much more heavily by equity rather than short-term debt" ([www.bankofengland.co.uk/publications/Documents/speeches/2010/speech455.pdf](http://www.bankofengland.co.uk/publications/Documents/speeches/2010/speech455.pdf)). Similarly, Timothy Geithner, then U.S. Secretary of the Treasury, emphasized in February 2010 that "first, we are going to make sure that financial firms hold a lot more capital than they did before the crisis" ([www.treasury.gov/press-center/press-releases/Pages/tg808.aspx](http://www.treasury.gov/press-center/press-releases/Pages/tg808.aspx)).

<sup>2</sup>Auerbach et al. (2010, Figure 9.5) document the increasing fiscal importance of the financial sector in the United States and the United Kingdom. In both countries, corporate tax revenues from financial corporations made up more than 25% of total corporate tax revenues in 2003, before the financial crisis.

several European policymakers that the United States might eventually refrain from adopting the tighter Basel III standards for its banks.<sup>3</sup>

On the other hand, several countries, such as Switzerland, have enacted capital standards that substantially exceed the Basel rules. Similarly, the United Kingdom announced in May 2012 that it planned to introduce national capital requirements above the Basel standards to protect domestic taxpayers. This announcement also met with resistance from most EU partners, who favored instead a strict harmonization of national capital requirements along the Basel standards.<sup>4</sup> This suggests that there may also be fears of a competitive advantage for banking sectors that operate under capital standards *above* those of their competitors.<sup>5</sup>

The present paper studies regulatory competition in capital standards for the banking sector in a model that incorporates several of the concerns that have featured prominently in these recent policy debates. Our model allows for banks that are heterogeneous in their monitoring ability, and hence in their expected profitability. This implies that the least profitable banks will exit the market in response to tougher capital requirements. We allow for signalling effects of national capital standards, as loan-taking firms anticipate that higher capital standards will drive the least efficient banks from the market and thus improve the pool quality of banks in the regulating country. Finally, we also incorporate the concerns about national public finances by introducing a savings deposit insurance that must be funded by taxpayers in the event of bank failure.

In this model a rich set of possibilities emerges as the outcome of regulatory competition. In particular, a downward competition of regulatory standards (the “competition of laxity”) is only one of the possible outcomes that arises when neither signalling effects nor the effects on taxpayers are strong. In contrast, a ‘race to the top’ in capital standards emerges in two very different situations. A first instance arises when signalling effects are sufficiently pronounced so that higher capital standards in one country hurt the business of banks in the neighboring country, even though the number of active

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<sup>3</sup>See “Delay seen in implementing U.S. bank capital rules”. Reuters, November 9, 2012.

<sup>4</sup>See “European Leaders to weigh new capital requirements for banks”, The New York Times, May 1, 2012.

<sup>5</sup>This is very different from the issue of tax harmonization, for example, where the concern is almost exclusively about a downward competition of tax rates (see Fuest et al., 2005, for a survey). Where EU-wide legislation exists, as in the field of value-added taxation, only minimum tax rates are therefore stipulated.

banks in the regulating country is simultaneously reduced. Secondly, an upward competition in capital standards can arise even in the absence of strong signalling effects when governments are sufficiently concerned about the tax revenue losses arising from bank failures. In this case, strict capital requirements are imposed to protect taxpayers, but the downsizing of the domestic banking sector will lead to market entry of banks abroad, worsening the pool quality of the banking sector there. Hence, the risk of paying for bankrupt banks is shifted from domestic to foreign taxpayers.

Our analysis is related to several strands in the existing literature. A first set of papers analyzes the effects of capital regulation on financial institutions (Rochet, 1992; Hellman et al., 2000; Repullo, 2004). This literature stresses that capital regulation increases the risk buffer of banks and curbs risky behaviour. In one of the few contributions that incorporate bank heterogeneity, Morrison and White (2005) show that capital regulation also serves to address adverse selection problems in the banking sector. Another paper that models bank heterogeneity in a framework with capital regulation is Kopecky and VanHoose (2006). All these models stress that capital regulation is costly for banks. An opposing view is taken by Admati et al. (2010), who argue that higher capital requirements reduce the risk premia incorporated in banks' equity capital, and therefore need not raise the overall financing costs of banks.

