Why 'Basel II' May Need a Leverage Ratio Restriction

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Abstract

We analyze regulatory capital requirements where the amount of required capital depends on the level of risk reported by the banks. It is shown that if the supervisors have a limited ability to identify or to sanction dishonest banks, an additional, risk-independent leverage ratio restriction may be necessary to induce truthful risk reporting. The leverage ratio helps to offset the banks' potential capital savings of understating their risks by (i) reducing banks' put option value of limited liability *ex ante*, and by (ii) increasing the banks' net worth, which in turn enhances the supervisors' ability to sanction banks *ex post*.

Keywords: Banks, capital requirements, leverage ratio restriction, Basel II.

JEL Classification Numbers: G21, G28

1 Introduction

The new international capital framework for banks, also known as 'Basel II', seeks to align regulatory capital requirements more closely to the underlying risks that banks face. This improved risk sensitivity is intended to be achieved through a greater use of assessments of risk provided by banks' internal systems as inputs to capital calculations.[1] Despite these innovations, in the US the Federal Deposit Insurance Corporation (FDIC) insists on maintaining an additional leverage ratio restriction. They even propose to consider the introduction of a leverage ratio restriction at an international level.[2] The main reason behind these efforts are the rising concerns about the ability of supervisors to validate the banks' risk assessments.[3] Banks on the other hand strongly oppose such a leverage ratio restriction. They argue that it would reduce or even eliminate the benefits of the new, but complex and costly capital framework. Furthermore, they view a simple leverage ratio as an old-fashioned, blunt instrument, which is at odds with today's risk management of banks. Given the prominent role of a leverage ratio restriction in US banking regulation and the fierce debate about its future, it is surprising that there is no formal analysis about the pros and cons of such a regulatory arrangement. This paper is trying to start to fill this gap.

In an adverse selection model with profit-maximizing banks and costly capital, the effectiveness of risk-sensitive capital requirements à la Basel II is analyzed. Because the supervisor has no information about the banks' risk *ex ante*, i.e., before any uncertainty about banks' investments has been resolved, he has to rely on banks' reporting their risk. Knowing that reporting a high risk leads to a higher level of required capital, banks have an incentive to understate their risk. In order to induce truthful revelation of banks' risks, it is necessary that the supervisor sanctions dishonest banks whenever such banks are detected *ex post*, i.e., after the return on banks' investments has been

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[1] See Basel Committee on Banking Supervision (2006).

[2] See Bair (2006).

[3] For instance, the so-called fifth quantitative impact study ('QIS5') has revealed a huge dispersion in banks' own calculations of required capital under Basel II. This dispersion is difficult to reconcile with supervisors' assessments of the analyzed banks' risks. See Basel Committee on Banking Supervision (2006b). For a general discussion of the potential problems associated with Basel II, see Bichsel and Blum (2005).

realized. If the supervisor's ability to detect or to sanction dishonest banks is limited, however, risky banks still have an incentive to understate their risk. In that case, an additional leverage ratio restriction helps to align risky banks' incentives and induces truthful revelation of their risk, by reducing the risky banks' gains of understating their risk: First, the leverage ratio puts a ceiling on the put option value of limited liability. Second, the possibilities of the supervisor to sanction dishonest banks are enlarged. Given limited liability, the size of the fine that can be imposed on banks is restricted by the level of the banks' capital. Hence, setting a capital floor ensures a minimum size of potential fines on banks. Both effects reduce the expected profits of banks that understate their risk. By imposing a sufficiently high leverage ratio, it becomes in the risky banks' own interest to report their risk truthfully. The better the supervisor's ability to detect and to punish untruthful banks, the lower is the necessary leverage ratio. If the supervisor's ability is very high, a leverage ratio even may become superfluous. At the other extreme, if the supervisor has no ability to detect or to punish banks, the second-best capital regulation reduces to a simple leverage ratio without any additional risk-sensitive requirements.

