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The Regulator's Trade-off: Bank Supervision vs. Minimum Capital

Florian Buck
Eva Schliephake

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Abstract

We develop a simple model of banking regulation with two policy instruments: minimum capital requirements and supervision of domestic banks. The regulator faces a trade-off: high capital requirements cause a drop in the banks' profitability, while strict supervision reduces the scope of intermediation and is costly for taxpayers. We show that the expected costs of a banking crisis are minimised with a mix of both instruments. Once we allow for cross-border banking, the optimal policy is not feasible. If domestic supervisory effort is not observable, our model predicts a race to the bottom in banking regulation. Therefore, countries are better off by harmonising regulation on an international standard.

JEL-Code: F360, G180, K230, L510.

Keywords: bank regulation, regulatory competition, supervision and capital requirements.

Florian Buck
Center for Economic Studies at the University of Munich
Schackstrasse 4
80539 Munich
Germany
florian.buck@lmu.de

Eva Schliephake
Economics of Business and Law
Otto-von-Guericke University
Universitätsplatz 2
39106 Magdeburg
Germany
eva.schliephake@ovgu.de

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1 Introduction

As demonstrated by the recent financial crisis, asymmetric information between depositors and banks can cause the breakdown of financial markets. Empirical studies suggest that the probability of such a confidence crisis, *i.e.,* the stability of the banking sector, responds to two factors: changes in the minimum capital requirement regulation (Barth et al. 2006, Laeven and Levine 2009) and to changes in domestic supervision (Mitchener 2005, Buch and DeLong 2008). However, the focus of regulatory reforms, has concentrated on capital regulation, whereas supervision is still left in the hand of national authorities.[3]

This paper disentangles the trade-off between higher capital requirements and more supervision by explicitely taking into account both policy tools to secure the stability of a domestic banking sector. Due to the coexistence of moral hazard and adverse selection, we show that both instruments are needed in order to prevent a banking crisis. Intuitively, both problems result from asymmetric information on the actual riskiness of banks. Capital regulation solves an individual bank's moral hazard reducing the cost of a market breakdown, while supervision reduces the adverse selection problem and the probability of a crisis. Therefore, a regulator minimises the expected cost of a banking crisis via a neo-classical production function with both input factors. However, the cost burden of intervention differs: The cost of increasing capital is born by the banks, the cost of supervision and improvement of the banking sector is assumed to be born by the regulator and, thus, by taxpayers.[4] Interestingly, if we allow for a certain degree of capturing by the regulator, this highly stylised model yields a rich set of results.

First, we examine the optimal regulation of a banking sector in a closed economy that consists of banks, which differ with respect to their ability to control the risk of their investment projects. If depositors cannot observe the actual ability of each bank, they will deposit less money in banks compared to fully informed depositors. In order to reduce the inefficiency stemming from asymmetric information, the regulator now selects an optimal combination of a minimum capital requirement level that incentivises banks to control their risk and supervisory effort that influences the quality of the banking sector (*i.e.*, the proportion of banks that are able to control their risky investments). Her choice depends on both the cost of supervisory effort in influencing the quality of the average bank, and the weight a regulator puts on the rent and the size of the domestic banking sector. This political economy approach represents a rather broad view of regulation when compared to the prudential framework that is found in most of the existing literature.[5]

Second, we show within our setting that with institutional competition between regulators, the optimal combination of policy instruments crucially depends on the moving costs and observability of differences in national regulation in the banking sector. If depositors can fully observe country-specific regulatory regimes, and are able to differentiate via adjusted interest rates, jurisdictions evolve into a "club" supplying a regulatory framework for banks. In such a situation, the regulatory

[3] Even after two substantial revision processes, the main focus of the Basel Accords created by the Bank of International Settlements remains the regulation of capital and liquidity standards. Although the regulatory framework encourages the convergence towards common supervisory standards, the rather general implementation guidelines are by far less detailed and matured as the regulation of capital requirements, which leaves national authorities room to incorporate supervisory practices which are best-suited to their own national systems. As a result, one can observe considerable variations in supervisory standards in jurisdictions that are adopting the Basel framework. Regulation differs, for example, with respect to definitions of the requested reporting items, time-tables or technical details.

[4] This assumption is consistent with recent empirical findings, *i.e.*, Masciandaro et al. (2007) analyse the financial governance of banking supervision in a sample of 90 countries. They conclude that full public financing is the most common budgetary arrangement for central banks as banking supervisors. However, some may be financed by both taxpayers and supervised institutions which is the case in Germany where the banking sector pays half of the costs.

[5] A recent paper by Becerra et al. (2012) make a similar argument. They argue that the level of financial development driven by political reforms is the result of the interaction of domestic interest groups that try to safeguard their rents and governments that struggle for political survival.

costs to prevent the breakdown of financial markets increase with the mobility of banks. However, if depositors cannot distinguish between different national regulatory regimes, a deregulation race in capital ratios appears resulting in an even higher increase in the probability of a global banking crisis. Moreover, this implies that competition among regulators causes a rent-shifting between banks and taxpayers compared to the optimal policy mix in autarky which always reduce domestic welfare.

Our results are related to the small but growing theoretical literature on the political economy of regulatory competition in banking. In a globalised world, regulators must take into account that banks seek to go abroad, and consequently must deal with externalities created by mobile banks. Empirical studies document increased foreign bank entries in many economies; for example, Barth et al. (2006) show in a sample of 91 countries that on average 45% of banking assets were counted for by banks that are more than 50% foreign owned. A recent study by Ongena et al. (2011) provides an analysis of spillover effects of national capital requirement regulation and supervision on the lending behaviour of cross-border banks. They find empirical evidence that stricter regulation and supervision reduces risk-taking of banks in the home country but increases risk-taking of lending in foreign countries. Their findings suggest that national capital regulation and supervision may have important spillover effects. Instead of enhancing bank stability, stricter capital regulation and supervision may simply reallocate the risk-taking behaviour to other countries.

In a seminal paper Dell'Arricia and Marquez (2006) develop a two-country model with structural spillovers between two national banking systems. Without a supranational regulator, externalities induce nations to select suboptimal low standards of minimum capital requirements. Trading off the benefits and costs of centralisation Dell'Arricia and Marquez show that nations with relatively homogenous banking systems have a stronger incentive to form a regulatory union. However, they do not allow for supervisory interventions.

By contrast, Acharya (2003) discusses the desirability of uniform capital requirements among countries with divergent closure policies. He illustrates that *ex post* policies can have an incremental effect on the optimality of *ex ante* regulation and, therefore, must be taken into account when designing prudential *ex ante* policies. He concludes that, with heterogeneous closure policies, level playing fields can result in a welfare-declining race to the bottom.

The main result of Morrison and White (2009), however, is the opposite. In their model, a less competent jurisdiction suffers from international financial integration, since good banks flee to the better jurisdiction which can cherry pick the best banks applying for licenses. Therefore, less competent jurisdictions benefit from international harmonisation of regulation, though international capital requirements alone cannot prevent the exit of sound banks. One can conclude that the catching-up of the weakest regulator over the best-regulated economy takes place when capital is mobile. Thus, in their view, level playing fields are desirable for weaker regulators.

Our model incorporates both of these ideas, establishing conditions where competition among regulators lead to a race to the bottom in capital ratios or an efficient outcome where the more efficient regulator expects higher volumes of deposits. In contrast to Acharya (2003), who concentrates on the interlinkage of capital requirement and closure policies, our model focuses on the link between optimal harmonised capital requirements and *ex-ante* supervisory efforts that will change the pool quality, and thereby the stability of the banking sector within a jurisdiction. Moreover, we combine our results with the political economy literature showing the distributional effects of regulatory competition between taxpayers and the banking sector which create incentives for lobbying activity.

Finally, the results from our analysis provide a rationale for the international harmonisation of minimum capital standards à la Basel when banks are mobile. We show that the equilibrium outcome of regulatory competition is welfare-inferior compared to a world with closed economies. Consequently, there are two driving forces for the international harmonisation of capital requirements: (1) independently of the information structure, harmonised capital regulation counters a regulatory race that lowers national utility, (2) network benefits of harmonisation reduce the costs of supervision for national regulators making optimal regulation cheaper.

This paper proceeds as follows: In section 2 we introduce our basic model setup in a closed economy showing under which conditions an unregulated banking sector can be characterised as a lemons market where no banking is possible. In order to prevent such a domestic market breakdown the regulator can now use capital standards and supervision. In section 3, we allow for free movement of banks and introduce regulatory competition to analyse the changes in the optimal policy mix. Section 4 summarises our findings and shortly discusses policy implications.

2 Optimal Regulation in Closed Economies

2.1 Lemons Equilibrium in an Unregulated Banking Sector

We develop our arguments in a one-period model with three types of risk-neutral agents: banks, depositors and regulators.[6]

Consider a continuum of banks normalised to 1. Banks collect funds from depositors and equity investors in order to finance risky projects. Unmonitored projects return R in case of success with probability p_L and zero in case of failure with $(1-p_L)$. We further assume that a "natural" fraction $\theta^n \in [0,1)$ of banks has access to a monitoring technology, which allows them to increase the probability of project success to $p_H = p_L + \triangle p > p_L$ at the cost m. We call these banks efficient. The remaining banks in the national banking sector $(1-\theta^n)$ are said to be goofy.

We assume a huge pool of risk-neutral depositors[7] that can provide an infinite amount of deposits. Each depositor, endowed with 1, can either invest in a risk less storage technology yielding a certain return of $\gamma \geq 1$ or lend it to a bank as deposits without any form of depositor insurance.[8] Hence, banks can raise deposits as long as the offered expected return on deposits exceeds the depositor's outside option $E(r_D) \geq \gamma$. Suppose that $R \cdot p_H > \gamma > R \cdot p_L$; non-monitored projects have a negative expected return. This implies that, if observable, a depositor is not willing to deposit with a bank that does not monitor. Depositors know the expected return on investments of each type of bank, but cannot observe the actual type of the bank, *i.e.,* only θ is observable. Therefore, the decision to deposit depends on the average quality of banks in the economy provided that efficient banks have enough "skin in the game" in the form of equity to monitor their projects. The unobservablitity of the bank's type implies that all banks can refund at the same deposit rate. This assumption reflects information asymmetries between depositors and banks and is in line with traditional banking models and recent empirical findings:[9] because of banks' opaqueness, a bank's

[6] The basic set-up follows Holmström and Tirole (1997) and Morrison and White (2009) with perfect correlation of risk.