The existing literature on regulatory competition in the banking sector stresses the result that nationally set capital standards are inefficiently low from a global welfare perspective. Sinn (1997, 2003) models the competition in regulatory standards as a direct application of the classical lemons problem (Akerlof, 1970), arguing that consumers are unable to discriminate between different levels of regulatory quality. Acharya (2003) models competition between bank regulators that choose both the level of capital requirements and the bailout policy when banks become insolvent. Our approach is closest to Dell'Araccia and Marquez (2006), where regulators choose nationally optimal capital requirements by trading off the aggregate level of banks' profits against the benefits of financial stability. None of these papers incorporates heterogeneity of banks, nor a benefit to the banking sector that arises from the signalling effect of higher capital standards.

A reputation effect that benefits banks is also present in the model of Morrison and White (2009). In their framework, however, the beneficial effect arises from the quality of the regulator, for which capital requirements act as a substitute. Hence, high capital requirements act as a negative signal in their paper, contrary to our approach.

Moreover, Morrison and White (2009) do not model international competition between banks and their focus is on the question whether a uniform regulatory standard is beneficial for countries that differ with respect to the quality of their national regulator.

The remainder of this paper is set up as follows. Section 2 describes the basic model and the nationally optimal regulation policy. Section 3 analyzes the possible outcomes of regulatory competition between the two countries. Section 4 discusses various extensions of our benchmark model. Section 5 concludes.

## 2 The basic model

### 2.1 Setup

We consider a region of two countries  $i \in \{1, 2\}$ , which are identical in all respects. In each country, multiple, heterogeneous banks operate under the authority of a local regulator who imposes capital requirements  $k_i$  for all national banks. The number of active banks in each country is endogenous. Banks in each country extend loans to firms in an integrated regional market. The amount of loans for each bank is fixed to one and we assume that each bank gives a loan to only a single firm, which uses the loan to finance a risky investment.<sup>6</sup>

Banks within each country differ exogenously in their monitoring skills.<sup>7</sup> These monitoring skills determine the ‘quality’ of a bank, which is expressed by the variable  $q$  and is distributed uniformly in the interval  $[0, 1]$ . Moreover, we assume that the quality  $q$  of the bank corresponds to the likelihood that the investment financed by the bank’s loan is successful. This is explained in more detail below. Each bank can fund itself either through equity capital, or through external funds, which we take to be saving deposits of individuals. In our benchmark model we assume that the savings deposits are fully insured by the government of the country in which the bank is located and we normalize the costs of deposits for the bank at unity.<sup>8</sup> In contrast, the cost per unit

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<sup>6</sup>Alternatively, the loan is divided between several firms, whose risks are perfectly correlated.

<sup>7</sup>See Morrison and White (2005) for a similar assumption. The bank’s monitoring decision could also be modelled explicitly, as in Dell’Ariccia and Marquez (2006), but this would complicate the analysis and leave our results qualitatively unchanged.

<sup>8</sup>In Section 4, we will consider an extension of our model where deposits are not insured and capital regulation helps to overcome the asymmetric information problem faced by depositors vis-à-vis the bank’s owners.

of equity is  $\rho > 1$ . Consequently, the bank will never choose to hold equity capital in excess of the minimum level  $k_i$  stipulated by the regulator.<sup>9</sup> The expected profits of a bank with success probability  $q$  are then given by:

$$\pi(q) = q[R_i - (1 - k_i)] - k_i\rho, \quad (1)$$

where  $R_i$  is the return on the bank's loan. Equation (1) incorporates that the return on the bank's loan is zero, if the borrowing firm's risky investment fails. In this case the bank will also go bankrupt and savers will be compensated by payments from the national deposit insurance fund. Equity holders of the bank are residual claimants and receive all profits, less their opportunity costs  $\rho k_i$ .

A central element of our analysis is the impact of minimum capital requirements  $k_i$  on the quality and quantity of banks in both countries. The equilibrium number of banks in each country is determined by the condition that the critical bank with quality  $\hat{q}_i$  receives zero expected profits from its operations:

$$\pi(\hat{q}_i) = \hat{q}_i(R_i - 1 + k_i) - k_i\rho = 0. \quad (2)$$

Equation (2) shows that capital standards in country  $i$  directly affect the quality level  $\hat{q}_i$  of the marginal bank, by increasing the cost of capital for all banks. As low-quality banks benefit most from limited liability and cheap deposit funding, they are hit hardest by an increase in capital standards, and are forced to exit the market.

