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Bank capital regulation: are local or central regulators better?

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Abstract

Using a simple two-region model where local or central regulators set bank capital requirements as risk sensitive capital or leverage ratios, we demonstrate the importance of capital requirements being set centrally when cross-region spillovers are large and local regulators suffer from substantial regulatory capture. We show that local regulators may want to surrender regulatory power only when spillover effects are large but the degree of supervisory capture is relatively small, and that bank capital regulation at central rather than local levels is more beneficial the larger the impact of systemic risk and the more asymmetric is regulatory capture at the local level.

Keywords: bank regulation; capital requirement; spillover; regulatory capture; financial architecture
JEL Classification: G21, G28

1 Introduction

The banking industry has experienced significant global integration over the last two decades, with banks expanding their activities beyond the authority of their local supervisors. When the regulatory architecture in place does not allow for the interdependencies between countries or regions that result from this financial integration, financial stability can be impaired. This problem is particularly relevant in Europe and in the US. In Europe, regulation and supervision of banks used to be national responsibilities; under the evolving "Single Supervisory Mechanism", "significant" banks are supervised directly by the European Central Bank (ECB), whereas smaller banks continue to be under national supervision. The U.S., on the other hand, has historically evolved into a dual supervisory system in which each depository institution is subject to regulation by its chartering authority (state or federal) and one of the federal primary regulators.[1] When economies have multiple regulators at possibly different levels, the question of what kind of arrangement is optimal from an overall perspective becomes crucial. Our paper aims to contribute to this discussion.

A growing theoretical literature examines such interactions of banks and regulators/supervisors and their institutional design implications. Several papers analyze the interplay between multinational banking activities and national supervision when the latter does not internalize its impact on the welfare of other countries (Holthausen and Rønde (2004), Calzolari and Loranth (2011), Beck et al. (2013), Agur (2013), Niepmann and Schmidt-Eisenlohr (2013)). Other authors focus on coordination problems between different banking regulators, which might be in different countries or have different objectives (Acharya (2003), Kahn and Santos (2005), Dell'Ariccia and Marquez (2006), Morrison and White (2009), Hardy and Nieto (2011)).

Several recent contributions have begun to focus more on the divergence between local and central regulators' objectives and their means to implement them. Colliard (2015) examines optimal supervisory architecture in a federal/international context where local supervisors have incentives to engage in forbearance as they do not allow for the cross-border externalities of a bank's distress, but also have more information about

[1] The Office of the Comptroller of the Currency, the Federal Reserve and the Federal Deposit Insurance Corporation are in charge of federally chartered banks, state member banks and state non member banks, respectively.

domestic banks than a central supervisor.[2] In a similar set-up, Carletti et al. (2016) demonstrate that even small differences in central and national supervisors' objectives may lead to inferior bank monitoring compared to completely centralized or national supervisory structures; local supervisors may prefer ignorance to acquiring information that might lead the central supervisor to decide against local interests. Górnicka and Zoican (2016) take these arguments further by arguing that the supranational regulator can actually distort bank risk-taking incentives as it is unable to commit to ex post inefficient bank liquidations, so that supranational resolution of insolvent banks does not necessarily improve welfare.

Our paper is most closely related to this more recent literature on optimal "vertical" bank regulatory structure. Whereas Colliard (2015), Carletti et al. (2016) and Górnicka and Zoican (2016) examine optimal bank resolution arrangements in frameworks that either take bank capital as given or abstract from it altogether, we specifically focus on the arguably no less important issue of optimal bank capital regulation, aiming to explore under what circumstances central bank regulation and/or supervision might be preferable to local one in this context.[3] For this, we develop a simple two-region model where local or central regulators set capital requirements as either risk sensitive capital or leverage ratios.[4] Local regulators are concerned about expected costs of their banks failing and the opportunity cost of capital, but ignore interregion spillovers associated with bank failures. A central regulator internalizes the positive spillover effects of higher capital ratios, but faces a potentially higher cost of observing bank types than local regulators due to its supervisory "remoteness"; it may furthermore attach less weight to banks' opportunity cost of capital if exposed to less regulatory capture than local regulators.

Our results demonstrate the importance of capital requirements being determined at

[2]Relevant empirical papers that examine differences in the behavior of bank supervisors at the state/federal level in the US are Rezende (2011) and Agarwal et al. (2014); they find significant differences in their treatment of supervised banks.

[3]In common with these related papers, and in order to keep our analysis tractable, we abstract from the inherent fragility arising from banks' liquidity structure, which provides a role for a lender of last resort in the avoidance of bank runs (Diamond and Dybvig (1983)). Goodhart and Huang (2000) examine the related issue of the lender of last resort function being carried out at the international level.

[4]Regulators in our framework impose either risk sensitive capital or leverage ratios, but never the two together, as this would lead to suboptimal outcomes (see Section 2).

a central level particularly when interregion or cross-country spillovers are large and local regulators suffer from substantial degrees of regulatory capture. We further highlight the importance for such a central regulator to deal with the potential issues relating to supervisory "remoteness" in this context, and show that local regulators may be inclined to surrender regulatory power to a central regulator only when spillover effects are large but the degree of supervisory capture is relatively small. We also demonstrate that bank capital regulation at the central rather than the local level is more beneficial the larger the impact of systemic risk and the greater the degree of asymmetry in regulatory capture at the local level.

The model is now developed in Section 2, our core results are derived and discussed in Section 3, Section 4 presents several extensions to our analysis, and Section 5 concludes the paper. All proofs are presented in the Appendix.

2 Model

To explore whether bank regulation and/or supervision should be set at central or local levels, we develop a simple model of bank regulation in which banks are located in symmetric regions/countries[5] A, B and subject to capital regulation from local and/or central regulators. We adopt the incentive approach to the modeling of solvency regulations, initiated by Giammarino et al. (1993), assuming that banks are better informed regarding their particular risk/return characteristics than the regulator(s).[6]

Banks Banks have projects that pay $x > 1$ with probability $1 - p$ and $x = 0$ otherwise, which are financed by raising deposits and capital. Deposits are protected by deposit insurance, making bank debt risk-free. Expected bank profit is then $\Pi = (1-p)(x-(1-k)) - kq$, with cost of capital $q > 1$ and capital ratio $0 < k < 1$. There is imperfect information about bank type such that p can be $p^h = p + \kappa < 1$ with probability 0.5 and $p^l = p - \kappa > 0$ otherwise, uncorrelated between regions.

[5]For simplicity we shall only refer to regions from now on.