[7] The assumption of risk neutral depositors does not drive our results but simplifies the model. The driving factor for our model is that depositors need to be compensated for expected shortfalls in their deposits.

[8] Alternatively, we can assume that depositors are fully insured, but the deposit insurance risk premium to be paid depends on the average risk in the banking sector. A risk-adjusted deposit guarantee system is welfare-neutral yielding the same equilibrium conditions for optimal policy (see Morrison and White 2011).

[9] Morgan (2002) provides empirical evidence on the opacity by comparing the frequency of disagreements among bond-rating agencies about the values of firms across sectors of activity. Disagreements are higher for financial institutions than for other sectors of the economy.

type is supposed to be private information and cannot be credibly communicated to depositors. In this context, we model a banking crisis as a confidence crisis where depositors are unwilling to give their money to a bank which they select at random.

In addition to deposits, banks can raise equity to finance their projects. We assume that equity has high opportunity costs and is, therefore, scarce, *i.e.,* $\rho > R \cdot p_H$. The assumption that equity is costly for a bank is very common in the theoretical literature on banking, however, it is not undisputed.[10] One justification for costly equity would be that depositors, compared to equity investors, receive additional private benefits for depositing, *e.g.*, depositing creates access to means of non-cash payment systems that helps to mitigate transaction costs, which depositors face in their daily life. In our model, the additional cost of capital also reflects the shrinking role of banks as financial intermediaries. We assume that the existence of financial intermediation is welfare enhancing. The more banks refund their investments with equity capital, the less deposits they take and, therefore, the less financial intermediation takes place.

As argued above, due to the opaqueness of the banking sector, depositors cannot observe the individual capital structure of each bank unless national regulation enforces an observable minimum capital requirement standard. Therefore, efficient banks cannot signal their "quality" by raising additional equity or publishing their profits via balance sheets, which would be a natural solution to the adverse selection problem. Without capital regulation, banks always minimise costly equity capital (to zero). Now we can construct the conditions for the existence of financial intermediation, *i.e.,* depositing:

First, monitoring must be incentive-compatible for efficient banks. The fraction θ of banks will choose to monitor projects if the return from monitoring exceeds the return from not doing so, *i.e.*, $(R - r_D)(p_L + \triangle p) - m \geq (R - r_D)p_L$. Thus, banks must receive a sufficiently high rent to incentivise them for monitoring. In other words, the monitoring incentive compatibility constraint of efficient banks gives an upper bound on the deposit rate:

$$r_D \leq r_D^{MIC} := R - \frac{m}{\triangle p}. \tag{1}$$

This upper bound on the refinancing cost is increasing in the value added of monitoring $\frac{\partial r_D^{MIC}}{\partial \triangle p} > 0$ and decreasing in the cost of monitoring $\frac{\partial r_D^{MIC}}{\partial m} < 0$. Any deposit rate $r_D > r_D^{MIC}$ will destroy the efficient bank's incentives to monitor, and will result in a homogenous banking sector where the probability that the project succeeds equals p_L. If $r_D < r_D^{MIC}$ the incentive constraint of banks with a monitoring technology holds. In that case, depositors anticipate that the fraction θ of banks monitor. Knowing the overall fraction of banks with monitoring technology allows for the deduction of an expected unconditional probability that the project succeeds of $(p_L + \theta \triangle p)$.

Anticipating this average probability, depositors are willing to deposit their endowments at the bank if the expected return from depositing exceeds their outside option $(r_D) \cdot (p_L + \theta \triangle p) \geq \gamma$. Therefore, the second condition for depositing is given by the participation constraint from depositors, which gives a lower bound on the deposit rate. Depositors require at least a deposit rate that is equal to, or greater than

$$r_D^{PCD} := \begin{cases} \frac{\gamma}{p_L} & \text{iff } r_D > r_D^{MIC}, \\ \frac{\gamma}{p_L + \theta \triangle p} & \text{iff } r_D \leq r_D^{MIC}. \end{cases} \tag{2}$$

[10] Admati et al (2011) argue that equity is only expensive because of debt subsidies resulting from an underpriced saftey net and special tax policies. From a social planner's point of view the loss of subsidies imply no (social) cost.

Because of the perfectly elastic supply of deposits, perfect competition will erode the depositor's rent, resulting in a binding participation constraint denoted by $r_D[\theta] := \frac{\gamma}{p_L+\theta\triangle p}$ if θ efficient banks monitor.

Yet, financial intermediation is only possible in an opaque banking sector when the deposit rate that is required by depositors does not violate the bank's monitoring condition. If the natural fraction of efficient banks is high enough, financial intermediation could exist without any regulation. However, throughout this paper, we will assume that the "natural" proportion of banks that have access to a monitoring technology is too small so that unregulated depositing is not feasible without any regulation.[11]

Definition 1. (Lemons Equilibrium) If $\theta^n < \hat{\theta} := \frac{\gamma}{\triangle pR-m} - \frac{p_L}{\triangle p}$, depositing is on average less productive than investments in the storage technology and the banking market disappears.

Proof. If $\theta^n < \hat{\theta}$, it follows that $\frac{\gamma}{p_L+\theta^n\triangle p} > R - \frac{m}{\triangle p}$. Depositors correctly foresee that no banks are monitoring. From (2), it follows that depositors require $r_D = \frac{\gamma}{p_L}$ in order to participate. However, for $\gamma > R \cdot p_L$, no bank would be able to pay such a deposit rate without making losses, *i.e.*, the required return for the depositor's participation constraint to hold will violate the participation constraint of the non-monitoring banks. Although lending to efficient banks is socially valuable, depositors are unwilling to deposit and, therefore, the banking market would break down; a lemons equilibrium à la Akerlof emerges.[12] □

In a lemons equilibrium, even banks with efficient monitoring technology would not be able to raise funds and no investments would take place, even though monitored projects could create a positive rent. As a result, the financial market is unable to channel funds effectively to those who have the most productive investment opportunities.

In the following sections we argue that the market inefficiency caused by asymmetric information could be alleviated by two alternative policy instruments: capital standards and supervision.

2.2 The Effects of Capital Standards

The introduction of a minimum capital requirement changes the individual incentive constraints of banks. The first effect of capital concerns the monitoring condition of efficient banks. To see this, note that if a bank refunds each dollar investment by a fraction of capital k, the incentive to monitor changes to $(R - r_D(1-k))(p_L + \triangle p) - m \geq (R - r_D(1-k))p_L$. It follows that the incentive constraint becomes

$$r_D \leq r_D^{MICk} := \frac{R - \frac{m}{\triangle p}}{(1-k)} > r_D^{MIC}. \tag{3}$$

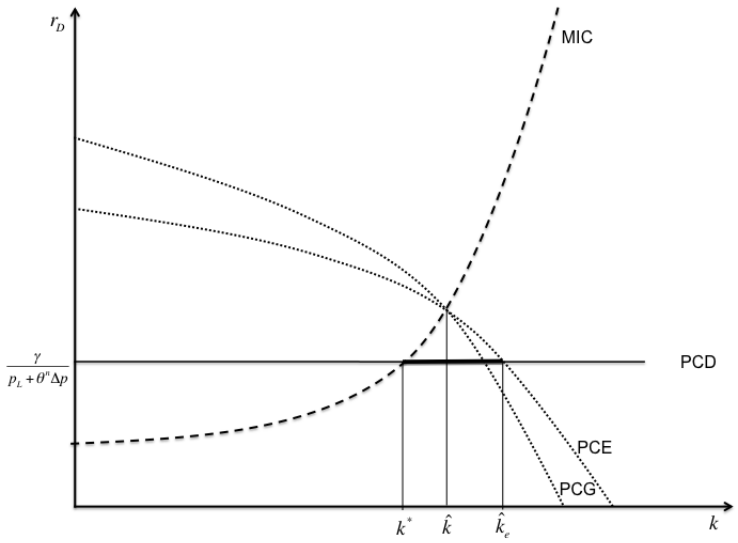
This tells us that a capitalised bank, which refunds a proportion of its investments with equity, can pay higher deposit rates without violating its incentive constraint. Because of $\frac{\partial r_D^{MICk}}{\partial k} > 0$, the incentive constraint *(MIC)* is upward sloping in a deposit rate-capital ratio space. Efficient banks wish to provide monitoring services only when the deposit rate is sufficiently low to compensate them for monitoring activities. A minimum capital requirement reduces the rent an efficient bank needs

[11] The participation constraints of a monitoring bank is given by the condition of non-negative profits: $(R-r_D)p_H - m \geq 0$ and hence $r_D \leq r_D^{PCE} := R - \frac{m}{p_H}$. Note that the lower bound on the deposit rate of the efficient bank's participation is always above the *MIC*, since $p_H > \Delta p$ and the *MIC* will be violated first. By contrast, goofy banks will make non-negative profits whenever $(R - r_D)p_H > 0$, which is the case for any deposit rate $r_D \leq r_D^{PCG} := R$.

[12] Akerlof's (1970) lemons problem describes a market failure that is born by asymmetric information. If consumers cannot distinguish qualities, producers will save production costs by reducing their product quality (moral hazard); in equilibrium, the qualities produced will be lower than those that would have been offered to informed buyers.

in order to be willing to monitor. Therefore, with "greater skin in the game," efficient banks can accept higher deposit rates, while still credibly assuring to monitor their projects *ex post*.[13] Figure 1 illustrates how the monitoring incentive constraint *MIC* is increasing in k. Without any regulation, depositing does not take place since all depositors prefer to invest in the storage technology instead of lending money to banks. The equity funding rate k^* gives the minimum capital requirement rate that establishes financial intermediation by solving the moral hazard problem of efficient banks for a given required return of depositors $r_D[\theta^n]$.

Fig. 1: Intermediation region for a high pool quality



However, since equity funding is costly, a higher capital requirement rate diminishes the rents of both bank types. Therefore, it also influences each bank type's incentive to participate, *i.e.*, the break even point.