We assume that, in each country  $i$ , there is an exogenously given number  $\bar{L}$  of potentially entering banks. Without any capital requirements ( $k_i = 0$ ), all banks will be active in the market ( $\hat{q}_i = 0$ ) as they do not lose any equity capital in case of failure. In contrast, full equity financing of banks ( $k_i = 1$ ) results in  $\hat{q}_i = \rho/R_i$ . Hence, a necessary condition for a positive number of banks to stay in the market even with full equity financing is that the cost of equity  $\rho$  is lower than the equilibrium return on loans  $R_i$ . For any given level of  $k_i$ , the number of active banks is larger if either equity is relatively cheap ( $\rho$  is low), or if the loan market is relatively attractive ( $R_i$  is high). With a uniform distribution of  $q$ , the number of active banks in market  $i$  is given by

$$L_i = (1 - \hat{q}_i)\bar{L}. \quad (3)$$

Next we turn to the banks' equilibrium return to loans  $R_i$  in the integrated loan market. We assume that the regional market for bank loans is imperfectly competitive, with

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<sup>9</sup>See Allen et al. (2011) for a model where banks choose to voluntarily hold equity beyond the required level, in order to signal a commitment to monitoring to its borrowers.

a linear demand function that negatively depends on the number of active banks  $L_i$ , and hence on the aggregate loan volume, in both countries. Banks in the two countries thus compete for market shares in the regional loan market.

Further, we think of the loan as being a ‘relationship loan’ that permits the bank to use its expertise to improve the borrower’s project payoff (see Boot and Thakor, 2000). Hence, the borrowers willingness to pay for a loan is influenced by the expected quality of the issuing bank.<sup>10</sup> A critical assumption in our analysis is that the borrowing firm can not observe the quality parameter  $q$  of a specific bank. However, the firm can observe the capital standards  $k_i$  in both countries and infer the pool quality of each country’s banks from eq. (2). We assume that firms compare the capital standards in both countries and that their marginal willingness to pay for a higher capital standard in country  $i$ , relative to that of country  $j$ , is given by  $\alpha$ . Banks in country  $i$  then face the demand function

$$R_i = A - L_i - L_j + \alpha(k_i - k_j). \quad (4)$$

Hence, national capital requirements  $k_i$  act as a signal in our model, which increases the price that borrowers are willing to pay for a bank loan from country  $i$ .<sup>11</sup> However, a precondition for the latter effect to arise is that the borrowers rightly infer a better pool quality of banks as a consequence of the increase in  $k_i$ . Therefore, in equilibrium, the negative cost effect of the stricter capital requirement must exceed the positive quality effect. This requires that, for any bank of type  $q$ , profits must be falling in the capital requirement  $k_i$ . Substituting eq. (4) in (1) and differentiating with respect to  $k_i$ , this condition implies:

$$\frac{\partial \pi(q)}{\partial k_i} = q \left[ 1 + \alpha + \bar{L} \left( \frac{\partial \hat{q}_i}{\partial k_i} + \frac{\partial \hat{q}_j}{\partial k_i} \right) \right] - \rho < 0. \quad (5)$$

Condition (5) ensures that, for any initial level of  $\hat{q}$ , an increase in country  $i$ ’s capital requirement will drive some banks in country  $i$  from the market and increase the pool

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<sup>10</sup>Several reasons are given in the literature for why firms should value banks of high (monitoring) quality. Besanko and Kanatas (1993) show that bank monitoring acts as a positive signal for capital markets, thus permitting the borrowing firm access to further financing options. Boot and Thakor (2000) argue that banks, due to their repeated interaction with various firms, can offer specific knowledge that is complementary to that of firms. This ensures that a high-quality bank directly raises the success probability of the firm’s investment project.

<sup>11</sup>This basic idea is thus similar to standard models of quality choice (Spence, 1975), where consumers are willing to pay a higher price for a higher quality of the product.



quality of the remaining active banks in this country. This condition therefore implicitly defines an upper bound on  $\alpha$  in our benchmark model.