[6]Our modeling choice of adapting a static, asymmetric information-based banking model, rather than a DSGE model with financial frictions, allows for analytical tractability with closed form solutions. Similar approaches are adopted throughout the related theoretical literature on interactions of banks, regulators/supervisors and their institutional design implications, as surveyed in the introduction above.

Regulators A central regulator considers objectives for the two regions jointly, allowing for the social costs associated with bank failure, the benefits associated with financial intermediation, as well as positive spillover effects of higher capital ratios in one region on the other one. In line with Giammarino et al. (1993) and Prescott (2004), these objectives are captured by the following (reduced form) loss function for the central regulator

$$\begin{aligned}\Lambda^s = 2m_s + \frac{1}{4}\sum_{i\in\Theta}\sum_{j\in\Theta}(p_A^i(1-k_A^i)^2 + \omega_s k_A^i\,(q-1) + \phi p_B^j(1-k_B^j) \\ + p_B^j(1-k_B^j)^2 + \omega_s k_B^j\,(q-1) + \phi p_A^i(1-k_A^i))\end{aligned} \tag{1}$$

where $m_s > 0$ is its cost of observing bank types in each region, and $\Theta = \{h, l\}$ is the set of bank types. The first term in the double sum reflects the social cost associated with bank failure in region A; the second term represents the opportunity cost of capital in region A, with weighting factor $\omega_s > 0$ (a reduced form of bank profits reflecting the benefits from financial intermediation); the third term captures the impact of negative spillovers from bank failures in region B on region A, with weighting factor $\phi > 0$; and the remaining three terms represent the equivalent items for region B.[7]

Local regulators in regions A, B consider analogous objectives for their respective regions, but ignore positive spillover effects of higher capital ratios on the other region. The corresponding (reduced form) loss function for the local regulator in region A is then

$$\Lambda_A^n = m_n + \frac{1}{4}\sum_{i\in\Theta}\sum_{j\in\Theta}(p_A^i(1-k_A^i)^2 + \omega_n k_A^i\,(q-1) + \phi p_B^j(1-k_B^j)) \tag{2}$$

where m_n is its cost of observing bank type, and ω_n its weight on the opportunity cost of capital; an analogous loss function applies to the local regulator in region B.

A central regulator, acting as a supervisor, faces a potentially higher cost of observing bank types than local regulators due to its supervisory "remoteness"; we thus assume $0 < m_n < m_s$. As a regulator, on the other hand, it may attach less weight to banks' opportunity cost of capital if it is exposed to less regulatory capture than local

[7] Our stylized setup assumes one bank per region. Our core results in Sections 2 and 3 would remain unchanged if we allowed n_A, n_B banks in regions A, B, as long as their types are also uncorrelated.

regulators; hence we assume $\omega_n > \omega_s$.

Optimal capital requirements Local or central regulators can observe bank type at a cost, in which case they can impose risk sensitive capital ratios; otherwise they have to resort to risk insensitive leverage ratios. Depending on whether or not it chooses to discover bank type, a central regulator then either solves for the optimal risk sensitive capital ratios k^{sh}, k^{sl}, by minimizing its loss function eq. (1) with respect to k^h, k^l, obtaining

$$k_A^{sh} = k_B^{sh} = 1 + \frac{\phi}{2} - \frac{\omega_s(q-1)}{2(p+\kappa)}, \quad k_A^{sl} = k_B^{sl} = 1 + \frac{\phi}{2} - \frac{\omega_s(q-1)}{2(p-\kappa)} \tag{3}$$

or solves for optimal leverage ratios k^s, by minimizing its loss function with respect to $k = k^h = k^l$, giving

$$k_A^s = k_B^s = 1 + \frac{\phi}{2} - \frac{\omega_s(q-1)}{2p} \tag{4}$$

Local regulators, on the other hand, minimizing their loss functions eq. (2) in a similar fashion, would solve for optimal risk sensitive capital ratios k^{nh}, k^{nl} or leverage ratios k^n as

$$k_A^{nh} = k_B^{nh} = 1 - \frac{\omega_n(q-1)}{2(p+\kappa)}, \quad k_A^{nl} = k_B^{nl} = 1 - \frac{\omega_n(q-1)}{2(p-\kappa)} \tag{5}$$

$$k_A^n = k_B^n = 1 - \frac{\omega_n(q-1)}{2p}. \tag{6}$$

We can observe that central leverage ratios are set higher than local ones; the same holds true for the corresponding risk sensitive capital requirements. These results are driven by the spillover effects that are internalized by the central regulator, and reinforced by its potentially more limited focus on the opportunity cost of capital. Leverage ratios are higher than expected risk sensitive capital requirements at both local and central levels, a result driven by the convexity in regulators' loss functions.[8]

[8] Note also that a sufficient condition for optimal capital ratios to be bounded below one would e.g. be $\phi < \omega_s(q-1)/(p+\kappa)$.

Risk sensitive capital vs. leverage ratios As a first result that will prove useful later, we can characterize what conditions would lead local and/or central regulators individually to choose risk sensitive capital ratios over leverage ratios. We achieve this by evaluating the local/central regulators' respective loss functions eqs. (1) and (2) using the corresponding optimal risk sensitive capital and leverage ratios from eqs. (3)–(6), allowing us to state

Lemma 1. *Both local and central regulators prefer risk sensitive capital ratios if* $m_s < m'_s$ *or leverage ratios if* $m_n > m'_n$*, where*

$$m'_n = \frac{(q-1)^2\kappa^2\omega_n^2}{4p(p^2-\kappa^2)} > m'_s = \frac{(q-1)^2\kappa^2\omega_s^2}{4p(p^2-\kappa^2)} > 0.$$

Otherwise, central regulators prefer leverage ratios while local regulators prefer risk sensitive capital ratios. The relative benefits of risk sensitive capital ratios are increasing in regulators' respective weights on the opportunity cost of capital ω_s, ω_n *and the difference in insolvency risk between bank types* κ*.*

Regulators' loss functions are assumed to be convex in payouts to depositors in the case of bank failure, thus risk sensitive capital ratios improve on leverage ratios to a larger extent the greater the difference in insolvency risk between bank types. Discovering bank type is costly for regulators, however, giving rise to thresholds in the cost of bank type discovery above which the reduction in expected losses from bank failures associated with risk sensitive capital requirements is insufficient to be worthwhile. Furthermore, as leverage ratios are higher than expected risk sensitive capital ratios, both local and central regulators value the latter even more the greater their emphasis on the opportunity cost of capital.