The participation constraint of a monitoring bank is given by the non-negative profits condition: $(R - r_D(1-k))p_H - m - \rho k \geq 0$. Solving for a maximum deposit interest rate, we get:

$$r_D[\theta^n] \leq r_D^{PCE} := \frac{R - \frac{m+\rho \cdot k}{p_H}}{(1-k)}. \tag{4}$$

Since we assumed $\rho > p_H \cdot R$, the minimum capital requirement must be small enough to keep efficient banks operating: $k < \hat{k}_e[r_D] := \frac{p_H(R - r_D[\theta^n]) - m}{\rho - p_H \cdot r_D[\theta^n]}$.

Goofy banks, on the contrary, will make non-negative profits whenever $(R - r_D(1-k))p_L - \rho k > 0$, which is the case for every deposit rate

$$r_D[\theta^n] \leq r_D^{PCG} := \frac{R - \frac{\rho k}{p_L}}{(1-k)}, \tag{5}$$

implying a break even capital standard that is equal to $\hat{k}_g[r_D] := \frac{p_L(R - r_D[\theta^n])}{\rho - p_L \cdot r_D[\theta^n]}$. Let $\hat{k}[r_D]$ denote the capital standard that solves $MIC = PCG = PCD$. For sufficiently high cost of capital $\rho > \frac{p_L \cdot m}{\Delta p}$, we can derive the following Lemma:

[13] Note that a lower deposit rate, ceteris paribus, increases a bank's rent. When a bank requires lower rents to compensate for monitoring effort this directly translates into the ability to accept higher deposit rates while still being credibly committed to monitoring.

Lemma 1. *For a sufficiently high natural proportion of efficient banks, where* $r_D[\theta^n] < r_D\left[\hat{k}\right]$, *there exists a continuum of minimum capital requirement rates* $k \in \left[k^*, \hat{k}_e\right]$ *that solves the moral hazard problem. Otherwise, capital requirements alone cannot guarantee financial intermediation,* $k \in [\emptyset]$.

Proof. With $\rho > \frac{p_L \cdot m}{\Delta p}$, it can be easily shown that $0 < \hat{k} < 1$. Therefore, there exists a maximum interest rate $r_D\left[\hat{k}\right]$ that simultaneously makes the *MIC* (3) and the *PCs* of each bank type (4), (5) binding. Any capital requirement above $\hat{k}_e$ would further decrease the required interest rate for monitoring incentives but violates (3). Hence, there exists no capital requirement that guarantees that efficient banks monitor and are willing to participate. □

Lemma 1 tells us that observable and binding minimum capital requirements can only overcome a lemons equilibrium in the market if the natural fraction of efficient banks is sufficiently high. Then, by decreasing the moral hazard incentives in an opaque banking sector, efficient banks credibly commit to monitor. However, capital regulation cannot solve the adverse selection problem by crowding out goofy banks. On the one hand, it is true that for any $k > \hat{k}$, monitoring banks are more profitable than goofy banks, $r_D^{PCE} > r_D^{PCG}$. Consequently, setting a sufficiently high capital requirement $\hat{k}_e \geq k > \hat{k}_g$ will induce the exit of goofy banks first. However, if depositors correctly anticipate that only efficient banks participate and monitor, the expected success of projects increases to p_H and the required return on deposit falls to $r_D = \frac{\gamma}{p_H}$. Yet, with lower deposit funding costs, goofy banks find it profitable to participate in banking - and enter the market again. Therefore, crowding out goofy banks by setting a sufficiently high capital requirement cannot be an equilibrium unless the capital requirement is set such that $\hat{k}_e\left[\frac{\gamma}{p_L+\theta\triangle p}\right] > k > \hat{k}_g\left[\frac{\gamma}{p_H}\right]$. From these observations we can define the depositors' participation constraint as follows:

$$r_D^{PCD} := \begin{cases} \frac{\gamma}{p_L} & k < k^* \\ \frac{\gamma}{p_L+\theta\triangle p} & \hat{k}_g \geq k \geq k^* \\ \frac{\gamma}{p_H} & k > \hat{k}_g. \end{cases} \tag{6}$$

The depositors' willingness to invest does not depend linearly on the capital requirement, since a bank's probability of success is not affected by the capital structure of the bank, but only by the monitoring incentives of banks and the incentives to enter the market.[14] Intuitively, depositors require a "goofy" risk premium for the average success probability in the banking sector. By contrast, if the capital standard is above the *PC* of goofy banks and the *MIC*, depositors will foresee that goofy banks leave the market (separating equilibrium) and only efficient banks stay in the banking sector.

The *PCs* of depositors, efficient and goofy banks, as well as the monitoring incentive constraint are plotted in Figure 1. The graph shows the deposit region for a sufficiently high pool quality of banks where $r_D[\theta^n] < r_D\left[\hat{k}\right]$. Without any capital standards, the required return of depositors $r_D[\theta^n]$ violates the upward sloping *MIC* of efficient banks. A capital standard k^*, as the intersection point of the *MIC*- and the *PCD-curve* for $\theta^n \in]0,1]$, labels the lowest capital ratio that has to be

[14] The fact that higher equity funding does not directly influence the bank's success probability, is a result of the simplicity of our model, where investment projects default with perfect correlation. One major argument in favour of higher capital requirements is that equity provides a buffer against unexpected losses. This could be implemented in our model by a shock to risky investment returns, where a proportion of the projects do not succeed. The more a bank has funded its investments with equity, the bigger the shocks a bank could absorb; in other words, the actual return on investment covers at least the deposit liabilities. However, this additional stability enhancing buffer effect does not change our results, but would increase the complexity of our model and is, therefore, neglected.

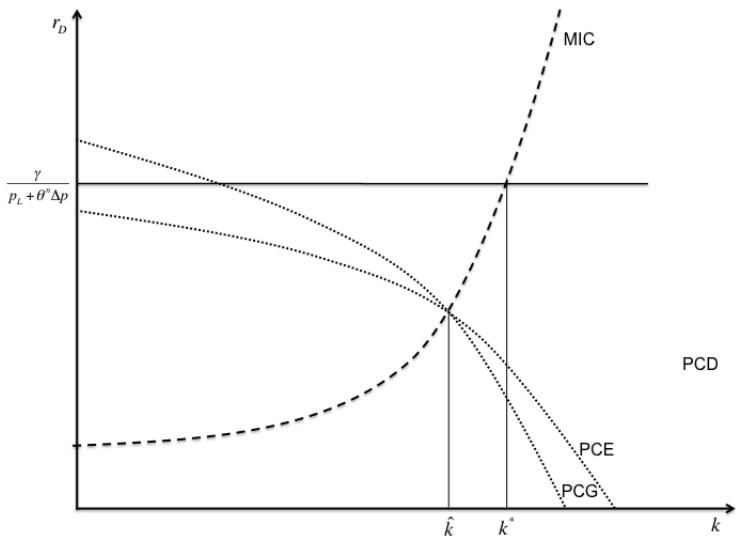
implemented in order to guarantee the existence of a national banking sector. Capital requirements that exceed this threshold can solve the moral hazard problem induced by asymmetric information, but a prohibitive high requirement $\hat{k}_e$ will violate the bank's participation constraint of non-negative profits. It follows that effective regulation is possible within the feasible set $k = \left\{k^*, \hat{k}_e\right\}$. Such a policy is welfare-superior compared to an unregulated economy: The expected output of the regulated banking sector is strictly higher. Since the transfer between the bank and the depositor is welfare-neutral, the level of the deposit rate is negligible from a regulator's point of view.

Definition 2. (Welfare) A policy is welfare-superior, if the expected output of the banking sector exceeds the cost of implementation.

One interesting corollary of the model setup is that we observe an implicit cross-subsidy for goofy banks. Efficient banks have to pay higher refinancing costs in an opaque banking sector compared to a transparent one; in contrast, goofy banks face lower refinancing costs. In other words, goofy banks free-ride on the monitoring activity of their efficient competitors. This positive externality can be interpreted as a cross-subsidy that is equal to $\left[\frac{1}{p_L+\theta\triangle p} - \frac{1}{p_L+\triangle p} > 0\right]$. It is straightforward that this has consequences for the reluctance of capital standards: If banks maximise profits, $\Pi^i = p^i \cdot (R - r_D\,(1-k)) - \rho \cdot k - m$, one can show that $\Pi^E > \Pi^G$ for any $k = \left\{k^*, \hat{k}_e\right\}$.

However, Figure 2 illustrates the second case of Lemma 1 where the natural fraction of efficient banks is too low, and the feasible set of capital requirement regulation is empty $k = \{\emptyset\}$. Capital regulation alone cannot solve the lemons market, *i.e.*, regulation cannot implement a situation where efficient banks will monitor and participate. In this case, non-relevant capital standards yield the same outcome and welfare as in an unregulated banking sector. In other words, depositors' confidence in the banking sector is so low that only a prohibitive high capital standard k^* satisfies the monitoring condition of efficient banks and the market breaks down.

Fig. 2: Intermediation region for a low pool quality



From here on, we assume the natural fraction of efficient banks is very low: without loss of generality, we assume the natural fraction to be zero. As a consequence, the regulator has to interfere and improve the quality of the banking sector. She has to make use of a second policy tool to influence financial intermediation: we call this tool supervisory effort.

2.3 The Effects of Supervision

We now introduce the alternative policy instrument used to enhance stability and foster depositors' confidence in the banking sector, which simultaneously influences the composition of efficient and goofy banks. The regulator has the possibility to spend resources on supervisory officers, watchdog institutions, and specialised equipment. Hence, the regulator may control a bank's risk taking behaviour and foster the efficiency of banks in a direct way via screening and auditing national banks, via on- and offsite examinations, or via disclosure requirements. In terms of our model, supervisory effort is assumed to affect the fraction θ in the closed economy, and thereby the absolute number of efficient banks E. Depositors will encounter this supervisory effort by adapting their beliefs of the overall market quality and, thus, the required deposit rate given that efficient banks have an incentive to monitor. However, supervision is costly and increasing in the number of supervised banks.[15]

For a given size of the banking sector, we postulate a positive relation between the fraction of efficient banks (as the output of supervision) and supervisory effort. In other words, we endogenise $\theta = \frac{E}{E+G}$ reflecting the supervisory effort e of the national regulator: $\theta(e) = f[e]$, $\theta(0) = 0$ where f is a production function for the pool quality in an economy. Given f, the more effort that is spent on running supervisory agencies and institutions to evaluate the soundness of national banks, the easier it is to discover offenses and select out goofy banks G.