## 2.2 Nationally optimal capital regulation

We consider a national regulator in each country  $i$  who sets capital requirements so as to maximize social welfare. The welfare function of country  $i$  comprises the expected profits of all national banks that are active on the regional market, less the expected costs to the taxpayer when banks fail and depositors must be compensated for their losses through the deposit insurance fund. In line with past experience, we thus assume that the costs of bank failures are fully borne by taxpayers.<sup>12</sup> In the following, we weigh one Euro of taxpayers' expected losses, relative to one Euro of banks' profits, by the factor  $\beta$ . Moreover, we abstract from international contagion effects and assume that the losses from failed banks arise only in the country in which the bank is located.<sup>13</sup> With these specifications, the welfare function of country  $i$  is:

$$\begin{aligned}
 W_i = & \int_{\hat{q}_i}^1 \{q \underbrace{[A - (1 - \hat{q}_i)\bar{L} - (1 - \hat{q}_j)\bar{L} + \alpha(k_i - k_j) - 1 + k_i]}_{\Omega} - k_i \rho\} \bar{L} dq \\
 & - \beta \cdot \int_{\hat{q}_i}^1 (1 - k_i)(1 - q) \bar{L} dq.
 \end{aligned} \tag{6}$$

We arrive at the first term in (6) by substituting (4) in (1) and integrating this profit function over the range of all active firms. The expected losses, captured in the second term, depend on the number of active banks, the amount of deposit funding for each bank  $(1 - k_i)$ , and the probability of default for each active bank  $(1 - q)$ .

The nationally optimal capital requirement is obtained by differentiating  $W_i$  with re-

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<sup>12</sup>Several countries, such as Germany, are currently building up special funds financed by compulsory bank levies, in order to make the banking sector participate in the costs of bank restructurings. The size of these insurance funds is (still) very small, however. In Germany, for example, the volume of this 'restructuring fund' is only slightly above 1 billion Euro after two years of collecting bank levies, out of a target volume of 70 billion Euro.

<sup>13</sup>See Niepmann and Schmidt-Eisenlohr (2013) for an analysis of international regulatory coordination when bank failures in one country have adverse effects on the other country.

spect to  $k_i$ . This gives:<sup>14</sup>

$$\begin{aligned} \frac{\partial W_i}{\partial k_i} &= \int_{\hat{q}_i}^1 \left\{ q \left[ 1 + \alpha + \bar{L} \left( \frac{\partial \hat{q}_i}{\partial k_i} + \frac{\partial \hat{q}_j}{\partial k_i} \right) \right] - \rho \right\} \bar{L} dq \\ &\quad + \beta \int_{\hat{q}_i}^1 (1 - q) \bar{L} dq + \beta \cdot \frac{\partial \hat{q}_i}{\partial k_i} (1 - k_i) (1 - \hat{q}_i) \bar{L} = 0. \end{aligned} \quad (7)$$

The first term in (7) measures the effect of  $k_i$  on the average profits of the remaining banks in country  $i$ , whereas the second and third terms quantify the change in the expected bailout costs for taxpayers in country  $i$ .

It is obvious from (7) that the welfare effects of capital regulations in country  $i$  depend critically on the average quality of active banks in the domestic and in the foreign country. To determine these effects, we first substitute eq. (4) in (2) and solve for  $\hat{q}_i$ . This yields

$$\begin{aligned} \hat{q}_i^2 \bar{L} + \hat{q}_i \Gamma_i - k_i \rho &= 0, \\ \text{with } \Gamma_i &= A - \bar{L} - (1 - \hat{q}_j) \bar{L} + \alpha(k_i - k_j) - (1 - k_i) > 0. \end{aligned} \quad (8)$$

Since countries are symmetric, it holds that  $\partial \hat{q}_j / \partial k_i = \partial \hat{q}_i / \partial k_j$ . We can then use the implicit function theorem to derive the interdependent effects of  $k_i$  on  $\hat{q}_i$  and  $\hat{q}_j$ , respectively:

$$\frac{\partial \hat{q}_i}{\partial k_i} = \frac{[\rho - \hat{q}(\alpha + 1)][2\hat{q}\bar{L} + \Gamma] - \bar{L}\hat{q}^2\alpha}{[2\hat{q}\bar{L} + \Gamma]^2 - \hat{q}^2\bar{L}^2} > 0, \quad (9a)$$

$$\frac{\partial \hat{q}_j}{\partial k_i} = \frac{-\hat{q}\{\bar{L}[\rho - \hat{q}(\alpha + 1)] - \alpha[2\hat{q}\bar{L} + \Gamma_i]\}}{[2\hat{q}\bar{L} + \Gamma]^2 - \hat{q}^2\bar{L}^2}, \quad (9b)$$

$$\frac{\partial \hat{q}_i}{\partial k_i} + \frac{\partial \hat{q}_j}{\partial k_i} = \frac{(\rho - \hat{q})(\hat{q}\bar{L} + \Gamma)}{(2\hat{q}\bar{L} + \Gamma)^2 - (\hat{q}\bar{L})^2} > 0. \quad (9c)$$