Whether local and/or central regulators prefer risk sensitive capital ratios or leverage ratios thus depends on their respective costs of discovering bank type; the different possible combinations are sketched in Figure 1. It is worthwhile noting that regulators in our framework optimally choose to impose either risk sensitive capital or leverage ratios, but never the two together; the leverage ratio would be binding for low-risk banks in such a dual-instrument arrangement (as $k > k^l$ throughout), leading to suboptimal outcomes.

3 Optimal regulatory framework

We now go further to investigate whether an optimal regulatory and supervisory framework involves setting bank capital requirements at either the local or central level, and that in the form of either risk sensitive capital or leverage requirements. A social planner's objectives would allow for the social costs associated with bank failure and the benefits associated with financial intermediation in both regions, as well as the impact of negative spillovers from bank failures in one region on the other one. In reduced form, the social planner's loss function would thus resemble that of the central planner's given in eq. (1) above, but for potential differences in the weighting factors ω and ϕ associated with the opportunity cost of capital and the spillover effect. For simplicity, but without major loss of generality, we assume for the remainder of this paper that the central regulator's preferences coincide with the social planner's. An examination of which particular regulatory arrangements the social planner would consider best can then be achieved by evaluating the central regulator's loss function eq. (1) using the respective optimal risk sensitive capital and leverage ratios from eqs. (3)–(6), while allowing for the actual costs of discovering bank types incurred. For these comparisons, we define $\omega_d \equiv \omega_n - \omega_s$ as regulators' weight differential on the opportunity cost of capital, and $m_d \equiv m_s - m_n$ as regulators' (potential) cost differential of discovering bank type; we further assume $\omega_d < \omega_s$ for ease of analysis.

Evaluating the central regulator's loss function using optimal leverage ratios at either the central or local level in this way, and similarly for optimal risk sensitive capital ratios, we can state

Lemma 2. *Central leverage ratios are preferable to local ones throughout. Their relative benefit is increasing in the size of the spillover ϕ and regulators' weight differential on the opportunity cost of capital ω_d.*

Central risk sensitive capital ratios are preferable to local ones if regulators' cost differential of discovering bank type m_d is below the threshold

$$m_d' = \frac{1}{4}\left((q-1)2\phi\omega_d + p\left(\phi^2 + \frac{(q-1)^2{\omega_d}^2}{p^2-\kappa^2}\right)\right) > 0$$

and the reverse holds otherwise. The central risk sensitive capital ratios' relative ben-

efit is increasing in the size of the spillover ϕ, regulators' weight differential on the opportunity cost of capital ω_d and the difference in insolvency risk between bank types κ.

The central leverage ratios internalize the effect of spillovers arising from bank failures in the other region, which are ignored by local regulators in their setting of the optimal leverage ratio. Additionally, local regulators are prone to be overly concerned by the opportunity cost of capital due to stronger regulatory capture, leading to capital requirements that are also too low from a central perspective.

As with leverage ratios, the central regulator internalizes the effect of interregion spillovers in its setting of optimal risk sensitive capital ratios, which are not taken into account by local regulators. Similarly, as local regulators overemphasize the opportunity cost of capital, they set risk sensitive capital requirements that are even further below what the central regulator would consider appropriate. These two benefits have, however, to be weighed against the potentially greater cost faced by the central regulator in determining bank type, due to the increased supervisory "remoteness" it faces. This gives thus rise to a threshold in how large regulators' cost differential of discovering bank type can be before it negates the benefits brought by central risk sensitive capital ratios in terms of internalization of spillovers and reduced exposure to regulatory capture. A natural consequence, relevant from an institutional design perspective, is then that central risk sensitive capital ratios are preferable to local ones throughout when central regulation is combined with supervision at the local level.

It is also interesting to evaluate the central regulator's loss function using either optimal central leverage ratios or optimal local risk sensitive capital ratios; we obtain

Lemma 3. *Central leverage ratios are preferable to local risk sensitive capital ratios if local regulators' cost of discovering bank type m_n is above the threshold*

$$m_n'' = \frac{1}{4}\left(\frac{(q-1)^2(\kappa^2\omega_s^2 - p^2\omega_d{}^2)}{p(p^2-\kappa^2)} - \phi\left(p\phi + 2\omega_d(q-1)\right)\right)$$

whereas the reverse holds otherwise. The central leverage ratio's relative benefit is increasing in the size of the spillover ϕ and regulators' weight differential on the opportunity cost of capital ω_d, but decreasing in the difference in insolvency risk between bank *types κ.*

When local regulators' cost of discovering bank type is larger than a given threshold, the potential advantage of risk sensitive capital ratios over leverage ratios, which stems from the convexity of regulators' loss functions, is outweighed by the fact that the central regulator internalizes the effect of interregion spillovers in the setting of optimal capital ratios, and also may be less exposed to regulatory capture than local regulators. On the other hand, local risk sensitive capital ratios can dominate central leverage ratios when spillover effects, the degree of regulatory capture and the local regulators' cost of discovering bank type are sufficiently small or the difference in insolvency risk between bank types is relatively large.

We can now draw on the relative results obtained so far to characterize the conditions under which risk sensitive capital or leverage requirements determined at either the local or central level are best overall from the viewpoint of the central regulator, and thus, given our assumptions, the social planner. We obtain

Proposition 1. *When either local or central regulators are also in charge of supervision, the best type of capital requirement from an overall perspective is given as follows:*

- *When the local regulator's cost of discovering bank type m_n is above the threshold m_n'', central risk sensitive capital ratios are preferable overall if the central regulator's cost of discovering bank type m_s is below the threshold m_s', whereas central leverage ratios are most preferred otherwise.*

- *When the local regulator's cost of discovering bank type m_n is below the threshold m_n'', central risk sensitive capital ratios are preferable overall if regulators' cost differential of discovering bank type m_d is below the threshold m_d', whereas local risk sensitive capital ratios are most preferred otherwise.*

Clearly, regulators' (relative) costs of discovering bank type are key in determining whether capital requirements set by local or central regulators are preferable, and whether these should be in the form of risk sensitive capital or leverage ratios. Capital requirements set by local regulators are best, in the form of risk sensitive capital ratios, only if their cost of discovering bank type is sufficiently small in a scenario where local and central regulators' cost differential of discovering bank type is sufficiently large. In all other scenarios, letting central regulators determine capital requirements emerges as best, generally in the form of risk sensitive capital requirements, but for the case where the central regulator's cost of discovering bank type is sufficiently large to warrant implementation of a central leverage ratio instead.[9] A natural consequence of these results, with particular relevance from an institutional design perspective, is that central regulation combined with supervision at the local level dominates the regulatory framework where either local or central regulators are also in charge of supervision.