We assume that the cost of supervisory effort is continuously increasing in effort, convex, and twice differentiable $c[0] = 0$, $c[e^{max}] = \infty$, $c'[0] = 0$, $c'[e] > 0$, $c''[e] > 0$. In particular, in order to keep our model simple and tractable, θ is a linear increasing function of effort such that $e = \theta$ where the cost function is equal to $c[e] = \frac{c}{2} \cdot \theta^2$. Accordingly, the better the screening ability of the regulator, the less effort is needed to raise the pool quality of banks. It is easy to show that an increase in the exogenous screening ability would reduce the costs of supervision *ceteris paribus* and, thus, the number of goofy banks in the banking sector. It follows that regulators, which face high supervisory effort cost, may allow more goofy banks. This is not because their basic motivation differs, but because their benefits and costs differ from a regulator that faces less effort cost. In other words, the efficiency of a supervisor's technology determines the composition within the national banking sector.

Thus, the introduction of supervision does not affect the *MIC* of efficient banks, but changes the composition of the banking sector, and thereby the *PCD* of depositors. This is because it alters the unconditional probability that a bank is efficient θ and all banks benefit from the more effective screening or enforcement provided by regulators because of lower deposit rates.

As a consequence, with closed economies, the rent of the domestic banking sector is greater in jurisdictions with better supervision ability, *i.e.*, lower supervisory costs $c[\theta]$. The highest rent can be achieved only when efficient banks are left in the banking sector, such that θ =1 (though this would imply prohibitively high effort cost). The source of financing of banking supervision is implicitly assumed to come directly (budget assigned by government) or indirectly (seigniorage) from taxpayers.[16] Intuitively, the size of the domestic intermediation sector is maximised if the regulator extensively engages in supervision with $c[\theta = 1]$: this leaves more profitable banks and,

[15] The intuition is that regulators have a certain capacity (manpower or time) that allows them to screen only a limited number of banks. It is straightforward that she can enhance the monitoring activities of the banks supervised, if she monitors intensively. While this would be easy for one bank, the more banks supervised, the higher the cost might be. For too many banks, it might not even be possible at all "to keep an eye" on each bank.

[16] See Masciandaro et al. (2007) for an in-depth analysis of the financing sources of banking supervision for 90 countries. They show that public financing is the most common budgetary arrangement for central banks as supervisors.

therefore, expands, the market for intermediation.

However, if the outside option of the depositor exceeds the value added from monitoring, then the beneficial effect from supervision, *i.e.,* cheaper refinancing, erodes and the banking market freezes regardless of the level of supervisory effort.

Lemma 2. *If* $\gamma > p_H\left(R - \frac{m}{\triangle p}\right)$*, supervision alone cannot solve the moral hazard problem.*

Proof. Consider the highest quality a banking sector can have, $\theta = 1$, where there are only efficient banks in the sector. The deposit rate required by depositors is $\frac{\gamma}{p_H}$ provided that the *MIC* is not violated. But with $\frac{\gamma}{p_H} > R - \frac{m}{\triangle p}$, this is not the case. Depositors foresee that efficient banks have no incentive to monitor and, therefore, require $\frac{\gamma}{p_L} > R$. Without any additional capital requirement, the market breaks down. □

Indeed, this means that the expected value of the depositors' alternative investment is more profitable than the expected return of efficient bank investments which may be an extreme case, because banking is not at all desirable. However, even if supervision alone can solve the moral hazard problem $\theta = 1$, it might not be optimal because of increasing supervision costs. Note that securing the existence of financial intermediation with supervision implies decreasing returns to scale.

After having introduced the two parameters of our model that govern the banking sector (directly to increase the number of efficient banks via supervision or indirectly via incentivising monitoring of efficient banks with capital standards), we now analyse the optimal policy mix.

2.4 The Optimal Policy Mix

The concern of the regulator is to prevent a banking crises, *i.e.,* the breakdown of financial intermediation. To reach this goal, she has to balance the cost and benefits of both policy instruments. The marginal cost of both policy instruments are exogenously given, and are driven by the characteristics of the regulator and the specific economy. However, we allow for the possibility that the regulator has a certain preference for both instruments; in other words, she weighs the rent of domestic efficient banks and the rent of the taxpayers.[17] Therefore, the regulator's objective function can be expressed as

$$\max_{\theta,k} U = \phi \cdot \Pi^E\left[\theta,\, k\right] + (1-\phi) \cdot \left(\Pi^D\left[\theta,\, k\right] - \frac{c}{2} \cdot \theta^2\right),$$

constrained by the conditions for monitoring of efficient banks (3), for the banks' participation (4), (5) and the depositors' participation constraint (6). The terms $\Pi^E\left[\theta\left[e\right],\, k\right]$ and $\Pi^D\left[\theta\left[e\right],\, k\right]$ denote the rents of efficient banks and depositors respectively and the parameter $\phi\,\epsilon\,[0,1]$ captures the weight that the regulator puts on the rent of efficient banks. Since we assume perfect competition on the deposit market, the profit of depositors is zero $\Pi^D\left[\theta\left[e\right],\, k\right] = 0$. Inserting the profit function of efficient banks, we can rewrite the utility maximisation problem, which is actually a cost minimisation problem:

$$\max_{\theta,k} U = \phi \cdot \left\{p_H \cdot \left(R - r_D\left[\theta\right] \cdot (1-k)\right) - m - \rho \cdot k\right\} - (1-\phi) \cdot \frac{c}{2} \cdot \theta^2 \tag{7}$$

s.t.

[17] Since goofy banks are inefficient we assume that the regulator does not take into account their profits.

$$
\begin{aligned}
r_D\left[\theta\right] &= \tfrac{\gamma}{p_L+\theta\triangle p},\\
k &\geq 1-\tfrac{\left(R-\frac{m}{\Delta p}\right)}{r_D},\\
k &\leq \tfrac{p_H(R-r_D)-m}{\rho-p_H r_D}\\
0 \leq k \leq 1,\ 0 &\leq \theta \leq 1,
\end{aligned}
$$

where $r_D\left[\theta\right]$ labels the deposit refinancing cost. The regulator now maximises welfare U and decides how to establish financial intermediation with the most cost efficient usage of her two tools capital standards k and supervisory effort θ. Partial derivation yields:

$$\frac{\partial U}{\partial k} = \left[\phi \cdot \left\{p_H \cdot r_D\left[\theta\right] - \rho\right\} < 0 \mid \rho > \frac{p_H}{p_L}\gamma\right],$$

$$\frac{\partial U}{\partial \theta} = -\phi p_H \frac{\partial r_D\left[\theta\right]}{\partial \theta}(1-k) - (1-\phi)\cdot c \cdot \theta.$$

The first derivative with respect to k is always negative for $\rho > \frac{p_H}{p_L}\gamma$: capital is comparatively costly by assumption for any feasible level of the deposit rate.

The regulator chooses the lowest feasible capital requirement and the *MIC* (3) becomes binding for any $\phi > 0$. Substituting (3) into $\frac{\partial U}{\partial \theta}$ yields

$$\frac{\partial U}{\partial \theta} = \phi p_H \left(\frac{R\cdot\Delta p - m}{p_L + \theta\triangle p}\right) - (1-\phi)\cdot c\cdot\theta.$$

Indeed, the chosen policy affects the rents of two interest groups, the banking industry and the taxpayers, who are assumed to have opposite interests regarding the policy. Tighter capital standards in an opaque banking sector reduce the profitability of banks, for example, by restricting the investment policy of banks, stifling innovation, or by preventing banks from expanding their activities. This can be regarded as the banking sector's direct regulatory burden consisting of opportunity costs for the banking sector or alternatively, as the forgone benefits from financial intermediation to depositors. Thus, banks have an incentive to minimise the capital standard and lobby for supervisory effort, thereby shifting the cost burden of regulatory intervention implicitly to taxpayers. On the other hand, taxpayers have the interest to maintain national financial stability via setting high capital requirements, since banks would ultimately bear the cost burden. Intuitively, the composition of both policy tools determines a rent shifting between taxpayers and banks.

Consider first the case where efficient banks receive no weight in the regulator's welfare function ($\phi = 0$). Since $\frac{\partial U}{\partial k} = 0$, $\frac{\partial U}{\partial e} < 0$, we know that the *MIC* determines the necessary supervisory effort. If the participation constraint never becomes binding before the monitoring incentive constraint, *i.e.*, $\rho < \frac{p_L\cdot m}{\Delta p}$, the regulator will just set $k = 1$ and save any effort on supervision with $\theta = 0$. However, with $k = 1$ the bank would lose its function as a financial intermediary and this trivial solution seems to be rather unconvincing. If equity capital is costly, *i.e.*, $\rho > \frac{p_L\cdot m}{\Delta p}$, then the regulator has to spend a minimum supervisory effort in order to secure the existence of financial intermediation, *i.e.*, the *MIC* and the *PCE* become binding. The regulator sets a capital requirement $\hat{k} = \frac{p_L}{\Delta p}\cdot\frac{m}{\rho}$ and spends supervisory effort just to allow *PCD=MIC=PCE, i.e.*, increasing the average bank quality just to the amount where the minimum deposit rate required by depositors equals the break even deposit interest rate up to $\theta = \frac{\gamma\cdot(1-\hat{k})}{\triangle pR-m} - \frac{p_L}{\triangle p}$.

We now consider the more relevant case where the regulator also takes the profits of efficient

banks into account.[18] A possible capture of the regulator by the banking industry can be motivated by a rich literature of empirical studies; *e.g.*, Colburn and Hudgins (1996) provide evidence that the voting behaviour of the House of Representatives in the 1980s was influenced by the interests of the thrift industry, or more recently, Igan et al. (2011) found that financial institutions that succeeded in lobbying on mortgage lending and laxity in securitization issues adopted riskier investment strategies and thereby contributed directly to the recent financial crisis.

If the profitability of banks influences the regulator's decision, then there arises a trade-off between spending more costly effort on supervision and allowing banks to yield higher profits. Intuitively, a policy-maker that gives more weight to efficient bank margins will vote for lower capital ratios, and *vice versa.* Such a regulator would balance the weighted marginal cost of supervision with the weighted marginal cost of higher capital requirements for the banks.