In eq. (9a), the effect of an increase in  $k_i$  on the quality of the marginal bank in country  $i$  can be signed from condition (5), which ensures that the effect of  $k_i$  on the financing costs for banks dominates the signalling effect described by the parameter  $\alpha$ .<sup>15</sup> In contrast, the effect of  $k_i$  on the quality of the critical bank in the foreign country, given in (9b), is ambiguous and depends on the sign of the term in curly brackets. We

<sup>14</sup>Note that the effect of changing the integration boundary  $\partial \hat{q}_i / \partial k_i$  on aggregate expected profits is zero, because the marginal active bank with quality  $\hat{q}_i$  has zero expected profits from (2).

<sup>15</sup>The equivalence between condition (5) and the condition for (9a) to be positive is seen by substituting (9c) into (5).

will return to this term below. Finally, adding up the effects of  $k_i$  on  $\hat{q}_i$  and  $\hat{q}_j$  in eq. (9c) shows that this sum is independent of  $\alpha$ . Intuitively, the positive signalling effect of an increase in  $k_i$  for banks in country  $i$  is fully offset by the negative signalling effect for banks in country  $j$ . Hence, only the negative effect of  $k_i$  on the financing costs of active banks remains.

In a second step, we integrate the first and the third term in eq. (7) to get:

$$\frac{\partial W_i}{\partial k_i} = \frac{1 + \hat{q}_i}{2} \left[ 1 + \alpha + \bar{L} \left( \frac{\partial \hat{q}_i}{\partial k_i} + \frac{\partial \hat{q}_j}{\partial k_i} \right) \right] - \rho + \frac{\beta}{2}(1 - \hat{q}_i) + \beta \frac{\partial \hat{q}_i}{\partial k_i} (1 - k_i) = 0. \quad (10)$$

Using eq. (1), the sum of the first two terms in (10) gives the change in the profit of the *average* active firm in country  $i$  resulting from the higher capital requirement  $k_i$ . From condition (5), the sum of these terms must be negative. The third term is positive, as a higher level of  $k_i$  reduces the compensation that must be paid to insured depositors, due to the lower amount of deposit funding for each bank. Finally, the fourth term is again positive, as a rise in  $k_i$  increases the average quality of the banking sector in country  $i$  and reduces the overall probability of default. Hence the optimal national regulation policy trades off the average losses in profitability for the domestic banking sector against the savings to national taxpayers, which result from a smaller and less risky banking sector.

In the following we assume that the government's objective function is concave in  $k_i$  so that the second-order condition for a welfare maximum holds. We further assume that  $\beta$  is sufficiently large so that  $\partial W_i / \partial k_i$  is positive at  $k_i = 0$  (where the values of the positive third and fourth terms are maximized), but  $\beta$  is sufficiently low to render  $\partial W_i / \partial k_i$  negative at  $k_i = 1$  (where the size of these terms is minimized). These assumptions are sufficient to ensure an interior optimum for the nationally optimal regulation policy. Finally, a higher valuation  $\beta$  of taxpayers' bailout payments increases the positive third and fourth terms in (10) and thus raises the optimal level of  $k_i$ .

### 2.3 Competition in regulation policies

We now turn to analyzing the efficiency of decentralized regulation policies. Since countries are symmetric in our benchmark model, we can simply define regional welfare as the sum of national welfare levels

$$W_W = W_i + W_j \quad \forall i, j \in \{1, 2\}, i \neq j, \quad (11)$$

where  $W_i$  is given in eq. (6). Maximizing (11) with respect to a common and cooperatively chosen capital requirement  $k_W$  would imply  $\partial W_W/\partial k_W = 0$ . The nationally optimal capital standards derived in the previous section are instead chosen so that  $\partial W_i/\partial k_i = 0$ . Hence, any divergence between nationally and globally optimal capital requirements is shown by the effect of country  $i$ 's policy variable  $k_i$  on the neighboring country's welfare. If  $\partial W_j/\partial k_i > 0$ , then the capital requirements chosen at the national level are too lax from a regional welfare perspective, as an increase in  $k_i$  would generate a positive externality on the welfare of the foreign country. The reverse holds if  $\partial W_j/\partial k_i < 0$ . In this case the externality on the foreign country is negative and nationally chosen capital requirements are too strict from a regional welfare perspective.