Our results are thus strongly supportive of the important role a central regulator can play particularly when interregion spillovers are large and local regulators are exposed to substantial degrees of regulatory capture. However, it also highlights the importance for such a central regulator to address potential issues relating to supervisory "remoteness" in this context, e.g. by delegating certain supervisory tasks to local supervisors that may be able to carry these out more cost-efficiently.

4 Extensions

4.1 Shifting from local to central regulation

We now go one step further by examining whether local regulators might ever agree to surrender regulatory power to a central regulator, or whether such a transition would have to be imposed on them. Given the results obtained in the previous section, we will frame this as a potential regulatory regime shift where a local regulator considers whether or not to cede regulatory powers to a central authority, while retaining its supervisory role in the case of regulation at the central level (i.e. $m_s = m_n$ as a result).

Evaluating now local regulator's loss function using optimal leverage ratios at either the central or local level, and similarly for optimal risk sensitive capital ratios, analogously to above, we can then state

Lemma 4. *Local regulators perceive central leverage ratios as preferable to local ones if*

[9] Additional comparative statics results are available in the Appendix.

the spillover ϕ is above the threshold

$$\phi' = \frac{(q-1)\omega_d}{p} > 0$$

whereas the reverse holds otherwise. The central leverage ratios' relative benefit is decreasing in regulators' weight differential on the opportunity cost of capital ω_d.

Local regulators perceive central risk sensitive capital ratios as preferable to local ones if the spillover ϕ is above the threshold

$$\phi'' = \frac{2(q-1)\omega_d}{2\sqrt{p^2-\kappa^2}} > 0$$

whereas the reverse holds otherwise. The central risk sensitive capital ratios' relative benefit is decreasing in regulators' weight differential on the opportunity cost of capital ω_d and the difference in insolvency risk between bank types κ.

As local regulators ignore positive spillover effects of higher capital ratios on the other region, central risk sensitive capital ratios or leverage ratios can nevertheless be perceived as preferable by local regulators as long as those spillover effects are substantial enough. This effect becomes weaker, however, the greater the weight differential on the opportunity cost of capital between local and central regulators: the higher capital ratios imposed by the central regulator are then perceived as being too costly by local regulators as they are facing greater regulatory capture.

Furthermore, it is similarly helpful to evaluate local regulators' loss function using either optimal central leverage ratios or optimal local risk sensitive capital ratios; we obtain

Lemma 5. *Local regulators perceive central leverage ratios as preferable to local risk sensitive capital ratios if the spillover ϕ is above the threshold*

$$\phi''' = \sqrt{\frac{(q-1)^2(p^2{\omega_d}^2 + \kappa^2\omega_s(2\omega_d+\omega_s))}{p^2(p^2-\kappa^2)} - \frac{4m_n}{p}} > 0 \quad \textit{for} \quad m_n \leq m_n'$$

whereas the reverse holds otherwise. The central leverage ratio's relative benefit is increasing in the local regulator's cost of discovering bank type m_n, but decreasing in *regulators' weight differential on the opportunity cost of capital ω_d and the difference in insolvency risk between bank types κ.*

We observe that, even from local regulators' perspective, as long as their cost of discovering bank type is larger than a given threshold, the potential advantage of risk sensitive capital ratios over leverage ratios is outweighed by the fact that the central regulator internalizes the effect of interregion spillovers in the setting of optimal capital ratios. This effect obviously becomes stronger the more substantial those spillover effects; it matters less, however, the greater the weight differential on the opportunity cost of capital between local/central regulators and the more sizeable the difference in insolvency risk between bank types.

We can now draw on the relative results obtained in this section to characterize the conditions under which risk sensitive capital or leverage requirements determined at the central level are also perceived as preferable from the viewpoint of local regulators. We obtain

Proposition 2. *Local regulators prefer to cede regulatory powers to a central authority, retaining their supervisory role in the case of regulation at the central level, if*

- *the spillover ϕ is above the threshold ϕ'' when the local supervisor's cost of discovering bank type m_n is below the threshold m'_s*
- *the spillover ϕ is above the threshold ϕ' when the local supervisor's cost of discovering bank type m_n is above the threshold m'_n*
- *the spillover ϕ is above the threshold ϕ''' when the local supervisor's cost of discovering bank type m_n lies between the thresholds m'_s and m'_n*

whereas they would prefer to retain their local regulatory powers otherwise.

We thus observe that local regulators may generally be inclined to surrender regulatory power to a central regulator as long as the spillover effects at play are substantial enough. However, this effect needs to be strong enough to outweigh the perceived disadvantage of relatively higher central capital ratios, stemming from local supervisors greater concern about the cost of capital faced by banks, in line with their greater exposure to supervisory capture.[10] Which of those two effects then gains the upper hand

[10] Further comparative statics results are available in the Appendix.

in practice is clearly an empirical question, and unfortunately lies largely outside the influence of central regulators or policymakers more generally.

4.2 Role of systemic risk

Recent events put emphasis on the importance of systemic in addition to bank-level risk. Systemic risk can be defined as "the risk of threats to financial stability that impair the functioning of a large part of the financial system with significant adverse effects on the broader economy" (Freixas et al., 2015, p. 13). It is of interest to revisit our results of Section 3 by characterizing what approach to bank capital regulation is best from an overall perspective when we additionally allow for such a notion of systemic risk in this context.

To approach this question, we remain within a framework where central regulation is combined with supervision at the local level and rewrite the loss function faced by the central regulator as

$$\Lambda^s = 2m_s + \frac{1}{4}\sum_{i\in\Theta}\sum_{j\in\Theta}(p_A^i(1-k_A^i)^2 + \omega_s k_A^i\,(q-1) + (\phi+\phi_s\mathbb{1}_{i=h,j=h})p_B^j(1-k_B^j)$$
$$+\,p_B^j(1-k_B^j)^2 + \omega_s k_B^j\,(q-1) + (\phi+\phi_s\mathbb{1}_{i=h,j=h})p_A^i(1-k_A^i)) \quad (7)$$

where $m_s = m_n$, and $\phi_s > 0$ is the differential spillover effect when both domestic and foreign bank are of type h; this reflects that foreign bank failures may have greater domestic impact when the banking sector is exposed to "systemic risk" in this sense. The corresponding loss function considered by the local regulator in region A is

$$\Lambda_A^n = m_n + \frac{1}{4}\sum_{i\in\Theta}\sum_{j\in\Theta}(p_A^i(1-k_A^i)^2 + \omega_n k_A^i\,(q-1) + (\phi+\phi_s\mathbb{1}_{i=h,j=h})p_B^j(1-k_B^j)) \quad (8)$$

and an analogous loss function applies to the local regulator in region B.