The regulator's optimal mix of capital requirements and effort spending on supervision depends on her marginal rates of substitution to the corresponding relative prices, *i.e.*, costs. Using (9) we can generally characterise her decision with the following Proposition.

Proposition 1. *For* $\phi \in \left[0, \frac{c_i}{R\Delta p - m + c_i}\right]$*, there exists a unique optimal pair of* k^* *and* $\theta^* \in [0,1]$ *that maximises regulator's utility.*

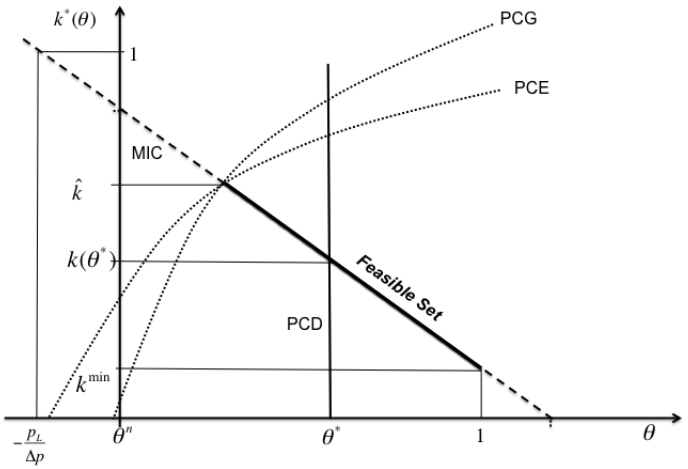
Proof. If (4) and (5) are non-binding, and effort costs are sufficiently high, *i.e.,* if $c > \frac{\phi}{(1-\phi)}\left(R \cdot \Delta p - m\right)$, there exists a unique interior solution. For a given level of effort cost, the first order condition implicitly defines the optimal supervisory level θ^* and capital standard $k\left[\theta^*\right]$. The detailed analysis can be found in Appendix A. □

The intuition for Proposition 1 comes from the fact that supervising banks reduces the number of goofy banks, and thereby the required interest rate in the domestic deposit market. The bank's incentive to monitor projects increases, and capital requirements can be reduced; optimal regulatory capital standards decrease with the number of efficient banks in an economy. The higher the fraction of efficient banks, the smaller the capital standard that is needed to maintain depositing in a banking sector: $\frac{dk^*}{d\theta} = -\frac{1}{\gamma}\left(R \cdot \Delta p - m\right) < 0$ (see Figure 3). A regulator will balance the weighted profitability of efficient banks with the marginal costs of supervision and select an optimal level of enforcement e^* that translates into a specific θ. Thus, if $k(\theta^*) < \hat{k}(\theta^*)$, then the regulator chooses an optimal supervisory effort that trades off the higher marginal effort cost with the lower marginal cost of capital requirements (and lower levels of financial intermediation).

Figure 3 illustrates the decision problem of the regulator by plotting the optimal capital standard and supervisory effort in a $k^* - \theta-$diagram. While the downward sloping curve graphs the MIC function, the upward sloping lines capture the participation constraints of the banks and the vertical line the participation constraint of depositors. The figure shows how the optimal choice of supervisory effort determines the optimal level of capital requirement constrained by the *PCs* and given that θ and k are proportions, *i.e.*, limited to the interval $[0,1]$. From Lemma 2, we know that for a prohibitively high outside option of depositors or monitoring costs, the effort spent on supervision alone cannot solve the moral hazard problem. Hence, the regulator still needs to set a capital requirement $k = k^{min}$ in order to ensure that efficient banks monitor and financial intermediation actually takes place. On the other hand, Lemma 1 tells us that capital requirement regulation alone cannot solve the adverse selection problem if the required capital requirement is

[18] A special case of the analysis, $\phi = 0,5$, will give us the social welfare function. This can be reinterpreted as a situation where the banking sector "regulates" itself by credibly agreeing on minimum capital ratios and bears the cost for spending effort on peer monitoring.

Fig. 3: The feasible regulatory set



above the capital requirement that ensures that banks break even, *i.e.*, $k(\theta^n) > \hat{k}$. Therefore, the regulator must spend a minimum supervisory effort such that financial intermediation takes place in equilibrium. The point of intersection between the optimal supervisory effort and the *MIC* is the regulator's optimum if their exists an interior solution. We see that from the standpoint of the regulator, capital standards and supervision are substitutes. The optimal capital ratio that maximises the regulator's utility depends on her supervisory efficiency and on the parameters of the domestic banking industry. The following table shortly summarises the comparative statics.

	θ	c	ρ	m	$\triangle p$
k^*	-	+	-	+	-

A jurisdiction in which a high effort on supervisory enforcement is spent has lower optimal capital requirements. However, it is optimal to have stricter capital regulation the less efficient a regulator is in controlling the quality of the banking sector, whereby a regulator's ability in efficient supervision is reflected by the marginal costs of supervision. Thus, lower cost efficiency in supervisory effort leads to higher optimal capital requirements.

As long as the regulator cares for the profit of efficient banks, increased cost of capital will reduce the optimal capital requirement and increase the optimal effort spent on the banking sector's quality. Higher monitoring cost decreases the profit of efficient banks which lowers the optimal effort level, thereby increasing the optimal capital requirement. Moreover, the *MIC* becomes more likely to be binding as well as the participation constraint of efficient banks. The more value added by monitoring, the more likely the *MIC* holds. In terms of our model, higher profits justify lower capital requirements.

To summarise the main findings in this section, our model suggests that there are two ways to induce more stability into the domestic banking sector: one is the introduction of minimum capital requirements that reduces banks' margins so that the banking sector shrinks with increasing capital ratios. The other is to spend effort on sophisticated supervision in order to improve the efficiency of the banks in the market. We obtained a lower bound for the cost of banking regulation based on the minimal rents necessary to implement both stability and the existence of the banking sector.

Our analysis shows that cost minimisation problem of the regulator requires two things: making monitoring profitable via capital standards (this ensures the existence of the pie we call a banking sector that is to be divided among depositors and banks), and assuring that no participation constraint is violated (minimising the costs, and thereby maximising the size of the pie). We show that for any domestic regulator, the optimal combination of both instruments that maximises domestic utility to the constraint that financial intermediation takes place, depends on her marginal rates of substitution to the corresponding relative costs where the first term is related to the weight the regulator puts on the rent of each interest group. Therefore, the regulator implicitly creates rents by selecting a policy mix of capital regulation and supervisory effort that deviates from the weighting of a benevolent social planner (*i.e.*, $\phi = 0,5$) .

In the following section, we now investigate the role of institutional competition between regulators on the optimal bundle of policy tools.

3 Optimal Regulation with International Spillovers

The essence of international competition is that the integration of national markets changes the allocation of banks, and consequently the economic environment for optimal national policies. The institutional framework determines the factors of production for banks. Thus, the following section analyses a regulator's optimal reply to the globalisation of banking markets, explicitly taking into account international spillovers. We discuss the conditions under which systems competition will work properly to improve global stability. In other words, we address the question, when does the invisible hand of institutional competition fail such that there is a need for collective action, *i.e.*, harmonisation of banking regulation à la Basel?

We argue that the effect of systems competition crucially depends on the information structure and observability of differences in national regulation in the banking sector. If depositors can fully monitor country-specific regulatory regimes, and they are able to differentiate via adjusted interest rates, jurisdictions evolve into a "club" supplying a regulatory framework for banks.[19] On the other hand, if depositors cannot distinguish between different national regulatory regimes, regulation becomes a lemons good and systems competition will bring about the same kind of market failure that justified regulatory intervention in the first place: a deregulation race occurs.

Two Heterogenous Countries

In order to discuss regulatory competition, consider two countries $i \in [A, B]$ with $\phi \in \left[0, \frac{c_i}{R\Delta p - m + c_i}\right]$ that are linked through bank mobility. With the home country principle in regulating foreign banks and two symmetric banking sectors, we allow banks to finance projects abroad. However, we assume that the regulator in each country differs with respect to her supervisory efficiency. More specifically, consider country A with effort cost c_A and country B with effort cost c_B where $c_A < c_B$ without loss of generality. *Ceteris paribus*, the ex-ante level of effort, and the resulting share of monitoring banks is $\theta_A^* > \theta_B^*$, and the respective optimal national capital ratios set by the domestic regulator are $k_A^*(\theta_A^*) < k_B^*(\theta_B^*)$. Note that even though country B has a higher observable capital requirement, the quality of the banking sector is lower, which results in a lower average rate of success. As argued above, a less cost efficient supervisor will compensate her low quality with higher capital

[19] The idea that a country can usefully be described as a club that organises the production of club goods goes back to Charles Tiebout (1956). Accordingly we argue that a regulatory product like banking regulation is characterised for depositors by immobility, rivalry in use and the possibility of exclusion for outsiders.

requirements. Intuitively, the better the quality of the banking sector, the less capital requirement is needed to discipline the banks.

Facing the possibility to move, banks compare their expected profits from staying in their home country and moving to the foreign jurisdiction. When moving implies switching cost ν, a bank of type $i \in [E, G]$, that is settled in country B, will move whenever $\Pi^i(A) - \nu > \Pi^i(B)$.

3.1 The Club-view: Observable Supervision in Competing Jurisdictions

In this subsection we assume complete information for all market participants regarding the quality and costs of banking supervision. Consequently, depositors adjust the deposit rates to the average bank quality of the national banking sector and there are additional incentives for banks to move abroad. Facing lower capital requirements in the foreign country, banks that are able to move to another jurisdiction have an incentive to choose the jurisdiction that allows for the highest profits. A potential entrant will now choose his regulatory environment by trading-off the benefits and costs of foreign certification.