Differentiating  $W_j$  in eq. (6) with respect to  $k_i$  gives:

$$\frac{\partial W_j}{\partial k_i} = \frac{(1 + \hat{q}_j)(1 - \hat{q}_j)\bar{L}}{2} \underbrace{\left[ -\alpha + \bar{L} \frac{\partial \hat{q}_j}{\partial k_i} + \bar{L} \frac{\partial \hat{q}_i}{\partial k_i} \right]}_{\varepsilon} + \beta \frac{\partial \hat{q}_j}{\partial k_i} (1 - k_j)(1 - \hat{q}_j). \quad (12)$$

The first term captures the effect of  $k_i$  on the profits of all active banks in country  $j$ , whereas the second term measures the effect of  $k_i$  on the taxpayers' costs for the deposit insurance fund in country  $j$ , which is caused by the change in the pool quality of banks in country  $j$ . As before, the induced change in the number of banks in country  $j$  has no effect on aggregate bank profits in country  $j$ , as the marginal bank with quality level  $\hat{q}_j$  has zero expected profits.

We first determine the effect of  $k_i$  on aggregate bank profits in country  $j$ , which depends on the sign of the term denoted by  $\varepsilon$ . The term  $\varepsilon$  incorporates two effects. On the one hand, the quality signal associated with a rise in  $k_i$  negatively affects banking profits in country  $j$ , as measured by the parameter  $\alpha$ . This partial effect therefore constitutes a negative externality on country  $j$ . On the other hand, the decrease in competition positively affects banking profits in country  $j$ . Using eq. (9c), we can rewrite  $\varepsilon$  as:

$$\varepsilon = \frac{(\hat{q}_j \bar{L} + \Gamma)\bar{L}\phi}{(2\hat{q}_j \bar{L} + \Gamma)^2 - \hat{q}_j^2 \bar{L}^2}, \quad \phi \equiv \rho - \hat{q}_i - \alpha (3\hat{q}_j \bar{L} + \Gamma) \gtrless 0. \quad (13)$$

The sign of  $\varepsilon$  is the same as the sign of  $\phi$ , which critically depends on the value of  $\alpha$ . For small values of  $\alpha$ , it holds that  $\phi > 0$ , implying that country  $j$ 's banks benefit from a higher capital requirement in country  $i$ . Intuitively, the positive signalling effect of higher capital standards in country  $i$  is weak in this case, and the decrease in competition from country  $i$  is the dominant effect. This leads to an increase in prices and profits for the banking sector in country  $j$ . For sufficiently high values of

$\alpha$ , however, the term  $\phi$  becomes negative and higher capital requirements in country  $i$  exert a negative externality on banking profits in country  $j$ . In this case, the signalling effect of a higher  $k_i$  is so strong that more loans are attracted to country  $i$ , despite the lower number of active banks in this country. As a result, the banking sector shrinks in the competing country  $j$ , and aggregate bank profits are reduced. This is seen from equation (9b), which shows that a rise in  $k_i$  will increase  $\hat{q}_j$  when  $\phi < 0$ .

In the next step we combine this effect with the externality that an increase in  $k_i$  imposes on taxpayers in country  $j$ . As taxpayers in country  $j$  benefit from an increase in the pool quality of their national banks, they will gain from an increase in  $k_i$  whenever country  $j$ 's banks collectively lose, and vice versa. Using (13) and (9b), the net externality of an increase in  $k_i$  on welfare in the neighboring country  $j$  is given by

$$\frac{\partial W_i}{\partial k_j} = \frac{\phi(1 - \hat{q}_i)\bar{L}}{(2\hat{q}_j\bar{L} + \Gamma)^2 - \hat{q}_j^2\bar{L}^2} \left[ \underbrace{\frac{(1 + \hat{q}_i)}{2}(\hat{q}_i + \Gamma) - \beta\hat{q}_i(1 - k_i)}_{\mu} \right], \quad (14)$$

where  $\phi$  is given in (13). Equation (14) thus shows a further ambiguity as the term labeled  $\mu$  cannot be signed, in general. In the absence of any capital requirements ( $k_i = 0$ ), it follows that  $\hat{q} = 0$  and  $\mu$  is unambiguously positive. At the other extreme,  $\mu$  is also positive when  $k_i = 1$ . In both cases a marginal increase in  $k_i$  does not change the aggregate pool quality of the banking sector of country  $j$ , and hence does not affect country  $j$ 's taxpayers, but it does affect aggregate profits in country  $j$ 's banking sector. For intermediate values of  $k_i$  it is possible, however, that  $\mu$  turns negative, implying that the externality of country  $i$ 's capital regulation on welfare in country  $j$  is dominated by the effects on  $j$ 's taxpayers.