Solving for local/central regulators' optimal risk sensitive capital and leverage ratios as in Section 2, and then evaluating the revised loss functions eqs. (7) and (8) with these, we can state

Lemma 6. *When systemic risk materializes through differential spillover effects, lo-*

cal/central regulators prefer risk sensitive capital ratios to leverage ratios if the cost of discovering bank type m_n is below the respective thresholds

$$m_n' = \frac{(q-1)^2\kappa^2\omega_n^2}{4p(p^2-\kappa^2)} > 0, \quad m_s'' = \frac{(\phi_s(p^2-\kappa^2)+4(q-1)\kappa\omega_s)^2}{64p(p^2-\kappa^2)} > 0$$

and the reverse holds otherwise. The relative benefits of risk sensitive capital ratios at the central level are increasing in the spillover differential ϕ_s associated with systemic risk.

While local regulators' choice is unaffected by the introduction of the systemic risk element, the central regulator is shown to value risk sensitive capital ratios more the greater the impact of systemic risk.[11]

It is then straightforward to obtain results that allow for the impact of systemic risk as follows

Proposition 3. *When central regulation is combined with supervision at the local level and systemic risk materializes through differential spillover effects, central risk sensitive capital ratios are preferable from an overall perspective if m_n is below the threshold m_s'', whereas central leverage ratios are most preferred otherwise.*

Our results reiterate that systemic risk matters for the optimal design of a regulatory framework, and in particular that bank capital regulation would generally be more beneficial at the central than at the local level the greater the impact of systemic risk in the economy.[12] Allowing for systemic risk properly in this context matters even more the larger the spillover effects between regions, and the greater the extent to which local regulators are subject to regulatory capture.

4.3 Asymmetry in regulatory capture at local level

Given our focus throughout on the importance of differences in regulatory capture between local and central supervisors, it is of further interest to examine what approach

[11]This result is driven by the convexity in regulators' loss functions, as optimal central leverage ratios exceed expected risk sensitive capital requirements more the larger the spillover differential ϕ_s associated with systemic risk.

[12]Detailed comparative statics results are available in the Appendix.

to bank capital regulation is best from an overall perspective when there is asymmetry in regulatory capture at the local level.

To address this issue, we remain once again within a framework where central regulation is combined with supervision at the local level. The loss function faced by the central regulator is then simply eq. (1) where $m_s = m_n$; the loss functions considered by the local regulators in regions A, B, on the other hand, are rewritten as

$$\Lambda_A^n = m_n + \frac{1}{4}\sum_{i\in\Theta}\sum_{j\in\Theta}(p_A^i(1-k_A^i)^2 + (\omega_n - \omega_a)\, k_A^i\,(q-1) + \phi p_B^j(1-k_B^j)) \tag{9}$$

$$\Lambda_B^n = m_n + \frac{1}{4}\sum_{i\in\Theta}\sum_{j\in\Theta}(p_B^i(1-k_B^i)^2 + (\omega_n + \omega_a)\, k_B^i\,(q-1) + \phi p_A^j(1-k_A^j)) \tag{10}$$

where $\omega_a > 0$ captures the degree of asymmetry in local regulators' respective weights on the opportunity cost of capital, to be interpreted here as asymmetry in regulatory capture at the local level, with $\omega_a < \omega_d$.[13]

While the central regulator's choice is obviously unaffected by this, the local regulator in region B values risk sensitive capital ratios more than their counterpart in region A the larger the degree of asymmetry in regulatory capture at the local level. We can then obtain a, now more complex, equivalent of Lemma 1 as

Lemma 7. *Both local and central regulators prefer risk sensitive capital ratios if $m_n < m'_s$ or leverage ratios if $m_n > m'_{nB}$; the central regulator prefers leverage ratios while both local regulators prefer risk sensitive capital ratios if $m'_s < m_n < m'_{nA}$; the central regulator and the local regulator in region A prefer leverage ratios while the local regulator in region B prefers risk sensitive capital ratios if $m'_{nA} < m_n < m'_{nB}$ (the thresholds m'_{nA}, m'_{nB} are defined in the Appendix).*

It is then straightforward to obtain results that allow for the impact of asymmetry in regulatory capture at the local level as follows

Proposition 4. *When central regulation is combined with supervision at the local level and there is asymmetry in regulatory capture at the local level, central risk sensitive capital ratios are preferable from an overall perspective if m_n is below the threshold*

[13] Without loss of generality, we assume that the local regulator in region A attaches a lower weight to the opportunity cost of capital than the one in region B, i.e. $\omega_s < \omega_n^A < \omega_n^B$.

m'_s, whereas central leverage ratios are most preferred otherwise. The relative benefits of central vs. local regulation are larger the greater the degree of asymmetry ω_a in regulatory capture at the local level.

Our results thus highlight that bank capital regulation would generally be more beneficial at the central than at the local level the greater the degree of asymmetry in regulatory capture at the local level. Differences in the degree of regulatory capture at the local level favor central regulation more the lower is (average) bank insolvency risk, but the larger the difference in insolvency risk between different bank types and the greater the difference in (average) regulatory capture between local and central regulators.[14]

5 Conclusion

We developed a simple two-region model where local or central regulators set bank capital requirements as either risk sensitive capital or leverage ratios. Local regulators are concerned about expected costs of their banks failing and the opportunity cost of capital, but ignore interregion spillovers associated with bank failures. A central regulator internalizes the positive spillover effects of higher capital ratios, but faces a potentially higher cost of observing bank types than local regulators due to its supervisory "remoteness"; it may furthermore attach less weight to banks' opportunity cost of capital if exposed to less regulatory capture than local regulators.

Our results demonstrated the importance of bank capital requirements being determined at a central level particularly when interregion spillovers are large and local regulators suffer from substantial degrees of regulatory capture. We stressed the importance for such a central regulator to address the potential issues relating to supervisory "remoteness" in this context, and showed that local regulators may be inclined to surrender regulatory power to a central regulator only when spillover effects are large but the degree of supervisory capture is relatively small. We also showed that bank capital regulation at the central rather than the local level is more beneficial the larger the impact of systemic risk and the greater the degree of asymmetry in regulatory capture

[14] Further details on these comparative statics results are available in the Appendix.

at the local level.