Since efficient banks are able to generate higher marginal profits than goofy banks, their rent from moving to the more efficient country is greater compared to the rent for goofy banks.[20]

Facing, lower capital requirements and more favourable deposit refunding rates, banks in country B have an incentive to either move to country A or at least to refund in country A. Intuitively, the first decision can be seen as opening a subsidiary, the second as opening a branch. Subsidiaries are separate entities from their parent banks, and are subject to the regulation of the host country, whereas branches are subject to the regulation of their parental bank.[21]

On the one hand, deposit rates in country A are lower than in country B so banks have an incentive to move from B to A. On the other hand, opening a subsidiary in a foreign country involves higher switching costs compared to opening a branch. Let us denote the cost for moving from one country to the other (founding a subsidiary) as ν_M and the cost of staying in the home country, but raising funds abroad, as ν_R. We assume that $\nu_M > \nu_R$, *i.e.*, the cost of moving into the foreign country and regulated under this jurisdiction involves higher switching costs than simply raising funds abroad and staying regulated in the home country. Depending on the specific level of switching costs, different scenarios arise. Figure 4 summarises the results.[22]

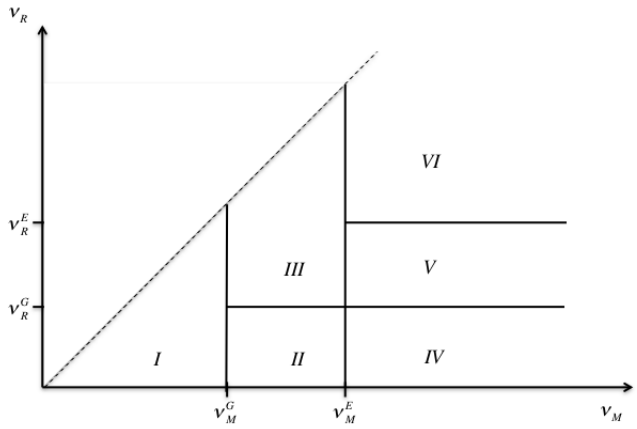
Consider first, the case I where overall switching costs are very low $\nu_R < \nu_R^G$ and $\nu_M < \nu_M^G$, *i.e.*, it is profitable for both efficient and goofy banks to move from country B to country A. In this case, the banking sector in country B disappears, while the banking sector in country A consists of two pools. However, the overall quality of the banking sector in country A is lower than before. If depositors observe this decrease in banking pool quality, they will require a higher deposit rate compared to autarky. For a given capital requirement in country A, a higher deposit rate will result in less monitoring incentives of efficient banks. In order to preserve the financial sector, the regulator in country A must either increase capital requirements or spend higher effort on supervision. With convex effort cost, the marginal increase in supervision becomes more costly. Hence, compared to autarky, the regulator in country A will gradually increase the capital requirement compared to the effort of supervision. Accordingly, case I implies a deviation from the optimum in autarky, resulting in a lower overall pool quality and a higher probability of a banking crisis.

[20] The sufficient condition for $\Delta\Pi^E > \Delta\Pi^G$ is $\Delta p \cdot R - m > 0$; in other words, marginal profits should exceed the monitoring cost.

[21] Cerruti et.al. (2007) find that regulatory variables have non-marginal effects on the form of foreign bank entry. They conclude that governments can design regulations to favour one structure over another.

[22] The derivation of the switching cost thresholds can be found in Appendix B.

Fig. 4: The jurisdiction choice of mobile banks with perfect observability



In situation II, where $\nu_R < \nu_R^G$ and $\nu_M^G < \nu_M < \nu_M^E$, only efficient banks have an incentive to move to the more efficient jurisdiction, while goofy banks remain in country B trying to borrow from depositors in country A. The effects in this case are similar to case I: financial intermediation in jurisdiction B breaks down, depositors in country A demand higher deposit rates, and the regulator in country A has to adapt the optimal policy mix.

Now, we consider the case III of sufficiently high switching costs, *i.e.*, $\nu_R^G < \nu_R < \nu_R^E$ and $\nu_M^G < \nu_M < \nu_M^E$. Now, only efficient banks in country B find it profitable to move to and borrow from jurisdiction A. In this case the pool size and quality of country A increases to $E_A + E_B + G_A$, while country B is left with G_A. If depositors can observe this change in the pool of banks in each jurisdiction, they would adapt to lower interest rates in country A due to the enhanced pool quality, while financial intermediation would collapse in country B. Since countries optimally set their capital requirement at the minimum, such that the MIC holds, country B cannot further increase its capital requirement rate to compensate the risk of depositors. The only possible reaction is to increase effort in supervision which is associated with additional costs for taxpayers in jurisdiction B.

In case IV, no bank has an incentive to move, but both bank types try to borrow in country A. While the pool quality in country A worsens, the financial sector increases. An increased deposit rate demanded by depositors decreases the monitoring incentives of efficient banks in A, while efficient banks in B still face the high capital requirements and monitor. Hence, in this case, a relatively small (compared to case I) increase in capital requirements as a reaction to the decreased pool quality prevents the banking sector from a crisis.

Case V describes a situation where only efficient banks try to borrow in the more efficient jurisdiction. In this case, the more efficient jurisdiction exclusively benefits from an increase in pool quality and size. The case VI describes autarky.

Thus, if depositors anticipate the migration of banks, and can adjust their country-specific interest rate, we can derive the following result regarding national rents in the non-cooperative equilibrium:

Proposition 2. *For a given regulatory policy $[k^*, \theta^*]$ in autarky, the more efficient the domestic supervision, the higher is the expected volume of deposits.*

a) If banks are completely mobile, the probability of a banking crisis in the efficient country increases (inefficient club competition).

b) If there are sufficiently high frictions to banking mobility, the probability of a banking crisis in the more efficient jurisdiction decreases (efficient club competition).

Interestingly, in our framework banks' mobility seeds a banking crisis. Sufficiently low switching cost yield the standard result where the banking sector in the less efficient country B always breaks down. However, even in the absence of systemic spillovers on the competing economy A, the movement of banks implies negative externalities on the regulatory policy in A and changes the redistribution.

In order to see how the outcome of regulatory competition affects the rents of the two interest groups, we need to analyse how the optimal policy mix changes. Compared to autarky the optimal minimum capital ratio in country A that prevents a banking crisis is increasing in the mobility of banks. Intuitively, a lower ν_M improves financial intermediation in A, but lowers the pool quality as long as $\nu_R < \nu_R^G$, increasing the minimum capital regulation that is required to secure financial intermediation. Thus, the rent of the banking sector will shrink as a result of low switching costs whereas the rent of taxpayers remains constant. Therefore, with lower switching cost club competition tends to decrease domestic welfare in both jurisdictions. However, financial intermediation concentrates in the country that spends more supervisory effort.[23]

3.2 International Deposit Rates: Unobservable Supervision in Competing Jurisdictions

Now, we assume that asymmetric information makes it hard for depositors to distinguish good regulatory systems from bad ones. The reason is that it is difficult for them to interpret national banking laws in foreign languages which may act in accordance with unwritten cultural habits and which may differ in the degree of strictness with which they implement the rules. Depositors can be expected to have an information deficit and, consequently, may demand a fixed interest rate independently from the bank's localisation.[24]

Since individual jurisdictions are not distinguishable and depositors lend their endowments with any bank without knowing the characteristics of its home jurisdiction, we assume the international deposit rate to be $r_D\left[\theta_A^*\right] < \bar{r_D} < r_D\left[\theta_B^*\right]$.

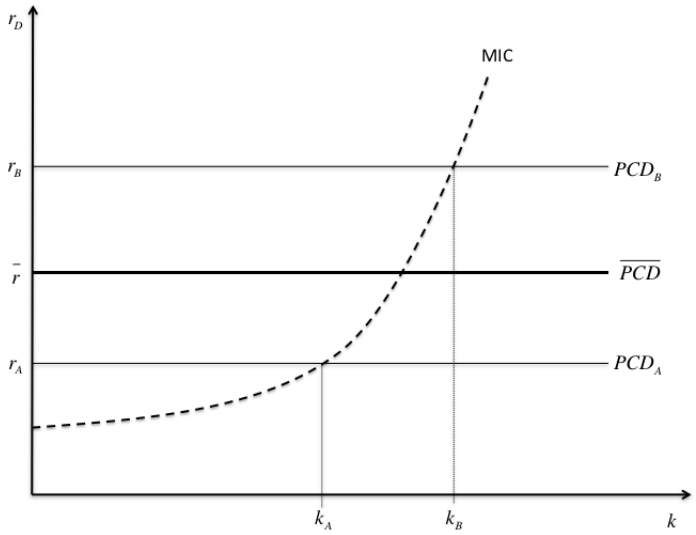
When banks can borrow from a pooled deposit market, but are regulated with $k_A^*(\theta_A^*) < k_B^*(\theta_B^*)$, this distorts the incentive in both countries. In country B, banks benefit from the lower overall lending rate. However, in country A, a higher deposit rate will prevent the efficient banks from monitoring, *i.e.*, $k_A^*(\theta_A^*)$ is too low to satisfy the monitoring incentive constraint.

Due to the lower capital requirement rate in country A, both types of banks migrate to A. However, since both jurisdictions are faced with the same international deposit rate there is no incentive for borrowing in the more efficient jurisdiction. Hence, only the scenarios of low and high switching costs are relevant.

[23] This effect is similar to the effect analysed in Huddart et. al. (1999). When agents hold private information on their specific type, enabling them to choose their preferred jurisdiction makes them revealing their type (here if switching costs are high only good banks can move). Therefore the good type agents prefers to move to the more efficient market.

[24] In other words, in this subsection, regulation is assumed to be a lemons good and depositors can only observe the average supervisory effort and capital regulation of national regulators. The assumption of regulatory policy being a lemons good is not new in economic literature. Sinn (1997) argues that governments only intervene in private markets if the invisible hand fails (selection principle); accordingly, he shows that a reintroduction of a market through the backdoor of systems competition does not work.

Fig. 5: International deposit rates



If switching costs are sufficiently low, both bank types have an incentive to move to the jurisdiction with lower capital requirements. The size of the financial sector in A increases. However, with low capital requirements, but relatively high deposit rates, efficient banks have no incentive to monitor in A.

The situation is similar to the case of high switching costs, where only efficient banks have an incentive to move to country A. By doing so, they face a capital requirement that is too low to compensate them for monitoring. In any case, the regulator in country A is faced with a growing financial sector that does not monitor. In order to prevent a banking crisis, she has to increase capital requirements. However, the crux of the argument is that the regulator does not benefit from an increase in capital requirements since depositors do not punish non-monitoring efficient banks.