The standard case discussed in the literature arises when  $\phi > 0$  and  $\mu > 0$ . In this case, a higher capital requirement in country  $i$  places this country's banks at a competitive disadvantage and benefits the banking sector in the competing country  $j$ , whereas the effects on country  $j$ 's taxpayers are of secondary importance. This leads to capitals standards in each country that are too low from a regional welfare perspective. This case thus corresponds to the 'competition of laxity' analyzed by Sinn (2003), Acharya (2003) and Dell'Araccia and Marquez (2006).

Our analysis show, however, that a 'race to the top' is equally possible in regulatory competition. This can arise for two very different reasons. In the first case, it holds that  $\phi < 0$  and  $\mu > 0$ . Hence, the effects of country  $i$ 's capital requirement on the profits of country  $j$ 's banking sector are more important than the effects on country  $j$ 's

taxpayers. However, the banking sector in country  $j$  is now hurt by an increase in country  $i$ 's capital standard, because the signalling effects of strict capital standards are strong.

The second instance of a ‘race to the top’ arises when  $\phi > 0$  and  $\mu < 0$ . In this case, the conventional wisdom holds that high capital standards in country  $i$  place this country’s banks at a competitive disadvantage and benefit the competing banks in country  $j$ . However, the effects on aggregate bank profits are now dominated by the spillover effects on taxpayers in the other country  $j$ . In this case, each country wants to protect domestic taxpayers by shrinking the domestic banking sector and simultaneously improve its average quality by driving the riskiest banks from the market. In equilibrium, the consolidation of country  $i$ 's banking sector will, however, induce market entry in country  $j$  and reduce the average quality of the banking sector there. In effect, taxpayers’ risks are therefore shifted from the home to the foreign country and this is the reason why nationally optimal capital standards are excessively strict in this case from a regional welfare perspective.

### 3 The extended model

We now want to extend our basic model in two dimensions. First, we want to explicitly derive the loan demand function of firms, thereby rationalizing the preference of firms for loans from high quality banks. Second, we want to allow for an endogenous operation size of each bank. We can then, again, analyze the effect of national capital standards on the quality and quantity of the national and foreign banking sector.

#### 3.1 Firms

As in the basic model, each firm is endowed with one project but without any private source of funds. Firms in the entire region are ordered by their return if the project succeeds. Each firm demands one unit of credit. Firms are numbered by  $n$ . Hence  $A - n$  is the return of firm  $n$ . Since each firm demands one unit of credit, this is equal to  $A - L_1 - L_2$  where  $L_1$  and  $L_2$  are the total bank lendings in country 1 and 2. Each firm has fixed cost  $c$  for its project. If  $R_i$  is the price to be paid for a loan from country  $i$ , the last firm makes zero profits and thus demands a loan if:

$$q_i^e(A - L_1 - L_2 - R_i) = c \tag{15}$$

Note that the loan is not repaid if the project fails, but the fixed cost must be paid in any case. The expected success rate of the project  $q_i^e$  depends entirely on the quality of the bank. The firm does not know the quality of the individual bank but it forms an expectation that is based on the observable capital requirement. Now, rearranging (15) we can solve for the loan price for firms when they borrow from banks in country  $i$ :

$$R_i = A - L_1 - L_2 - \frac{c}{q_i^e} \quad (16)$$

We can see immediately that, as postulated in the basic model, the loan rate in country  $i$  positively depends on the expected quality in the banking sector of country  $i$ . More specifically, if the firm knows that the quality of banks in country  $i$  is uniformly distributed, then it can directly infer the expected quality of banks in country  $i$  that is:

$$q_i^e = \frac{\hat{q}_i + 1}{2} = \frac{1}{2} + \frac{\hat{q}_i(k_i)}{2} \quad (17)$$

where the expected quality is rising in  $k_i$ . Hence the price of bank loans differs systematically between the two countries whenever the capital requirements differ, so that banks from the country with the higher capital ratio get a higher return.