The results are relevant for the optimal design of "vertical" regulatory architecture in any economy that has multiple bank regulators and/or supervisors at possibly different levels, and may thus be of interest to policymakers regarding the evolving "Single Supervisory Mechanism" in Europe, the dual supervisory system existing in US banking, or other analogous regional financial and regulatory arrangements across the globe.

Appendix

A Proofs

Proof of Lemma 1 The central regulator's loss differential $\Delta^s_{sl,sr} = \Lambda^s\left(k^s_A, k^s_B\right) - \Lambda^s\left(k^{sh}_A, k^{sl}_A, k^{sh}_B, k^{sl}_B\right)$ evaluates to

$$-2m_s + \frac{(q-1)^2\kappa^2\omega_s^2}{2p(p^2-\kappa^2)}$$

while local regulators' loss differentials $\Delta^n_{nl,nr} = \Lambda^n\left(k^n_A, k^n_B\right) - \Lambda^n\left(k^{nh}_A, k^{nl}_A, k^{nh}_B, k^{nl}_B\right)$ evaluate to

$$-m_n + \frac{(q-1)^2\kappa^2\omega_n^2}{4p(p^2-\kappa^2)}$$

for which the roots $m'_s < m'_n$ are readily obtained; the comparative statics $\frac{\partial\Delta^i_{il,ir}}{\partial\omega_i} > 0$, $\frac{\partial\Delta^i_{il,ir}}{\partial\kappa} > 0$ are straightforward.

Proof of Lemma 2 The respective loss differential $\Delta^s_{nl,sl} = \Lambda^s\left(k^n_A, k^n_B\right) - \Lambda^s\left(k^s_A, k^s_B\right)$ evaluates to

$$\frac{(p\phi + (q-1)\omega_d)^2}{2p}$$

which is positive; the comparative statics $\frac{\partial\Delta^s_{nl,sl}}{\partial\phi} > 0$, $\frac{\partial\Delta^s_{nl,sl}}{\partial\omega_d} > 0$ are then straightforward to obtain.

The respective loss differential $\Delta^s_{nr,sr} = \Lambda^s\left(k^{nh}_A, k^{nl}_A, k^{nh}_B, k^{nl}_B\right) - \Lambda^s\left(k^{sh}_A, k^{sl}_A, k^{sh}_B, k^{sl}_B\right)$ evaluates to

$$\frac{1}{2}\left(-4m_d + (q-1)2\phi\omega_d + p(\phi^2 + \frac{(q-1)^2{\omega_d}^2}{p^2-\kappa^2})\right)$$

for which the root m'_d is readily obtained; the comparative statics $\frac{\partial\Delta^s_{nr,sr}}{\partial\phi} > 0$, $\frac{\partial\Delta^s_{nr,sr}}{\partial\omega_d} > 0$, $\frac{\partial\Delta^s_{nr,sr}}{\partial\kappa} > 0$ are straightforward.

Proof of Lemma 3 The respective loss differential $\Delta^s_{nr,sl} = \Lambda^s\left(k^{nh}_A, k^{nl}_A, k^{nh}_B, k^{nl}_B\right) - \Lambda^s\left(k^s_A, k^s_B\right)$ evaluates to

$$2m_n + \phi(\frac{1}{2}p\phi + \omega_d(q-1)) + \frac{(q-1)^2(p^2{\omega_d}^2 - \kappa^2\omega_s^2)}{2p(p^2-\kappa^2)}$$

for which the root m''_n is readily obtained; the comparative statics $\frac{\partial\Delta^s_{nr,sl}}{\partial\phi} > 0$, $\frac{\partial\Delta^s_{nr,sl}}{\partial\omega_d} > 0$, $\frac{\partial\Delta^s_{nr,sl}}{\partial\kappa} < 0$ are reasonably straightforward.

Proof of Proposition 1 It holds that $m'_s - m''_n = \frac{1}{4}\left(p\left(\frac{(q-1)^2\omega_d^2}{p^2-\kappa^2} + \phi^2\right) + 2(q-1)\phi\omega_d\right) > 0$ (see Figure 2). Part 1 follows from Lemma 1 and Lemmas *2* and *3,* resulting in the preference ordering $SR \succ SL \succ NR \succ NL$ or $SR \succ SL \succ NL \succ NR$, and $SL \succ NR \succ NL$, $SL \succ SR$ or $SL \succ NL \succ NR$, $SL \succ SR$, respectively. Part 2 follows from Lemmas *2* and *3,* resulting in the preference ordering $SR \succ NR \succ SL \succ NL$ and $NR \succ SL \succ NL$, $NR \succ SR$, respectively.

Proof of Lemma 4 The respective loss differential $\Delta^n_{nl,sl} = \Lambda^n\left(k^n_A, k^n_B\right) - \Lambda^n\left(k^s_A, k^s_B\right)$ evaluates to

$$\frac{1}{4}p\left(\phi^2 - \frac{(q-1)^2{\omega_d}^2}{p^2}\right)$$

for which the (positive) root ϕ' is readily obtained; the comparative statics $\frac{\partial\Delta^n_{nl,sl}}{\partial\omega_d} < 0$ are straightforward.

The respective loss differential $\Delta^n_{nr,sr} = \Lambda^n\left(k^{nh}_A, k^{nl}_A, k^{nh}_B, k^{nl}_B\right) - \Lambda^n\left(k^{sh}_A, k^{sl}_A, k^{sh}_B, k^{sl}_B\right)$ evaluates to

$$\frac{1}{4}p\left(\phi^2 - \frac{(q-1)^2{\omega_d}^2}{p^2-\kappa^2}\right)$$

for which the (positive) root ϕ'' is readily obtained; the comparative statics $\frac{\partial\Delta^n_{nr,sr}}{\partial\omega_d} < 0$, $\frac{\partial\Delta^n_{nr,sr}}{\partial\kappa} < 0$ are straightforward.