Proposition 3. *With unobservable supervision, there is a race to the bottom in capital standards.*

Proof. Country B observes an outflow of her banks. If switching costs are low, the whole banking sector disappears. Otherwise, goofy banks remain in country B. However, with an international deposit rate, the reduced banking sector in country B does not break down due to the low pool quality. A regulator caring for the existence of a domestic banking sector will decrease the capital ratio in order to prevent the outflow of domestic banks. It is straightforward to see that the dominant strategy in this institutional battle is to slightly decrease the capital ratio offered by the other jurisdiction. □

The undersupply of banking regulation appears to be the non-cooperative equilibrium. In equilibrium, the deposit market rate pins down to $r_D = R - \frac{m}{\triangle p}$ where the capital standard is equal to zero.[25] This can be translated into a minimum fraction of efficient banks θ' that ensures depositing even with $k = 0$. Thus, the profitability of banks will increase as a result of the *race to the bottom* and regulators are forced to intensify their supervisory effort to guarantee the existence

[25] In fact, most recently Houston et al. (2012) provide empirical evidence that supports the lemons-result, where banks transfer funds to financial markets with fewer regulation. In order to avoid costly regulation, their study indicates that bank flows are positively related to the stringency of capital regulation imposed on banks in their source country, and negatively related to regulations in the recipient country. However, these effects are stronger if the recipient country is a developed country with strong property and creditor rights, which is also in line with our model prediction.

of domestic banking, which is financed by the taxpayer. Accordingly, if domestic banking policy is not observable, the regulatory cost burden is shifted to the taxpayer.

However, the regulator of country A has to increase the capital requirements to guarantee the monitoring of efficient banks. While country B has an incentive to decrease capital requirements until both countries have equal capital requirements. International harmonisation of capital requirements is desirable for both countries. But with higher capital requirements the regulator in A has less incentives to spend costly effort on supervision, while country B does not need to increase its effort in supervision in the pooled banking world. In other words, the more efficient producer of bank quality spends less effort and hence, the overall stability might decrease compared to the situation of isolated countries.

In general, we can derive that, due to the pooling of deposit rates, regulators have an incentive to shirk, while banks will not monitor. This creates an unstable global economy, where depositors overestimate the average expected repayment. When depositors update their beliefs, the global banking system faces a banking crisis. Again, with cross-border banking both countries will lose in welfare terms compared to the case of autarky. But the jurisdiction with the lowest supervisory costs is expected to be the relative winner of such a regulatory race to the bottom.

The question we posed in this section was whether regulatory competition can avoid the existence of a lemons equilibrium at lower costs by mitigating the efficient banks' moral hazard problem. We have seen that, with open economies, the political equilibrium is no longer the only result of an analysis of the marginal rates of substitution between the costs of supervision and capital requirements. Instead, it reflects the strategic interaction with other jurisdictions in regulatory competition where observable capital ratios become a strategic weapon in the battle for attracting banks. The intuition is that banks seek the most lenient of all possible regulators. In this respect, systems competition turned out to be counterproductive depending on the opacity of international financial markets. Optimal strategic choices of domestic regulators are rooted in the degree of observability of differences in country-specific regimes for depositors. If observability is sufficiently low, domestic capital ratios cannot send any price signals to investors and cannot reward efficient banks in better regulated economies with cheaper refinancing.

It is plausible that both jurisdictions have an incentive to cooperate in order to ensure the lowest combination of capital ratios and supervisory effort that is necessary to maintain global banking. Thus, regulators demand for collective actions in order to govern the global banking sector. This provides an impetus for coordinating capital ratios and striving towards an international standard on banking capital adequacy, which is what we will turn to in the next subsection.[26]

However, the harmonisation of capital requirements without the explicit contracting of minimum supervision, reduces the incentives of efficient regulators to spend high supervisory effort. In fact, any minimum capital requirement regulation above the capital requirement will lead to supervisory effort below the individually optimal level. Hence, our model predicts that in the case of the harmonisation of capital requirement regulation, the most efficient regulator will spend lower supervisory effort implying a rent-shifting between banks and taxpayers.

[26] Indeed, some authors argue that the genesis of the Basel Accords may support the idea of such a destructive regulatory race (see Kapstein 1991). In the 1980s, it was said that raising the capital requirements for US banks would negatively affect their international competitiveness unless foreign banks were forced to recapitalise in a similar fashion. In the light of the Mexican crisis in 1982, this provided the impetus for US authorities to push for an international agreement on capital ratios and the Basel Committee on Banking Supervision quickly emerged as the ideal forum to achieve this.

3.3 Incentives for Policy Coordination

With a loss in utility due to decreasing switching costs for mobile banks, national regulators are faced with a collective action problem and have an incentive to cooperate independently whether there is a club competition or international deposit rates. The reduction in regulator's utility comes from the uncoordinated behaviour of competing jurisdictions. If all regulators could agree on the same level of capital standards, there would be no utility-reducing bank flight. Thus, our model explains a strong demand for harmonising activity of self-interested regulators. Such international coordination can be interpreted as an act of collusion among policy-makers. By removing utility-reducing institutional competition, regulators would be able to reduce the cost of financial stability.

The following Proposition gives the necessary and sufficient condition for a level of harmonised capital standards k^H and supervision cost c^H that simultaneously ensures the existence of a stable banking sector in both countries.

Proposition 4. *Harmonised capital standards c^H are self-enforceable if and only if:*

- $c^H \in (0, \tilde{c}]$, where $\tilde{c} = c\left[\theta'\right] + U\left[k'\right] - U\left[k^H\right]$;
- $k^H \in \left[k_A\left[\theta\right], k_B\left[\theta\right]\right]$ where $k_A\left[\theta\right]$ and $k_B\left[\theta\right]$ are the solution of the following programs:
  $k_A\left[\theta\right] = \arg\max U_A$ such that $U_A\left[k^H, c^H\left[\theta^H\right]\right] - U_A\left[k', c\left[\theta'\right]\right] \geq 0$,
  $k_B\left[\theta\right] = \arg\max U_B$ such that $U_B\left[k^H, c^H\left[\theta^H\right]\right] - U_B\left[k', c\left[\theta'\right]\right] \geq 0$.

We say that both jurisdictions will agree on a common capital standard if the supervision costs for the supranational capital adequacy lie within the interval $c^H \in (0,\ c\left[\theta'\right] + U\left[k'\right] - U\left[k^H\right]]$ making harmonisation profitable compared to the non-cooperative equilibrium with $U_i\left[k', c\left[\theta'\right]\right]$. It follows that, for any $c^H \in (0, \tilde{c}]$, there exists a subset of self-encorceable agreements of size $(k_A - k_B)$. In other words, we say that a policy cartel can be welfare-superior even if supervision cost c^H will increase for all participating jurisdictions that harmonise their capital requirements.

However, in the literature it is argued that there are network benefits of harmonisation for national regulators which decrease the cost of supervision. The intuition for this argument is straightforward: these benefits roughly capture four elements discussed in Tarullo (2008). First, international harmonisation in the sense of Basel provides reassurance to all members, that the banking system of all other member countries is sufficiently capitalised, and is stable and sound with a low probability to trigger an international financial crisis. Second, there is the benefit of bringing into line the competitive framework in all participating countries. Third, Tarullo mentions that international harmonisation fosters the implementability and efficiency of supervision of internationally active banks. Finally, there are direct benefits for internationally active banks themselves, facing one harmonised capital requirement instead of different regulations in each country they are active. Thus, supranational standards fosters the implementability and efficiency of supervision by providing reassurance that the banking system of all other member countries is sufficiently stable with a low probability to trigger an international financial crisis (reputation building).[27]

Therefore, if network benefits reduce the cost of supervision such that $c^H(e) \leq c(e) \forall e \in [0, e^{max}]$, it is easy to see that international convergence of capital adequacy is desirable even with heterogenous countries. Thus, the provided welfare-theoretic argument for international agreements is enforced in the presence of network benefits. With institutional competition, national regulators are better off by harmonising their capital requirements.

[27] Following Schüler and Heinemann (2005) who find clear evidence for the existence of economies of scale in banking supervision of financial markets in Europe, one can incorporate this cost-saving effect of regulatory unions in our model by a downward shift of the cost function in supervision.

4 Conclusion and Discussion

We have built a simple framework to jointly discuss the stability and welfare implications of capital standards and supervisory enforcement in the context of international regulatory competition. In our model, banking regulators seek to prevent a banking crisis. Direct forms of regulation (supervision) enhances the abilities of banks to control risk whereby indirect regulation via capital requirements establishes incentives that elicit socially desired monitoring activity by banks. Thus, both regulatory instruments reduce the banking sector's vulnerability to a crisis. However, each instrument imposes cost on different interest groups. The opportunity cost of capital regulation is borne by the banking sector, while the cost of supervision is burdened by the taxpayer. We show that in a closed economy, there exists a unique optimal policy mix, that outweighs the cost and benefits of each instrument.

The model presented here could be easily extended to a two-period setting where in the first stage both interest groups contest for the weighting factor for their rent in the regulator's objective function. Incorporating an endogenous motive for ϕ in the spirit of Becker's (1983) well-known pressure group-model would shed some light on the relationship between the chosen policy mix and other policy variables like the distribution and organisation among the affected interest groups in an economy.

Second, we discuss the consequences of differences in individual optimal policy mixes in an integrated financial world. We distinguish between the two cases of fully observable regulatory effort and capital requirements and internationally harmonised deposit rates, where individual characteristics of countries cannot be observed. In the first case, we show that international financial integration increases the financial sector of a country that is more efficient in supervision, while the relatively inefficient country's banking sector shrinks. However, if banks are fully mobile, this may increase the probability of a banking crisis in the efficient country, and, therefore reduce the stability of the global banking system.

In an opaque world, where supervisory effort cannot be observed for each country, we find that the moral hazard problem of banks cannot be solved. Moreover, regulators may have an incentive to reduce capital requirements in order to free ride on an international deposit rate. The free movement of banks even worsens the situation. While depositors can only observe the average quality of international banking sectors, banks move to the countries with lowest capital requirements. The result is an unstable global banking sector, where depositors believe that the banking sector is safer than it actually is. If depositors update their beliefs, a global banking crisis arises. These negative spillovers are the more serious, the higher the differences among countries.