### 3.2 Banks

As in the basic model, banks differ exogenously in  $q$ . Additionally, banks can now choose the volume of their lending ( $x$ ). The profit function for a bank in country  $i$  is then given by:

$$\pi(q, x) = \{q[R_i - 1 + k_i] - k_i\rho\}x - \frac{1}{2}bx^2 \quad (18)$$

where the quadratic cost term  $\frac{1}{2}bx^2$  limits operations of each bank. It can be thought of as increased transaction costs when the bank's level of operation rises.<sup>16</sup> We can now derive the optimal choice of  $x$ . We assume that all banks are small and take  $R_i$  as given when choosing  $x$  so that:

$$x^* = \frac{q[R_i - 1 + k_i] - k_i\rho}{b} \quad (19)$$

It is clear from (19) that the volume of lending for each bank increases in its quality and the price of loans in its home country, while it decreases with the amount of capital it has to hold. Thus, a better bank is also larger.

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<sup>16</sup>See Acharya (2003) for a similar assumption.

We can now substitute (19) in (18) to determine the profit of a bank of quality  $q$  that is located in country  $i$ :

$$\pi^*(q) = \frac{[q(R_i - 1 + k_i) - k_i\rho]^2}{2b} \quad (20)$$

Obviously, the profit of banks increases in their quality and their return on loans, while it decreases in the amount of equity they have to hold.

We are now interested in the aggregate loan volume of all banks that are located in country  $i$ . As in the basic model, we assume that there is an exogenously given number  $\bar{L}$  of potentially entering banks with uniform distribution of  $q$ . We are then left to integrate the operation size of each bank from (19) over the range of all active banks to arrive at:

$$L_i = \bar{L}(1 - \hat{q}_i) \frac{R_i - 1 + k_i}{2b^2} [R_i - 1 + k_i - k_i\rho] \quad (21)$$

While in the basic model, due to the fixed amount of loans for each bank, the aggregate loan volume was equal to the number of banks in the market ( $\bar{L}(1 - \hat{q}_i)$ ), we now have an additional term in Eq. (21) equal to the average loan volume per active bank.

### 3.3 Welfare analysis

As in the basic model, the welfare function of country  $i$  comprises the expected profits of all national banks that are active on the regional market, less the expected costs to the taxpayer when banks fail and depositors must be compensated for their losses through the deposit insurance fund:

$$W_i = \frac{\bar{L}}{2b} \int_{\hat{q}_i}^1 \underbrace{[q(A - L_i - L_j - \frac{c}{q_i^e} - 1 + k_i) - k_i\rho]^2}_{\Delta} dq - \beta \cdot \int_{\hat{q}_i}^1 (1 - k_i)(1 - q)L_i(q) dq \quad (22)$$

where we arrive at the first term by substituting Eq. (16) in (18) and integrating this profit function over the range of all active firms. The expected losses, captured in the second term, depend on the aggregate loan volume, the amount of deposit funding for each bank  $(1 - k_i)$ , and the probability of default for each active bank  $(1 - q)$ .

(to be continued)



## 4 The model without deposit insurance

In our benchmark model we have assumed that national governments, and thus taxpayers, provide full insurance for saving deposits. This assumption corresponds to the institutional framework in most developed countries. It eliminates, however, a further role that capital requirements can play in reducing moral hazard problems and increasing the volume of savings available to banks. In the following we extend our model to incorporate this additional function of capital requirements.

(to be continued)

## 5 Conclusions

In a setting with international competition between heterogeneous banks and a taxpayer bailout for failing financial institutions, we have shown that a ‘race to the top’ in capital regulation is an equally plausible scenario as a ‘race to the bottom’, on which the existing literature has focused. This ‘race to the top’ can arise for two entirely different reasons. First, countries imposing capital standards that are tighter than those of their neighbors may do so because their banking sectors benefit from the positive signalling effect of stricter capital ratios, which improve the average quality of the banking sector in the regulating country. Alternatively, tough capital standards can be imposed to protect domestic taxpayers and shift the risk from bailing out bankrupt financial institutions from the home to the foreign country. Both of these scenarios may explain why countries such as Switzerland and the United Kingdom, which are characterized by large banking sectors and accordingly a high risk exposure of national taxpayers, resort to capital adequacy rules that exceed the Basel III standards. At the same time, it may also explain why most European countries insist on setting *upper* limits on capital standards, along with lower ones.

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