Proof of Lemma 5 The respective loss differential $\Delta^n_{nr,sl} = \Lambda^n\left(k^{nh}_A, k^{nl}_A, k^{nh}_B, k^{nl}_B\right) - \Lambda^n\left(k^s_A, k^s_B\right)$ evaluates to

$$m_n + \frac{p}{4}\phi^2 - \frac{(q-1)^2(p^2{\omega_d}^2 + \kappa^2\omega_s(2\omega_d + \omega_s))}{4p(p^2-\kappa^2)}$$

This is positive for $m_n \geq m_n''' = \frac{(q-1)^2(p^2{\omega_d}^2+\kappa^2\omega_s(2\omega_d+\omega_s))}{4p(p^2-\kappa^2)}$; as $m_n''' > m_n'$, however, local regulators actually prefer leverage to risk sensitive capital ratios in that region (from Lemma 1). The (positive) root ϕ''' is readily obtained otherwise; the comparative statics $\frac{\partial \Delta^n_{nr,sl}}{\partial m_n} > 0$, $\frac{\partial \Delta^n_{nr,sl}}{\partial \omega_d} < 0$, $\frac{\partial \Delta^n_{nr,sl}}{\partial \kappa} < 0$ are straightforward.

Proof of Proposition 2 It was previously shown that $m_s' < m_n'$ holds (see Figure 1). Then in line with Lemma 1, Lemma 4 applies if $m_n < m_s'$ or $m_n > m_n'$, and Lemma 5 applies if $m_s' < m_n < m_n'$.

Proof of Lemma 6 The central regulator's loss differential $\Delta^s_{sl,sr}$ evaluates to

$$-2m_s + \frac{(\phi_s(p^2-\kappa^2) + 4(q-1)\kappa\omega_s)^2}{32p(p^2-\kappa^2)}$$

while local regulator's loss differential $\Delta^n_{nl,nr}$ evaluate to

$$-m_n + \frac{(q-1)^2\kappa^2\omega_n^2}{4p(p^2-\kappa^2)}$$

for which the roots m_s'', m_n' are readily obtained; the comparative statics $\frac{\partial \Delta^s_{sl,sr}}{\partial \phi_s} > 0$, $\frac{\partial \Delta^n_{nl,nr}}{\partial \phi_s} = 0$ are straightforward.

Proof of Proposition 3 In this case, central risk sensitive capital ratios are preferred to local ones throughout as the respective loss differential $\Delta^s_{nr,sr}$ evaluates to

$$\frac{1}{16}\left(\left(4\phi+\phi_s\right)\left(\phi_s\kappa + 4\omega_d(q-1)\right) + p\left(8\phi^2 + 4\phi\phi_s + \phi_s^2 + \frac{8(q-1)^2\omega_d^2}{(p^2-\kappa^2)}\right)\right) > 0$$

Also, central leverage ratios are always preferred to local ones as the respective loss differential $\Delta^s_{nl,sl}$ evaluates to

$$\frac{(p(4\phi+\phi_s) + \phi_s\kappa + 4(q-1)\omega_d)^2}{32p} > 0$$

This results in the following preference ordering when $m_n < m_s'' : SR \succ SL \succ NL$ and $SR \succ NR$. When $m_n > m_s''$, we have $SL \succ SR \succ NR$ and $SL \succ NL$.

Proof of Lemma 7 When there is asymmetry in regulatory capture at the local level, local regulators in regions A, B and the central regulator prefer risk sensitive capital ratios to leverage ratios if the cost of discovering bank type m_n is below the respective thresholds

$$m'_{nA} = \frac{(q-1)^2\kappa^2\left(\omega_n - \omega_a\right)^2}{4p(p^2-\kappa^2)} > 0 \quad , \quad m'_{nB} = \frac{(q-1)^2\kappa^2\left(\omega_n + \omega_a\right)^2}{4p(p^2-\kappa^2)} > 0$$
$$m'_s = \frac{(q-1)^2\kappa^2\omega_s^2}{4p(p^2-\kappa^2)} > 0$$

and the reverse holds otherwise. We then have $m'_{nB} > m'_{nA} > m'_s$.

Proof of Proposition 4 In this case, central risk sensitive capital ratios are preferred to local ones throughout as the respective loss differential $\Delta^s_{nr,sr}$ evaluates to

$$\frac{1}{2}\left(2(q-1)\phi\omega_d + p(\phi^2 + \frac{(q-1)^2\left(\omega_d^2+\omega_a^2\right)}{p^2-\kappa^2})\right) > 0$$

Also, central leverage ratios are always preferred to local ones as the respective loss differential $\Delta^s_{nl,sl}$ evaluates to

$$\frac{(p\phi + (q-1)\omega_d)^2 + (q-1)^2\omega_a^2}{2p} > 0$$

Finally, central leverage ratios are preferred to local leverage ratios in region A combined with local risk sensitive capital ratios in region B if the respective loss differential $\Delta^s_{nl_A r_B, sl}$, which evaluates to

$$\frac{2p\left(p^2-\kappa^2\right)\left(4m_n + p\phi^2 + 2(q-1)\phi\omega_d\right)}{4p\left(p^2-\kappa^2\right)} +$$
$$\frac{(q-1)^2\left(2p^2\left(\omega_d^2+\omega_a^2\right) - \kappa^2\left((\omega_d-\omega_a)^2 + \omega_s^2\right)\right)}{4p\left(p^2-\kappa^2\right)}$$

is positive; this is satisfied if

$$m_n > m_n''' = \frac{(q-1)^2\kappa^2\left((\omega_d-\omega_a)^2+\omega_s^2\right)}{8p\left(p^2-\kappa^2\right)} - \frac{2p\left(\left(p^2-\kappa^2\right)\left(p\phi^2+2(q-1)\phi\omega_d\right)+p(q-1)^2\left(\omega_d^2+\omega_a^2\right)\right)}{8p\left(p^2-\kappa^2\right)}$$

which holds in the region (see Figure 3) where $m_n > m_s'$ as

$$m_s' - m_n''' = \frac{(q-1)^2\left(2p^2\left(\omega_d^2+\omega_a^2\right)+\kappa^2\left(\omega_s^2-(\omega_d-\omega_a)^2\right)\right)}{8p\left(p^2-\kappa^2\right)} + \frac{2p\phi\left(p^2-\kappa^2\right)\left(p\phi+2(q-1)\omega_d\right)}{8p\left(p^2-\kappa^2\right)} > 0$$

with $\omega_a < \omega_d < \omega_s$ by assumption.

This results in the following preference ordering when $m_n < m_s' : SR \succ SL \succ NL$ and $SR \succ NR$. When $m_n > m_s'$, we have $SL \succ SR \succ NR$, $SL \succ NL$ and $SL \succ NL_AR_B$.