We gain similar effects if we allow for heterogeneity with respect to the weighting of the rent of the banking sector between both jurisdictions, *i.e.,* in the capturing of a regulator. Suppose both countries are identical with regards to supervisory efficiency ($c_A[\theta_i] = c_B[\theta_i]$). Let k^* be an interior equilibrium in case of autarky. For this equilibrium, it holds that $k_A^* < k_B^*$ if $\phi_A > \phi_B$. Intuitively, country B values capital regulation more highly than country A, but its costs with regards to its equity costs and opportunity costs, in terms of supervision, are the same. As we have shown above, a higher preference for capital requirements is a stigma in regulatory competition resulting in a loss in welfare if we allow for banks' mobility. An obvious implication of this re-interpretation of different regulatory bliss points in capital ratios is that institutional competition will decrease stability matters when the differential of the regulator's weighting for domestic banks in autarky is sufficiently high between the competing jurisdictions. The larger the differential $[\phi_A - \phi_B]$, the more likely that competition among regulators has a role to play in destabilising the financial sector;

or to put it differently, the laxity in capital standards by only one captured banking regulator makes regulatory harmonisation more likely to be needed in order to prevent a banking crisis.

One solution to the negative effects of free bank movement is an agreement on international capital requirement standards that prevents a regulatory race with other jurisdictions. However, our results suggest that a supranational minimum capital requirement regulation as in the Basel III Accord might give the incentive to the most efficient supervisors to spend less effort in supervision, thereby, missing an important input factor of financial stability. The inefficiency arises from the unobservability and non-contractibility of supervisory standards leading to a destabilising race to the bottom. If countries are not homogenous with respect to their supervisory efficiency or degree of capturing, any international capital requirement standard that neglects supervisory efforts leaves room for free-riding and, therefore, might even destabilise the global financial sector. Thus, our results suggest that the implementation of binding minimum supervisory standards are required in order to secure financial stability.

A Appendix: Proof of Proposition 1

The regulator can stabilise the opaque banking sector via a production function with two input factors. Both capital standards k and supervision e combat market inefficiencies caused by goofy banks. Thus, the regulator takes only into account the rent of efficient banks with a weighting factor ϕ, conditional on their incentive-constraint and the participation-constraint of depositors.

Assume that θ is a linear increasing function of effort; thus, effort can be simplified to $e = \theta$, $c(e) = \frac{c}{2} \cdot \theta^2$. The maximisation problem of the regulator can be written as

$$\max_{e,k} U = \phi \cdot (p_H (R - r_D [\theta] (1 - k)) - m - \rho \cdot k) - (1 - \phi) \cdot \tfrac{c}{2} \cdot \theta^2$$

s.t.

$$\begin{gathered} r_D [\theta] = \tfrac{\gamma}{p_L + \theta \triangle p}, \\ k \geq 1 - \tfrac{\left(R - \frac{m}{\triangle p}\right)}{r_D}, \\ k \leq \tfrac{p_H (R - r_D) - m}{\rho - p_H \cdot r_D} \\ 0 \leq k \leq 1,\, 0 \leq \theta \leq 1. \end{gathered}$$

The first optimality condition with respect to the capital standard is

$$\frac{\partial U}{\partial k} = \left[\phi \cdot \{ p_H \cdot r_D [\theta] - \rho \} < 0 \mid \rho > \frac{p_H}{p_L} \gamma \right],$$

The first term captures the marginal benefit of an increase in capital standards resulting from decreasing cost of deposits (decreasing refinancing rate and decreasing amount of deposits), while the second term ρ is simply the marginal cost of capital. Since equity funding is assumed to be costly, the marginal benefit of lower deposit costs never outweighs the marginal cost. Therefore, the second constraint is binding - the regulator tries to reduce costly capital requirements to a minimum and just requires banks to refund their investments with a minimum requirement that secures that the monitoring incentive constraint holds.

The optimality condition with respect to supervisory effort is

$$\frac{\partial U}{\partial \theta} = -\phi p_H \frac{\partial r_D [\theta]}{\partial \theta} (1 - k) - (1 - \phi) \cdot c \cdot \theta.$$

$$= \phi \left(\frac{p_H \Delta p \cdot \gamma(1-k)}{(p_L + \theta \triangle p)^2} \right) - (1-\phi) \cdot c \cdot \theta$$

$$= \phi \left(\frac{p_H \Delta p \cdot r_D[\theta] \cdot (1-k)}{(p_L + \theta \triangle p)} \right) - (1-\phi) \cdot c \cdot \theta$$

The first two terms capture the benefits of increased enforcement: the former reflects the induced rise of efficient banks' rent (marginal increase of the number of efficient banks in the pool of the domestic banking sector multiplied with their expected profit), the latter describes the cost-savings of refinancing as a consequence of a higher fraction of efficient banks. Thus, more supervisory effort - a better pool quality - will always improve the profitability of efficient banks. Comparing the increase in marginal profits (weighted with ϕ) with the marginal costs of supervision, the regulators selects an optimal level of enforcement. If the regulator would not take into account the profits at all, ($\phi = 0$), optimal effort spent is zero.

If the participation constraint of banks is non-binding, there exists a unique interior solution for the optimal level of supervisory effort if effort costs are sufficiently high. Using the binding monitoring constraint $1 - k = \frac{\left(R - \frac{m}{\Delta p}\right)}{r_D[\theta]}$, gives:

$$\frac{\partial U}{\partial \theta} = \phi p_H \left(\frac{R \cdot \Delta p - m}{p_L + \theta \triangle p} \right) - (1-\phi) \cdot c \cdot \theta.$$

We define $A_1(\theta) = \phi p_H \left(\frac{R \cdot \Delta p - m}{p_L + \theta \triangle p} \right)$ and $A_2(\theta) = (1-\phi) \cdot c \cdot \theta$. Without any efficient banks $A_1(0) = \phi \frac{p_H}{p_L} (R \cdot \Delta p - m) > 0 = A_2(0)$. Note that A_1 is continously decreasing $\frac{\partial A_1}{\partial \theta} < 0$, while A_2 is continously increasing $\frac{\partial A_2}{\partial \theta} > 0$ in θ . Therefore, if $A_1(1) = \phi \ (R \cdot \Delta p - m) < (1-\phi) \cdot c = A_2(1)$, there is a unique value $\theta^* \in (0,1)$ that fullfills the first order condition.

In particular, if $(1-\phi) \cdot c > \phi (R \cdot \Delta p - m)$. For a given level of effort cost, the first order condition then implicitly defines a unique optimal supervisory level:

$$\theta^* = \left[\frac{1}{2} \left(\frac{\sqrt{(1-\phi)^2 \cdot p_L^2 - \phi \cdot \frac{4 \cdot p_H \cdot \Delta p (R \cdot \Delta p - m)}{c}}}{(1-\phi) \cdot \Delta p} - \frac{p_L}{\Delta p} \right) \right].$$

This implies a capital requirement level

$$k(\theta^*) = 1 - \frac{1}{\gamma} (p_L + \theta^* \triangle p) \left(R - \frac{m}{\Delta p} \right).$$

Taking the partial derivative of the regulator's optimal supervisory effort *w.r.t.* k, gives

$$\frac{\partial^2 U}{\partial k \partial \theta} = -\phi \left(\frac{p_H \Delta p \gamma}{(p_L + \theta \triangle p)^2} \right) < 0.$$

It follows that capital standards and supervision behave as substitutes for the regulator.

B Appendix: Switching Costs

Consider the case where country A is able to supervise her banks at lower marginal costs than country B. Therefore, $\theta_A > \theta_B$, $k_A(\theta_A) < k_B(\theta_B)$, and if the characteristics of both jurisdictions are observable by depositors, banks in country A can refund their investments at a more favourable

rate than in country B $r_D(\theta_A) < r_D(\theta_B)$. For simplicity, we denote the deposit rate in each country as $r_D(\theta_i) = r_i$.

We first analyse the critical switching costs for efficient banks from country B moving to country A. The efficient bank will move to A whenever $\Pi^E(A) - \vartheta > \Pi^E(B)$. More specifically

$$p_H((R - r_A)(1 - k_A)) - m - \rho \cdot k_A - \nu_M > p_H((R - r_B)(1 - k_B)) - m - \rho \cdot k_B.$$

This can be summarised as follows:

$$\nu_M < \nu_M^E := p_H((R - r_A)(1 - k_A) - (R - r_B)(1 - k_B)) + \rho \cdot (k_B - k_A).$$

In order to be willing to move abroad, the switching costs for an efficient bank should not outweigh the additional revenue per deposit and the saving in capital investment. Hence, the critical switching cost equals the gain in profitability from moving in the foreign jurisdiction. In the same way, we can derive the moving condition for goofy banks:

$$\nu_M < \nu_M^G := p_l((R - r_A)(1 - k_A) - (R - r_B)(1 - k_B)) + \rho \cdot (k_B - k_A).$$

Since efficient banks are more productive than goofy banks, the critical cost is greater for efficient banks than for goofy banks:

$$\nu_M^E - \nu_M^G = \Delta p \cdot ((R - r_A)(1 - k_A) - (R - r_B)(1 - k_B)).$$

Now, consider the case that a bank does not move to the foreign jurisdiction, but opens branches and borrows at the lower deposit rate. An efficient bank has the incentive to do so as long as the gained profit outweighs the costs connected with opening up a branch:

$$p_H((R - r_A)(1 - k_B)) - m - \rho \cdot k_B - \nu_R > p_H((R - r_B)(1 - k_B)) - m - \rho \cdot k_B.$$

This results in the condition:

$$\nu_R < \nu_R^E := p_H(r_B - r_A)(1 - k_B).$$

And similarly for the goofy bank:

$$\nu_R < \nu_R^G := p_l(r_B - r_A)(1 - k_B).$$

Again, the efficient bank is more productive and outweighs higher switching costs: $\nu_R^E - \nu_R^G = \Delta p \cdot (r_B - r_A)(1 - k_B)$. Yet, the gain in profitability from moving compared to opening a branch is greater for each type:

$$\nu_M^E - \nu_R^E = (p_H(R - r_A) + \rho)(k_B - k_A),$$

and similarly:

$$\nu_M^G - \nu_R^G = (p_l(R - r_A) + \rho)(k_B - k_A).$$

Figure 4 illustrates the six cases.

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