In line with Lemma 7, the relevant comparative statics result on the relative benefits of central vs. local regulation with respect to the degree of asymmetry ω_a in local regulators' respective weights on the opportunity cost of capital in this case are

$$\frac{\partial \Delta^s_{nr,sr}}{\partial \omega_a} = \frac{\partial \Delta^s_{nr,sl}}{\partial \omega_a} = \frac{p(q-1)^2\omega_a}{p^2-\kappa^2} > 0$$
$$\frac{\partial \Delta^s_{nl,sl}}{\partial \omega_a} = \frac{(q-1)^2\omega_a}{p} > 0$$
$$\frac{\partial \Delta^s_{nl_Ar_B,sl}}{\partial \omega_a} = \frac{(q-1)^2\left(\omega_a\left(2p^2-\kappa^2\right)+\kappa^2\omega_d\right)}{2p\left(p^2-\kappa^2\right)} > 0$$

B Further comparative statics

Comparative statics for Proposition 1 The relative benefits of central vs. local regulation are greater the larger the spillover ϕ and regulators' weight differential on the opportunity cost of capital ω_d. They are also greater the larger the difference in insolvency risk between bank types κ when $m_n < m_s''$, inversely related to it when $m_s'' < m_n < m_n'$, but unaffected by it when $m_n > m_n'$.

This follows from the comparative statics in Lemmas *2* and *3*.

Comparative statics for Proposition 2 From local regulators' perspective, the relative benefits of central vs. local regulation are smaller the larger regulators' weight differential on the opportunity cost of capital ω_d. They are also (weakly) smaller the larger the difference in insolvency risk between bank types κ, and (weakly) greater the larger local supervisors' cost of discovering bank type m_n.

This follows from the comparative statics in Lemmas *4* and *5*.

Comparative statics for Proposition 3 When the spillover differential ϕ_s associated with systemic risk is not too large, i.e. $\phi_s < \phi_s^{'}$, the relative benefits of central vs. local regulation are larger the greater the degree of systemic risk affecting the economy when $m_n < m_s''$ or $m_n > m_n'$, or as long as $p\omega_d > \kappa\omega_s$ (a sufficient condition) when $m_s'' < m_n < m_n'$. The impact of the degree of systemic risk on the relative benefits of central vs. local regulation is greater the larger the spillover ϕ and regulators' weight differential on the opportunity cost of capital ω_d; it is also greater the larger the difference in insolvency risk between bank types κ when $m_n < m_s''$ or $m_n > m_n'$, but indeterminate when $m_s'' < m_n < m_n'$.

These results hold noting that, as long as the spillover differential ϕ_s associated with systemic risk is sufficiently small, i.e. $\phi_s < \phi_s^{'} = \frac{4(q-1)\kappa(\omega_n-\omega_s)}{p^2-\kappa^2}$, Lemma 1 holds (with $m_s = m_n$). Then, the relevant comparative statics results on the relative benefits of central vs. local regulation with respect to the degree of systemic risk ϕ_s in this case are

$$\frac{\partial \Delta^s_{nr,sr}}{\partial \phi_s} = \frac{1}{8}((2\phi+\phi_s)(p+\kappa)+2(q-1)\omega_d) > 0$$
$$\frac{\partial \Delta^s_{nl,sl}}{\partial \phi_s} = \frac{(p+\kappa)\left(p(4\phi+\phi_s)+\phi_s\kappa+4(q-1)\omega_d\right)}{16p} > 0$$

and
$$\frac{\partial \Delta^s_{nr,sl}}{\partial \phi_s} = \frac{p^2(4\phi+\phi_s)+2p\kappa(2\phi+\phi_s)+\phi_s\kappa^2+4\left(q-1\right)\left(p\omega_d-\kappa\omega_s\right)}{16p}$$

for which a sufficient condition to be positive clearly is $p\omega_d > \kappa\omega_s$. The respective second-order partial derivatives $\frac{\partial^2\Delta^s}{\partial\phi_s\partial\phi} > 0, \frac{\partial^2\Delta^s}{\partial\phi_s\partial\omega_d} > 0$ and $\frac{\partial^2\Delta^s_{nr,sr}}{\partial\phi_s\partial\kappa} > 0, \frac{\partial^2\Delta^s_{nl,sl}}{\partial\phi_s\partial\kappa} >$

0, $\frac{\partial^2 \Delta^s_{nr,sl}}{\partial \phi_s \partial \kappa} \gtrless 0$ are then straightforward to obtain.

Comparative statics for Proposition 4 The impact of the degree of asymmetry in regulatory capture at the local level on the relative benefits of central vs. local regulation is lower the higher is average bank insolvency risk p; it is (weakly) greater the larger the difference in insolvency risk between bank types κ and local and central regulators' (average) weight differential on the opportunity cost of capital ω_d.

This follows from the respective second-order partial derivatives $\frac{\partial^2 \Delta^s}{\partial \phi_s \partial p} < 0$, $\frac{\partial^2 \Delta^s}{\partial \phi_s \partial \kappa} \geq 0$, $\frac{\partial^2 \Delta^s}{\partial \phi_s \partial \omega_d} \geq 0$, which are reasonably straightforward to obtain.

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Figure 1: Regulators' preference of risk-sensitive capital (RW) vs leverage (Lev) ratios depending on cost of discovering bank type

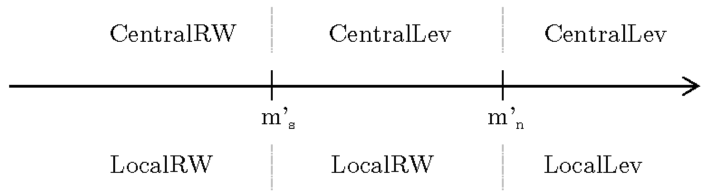

Figure 2: Regulators' preference of risk-sensitive capital vs leverage ratios and further cost threshold of discovering bank type

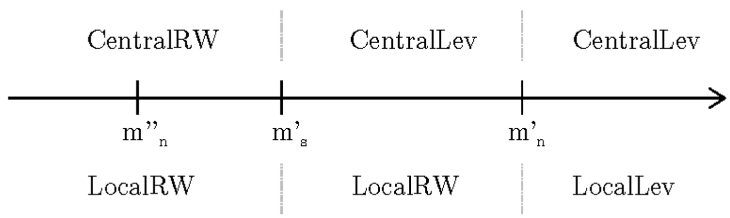

Figure 3: Regulators' preference of risk-sensitive capital vs leverage ratios and alternative cost thresholds of discovering bank type