To our knowledge, the complementary use of risk-sensitive capital requirements and of leverage ratio restrictions has not yet been formally analyzed. Most closely related to this paper, Rochet (1992) argues that risk-averse banks may exhibit risk-loving behavior, if capital is very low or even negative. The reason for this result is the fact that at very low levels of capital, the convexity of the profit function induced by limited liability dominates the concavity of the banks' utility function. To keep banks away from this region of excessive risk taking, Rochet suggests a capital floor in addition to risk-sensitive requirements. In contrast to the present paper, however, there are no asymmetries of information between the supervisors and the banks. In particular, the systematic risk of all the banks' assets are known to everybody. Moreover, the mentioned capital floor is an absolute value, i.e., independent of the banks' size,[4] while in this paper the relevant capital restriction is proportional to the total value of banks'

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[4]Minimum capital levels that are independent of banks' size and risk are often part of banking regulation. In Switzerland, for instance, banks need at least 10 mio. Swiss Francs of capital in order to obtain a banking licence.

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assets.

Despite the lack of theoretical work on this topic, there is some empirical evidence that having a combination of risk-sensitive requirements and of a leverage ratio is superior to having either one by itself (e.g., Avery and Berger 1991, or Estrella, Park, and Peristiani 2000). Furthermore, it has been suggested informally that a leverage ratio may serve as a safeguard against potential shortcomings of risk-sensitive requirements, notably regulatory arbitrage and problems of validation (e.g., Bichsel and Blum 2005).

The rest of the paper is organized as follows. The next section describes the model. The capital choice of unregulated banks is compared with various regulatory arrangements: A simple leverage ratio, risk-weighted capital requirements, risk-weighted requirements with sanctions, and the combination of a leverage ratio and risk-weighted requirements. The subsequent section discusses the analysis. The final section contains a summary.

2   The Model

The model described in this section aims to capture three essential features of banking that are relevant for the analysis of capital regulation, especially risk-sensitive capital regulation à la Basel II. First, there is heterogeneity among banks' risks. Some banks are riskier than others. Second, banks are highly opaque. As a consequence, outsiders, including relatively well-informed supervisors, have great difficulties in assessing banks precisely. In particular, while it may seem clear in some cases *ex post* that some banks have incurred high risks, it is very difficult to assess banks' risks *ex ante*. And third, from a welfare point of view, banks have a tendency to hold too little capital relative to their risks. Due to limited liability and negative externalities, banks do not fully take into account all the costs that arise to third parties in the event that the banks default.

There are two types of banks, safe banks and risky banks.[5] The types are known to the banks themselves, but due to banks' opaqueness the types are not observable or

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[5]The assumption of only two exogenous risk types does not affect the qualitative results that follow. Possible extensions to many risk types and to endogenous choices of risk will be discussed at the end of this Chapter.

verifiable by outsiders *ex ante*, i.e., before any uncertainty about the banks' investments is resolved.[6] There is a large number of both types of banks. Moreover, all banks are independent, which implies that information on one bank does not reveal information about any other banks.

Both types have total assets normalized to one and both are financed with deposits D and capital W. For convenience, we assume that there is full deposit insurance. As a consequence, deposits are riskless and the gross interest rate on deposits is equal to the riskfree rate, which is set to one.[7] Since banks' risk cannot be observed, the insurance premium is constant and by assumption set to zero. Capital is assumed to be more expensive than deposits. Specifically, the opportunity cost of capital, c_w, is larger than the interest rate on deposits, i.e., $c_w > 1$.

A bank supervisor may learn the true type of a bank with probability q *ex post*, i.e., after the return of the bank's investment has been realized. This corresponds to the backtesting mechanism that is used for the internal-models approach for market risks under Basel I.[8] It seems very likely that this will also be the mechanism used under Basel II, as it is very difficult to assess precisely banks' risks *ex ante*. The simplifying assumption that supervisors have no information at all *ex ante* is, of course, extreme. But the qualitative results of this paper would not be changed in a more realistic setting where supervisors do have some information *ex ante*. It is important, however, that irrespective of the initial information supervisors do know more *ex post*. This ensures that supervisors are in a better position to discipline misbehaving banks *ex post* than *ex ante*. Note that the validation of risk models is not an issue here: Both banks have perfect internal models in the sense that they know exactly what risk type they are. The difficulty for the supervisor consists in verifying the information input that goes into these models, as most of this information is soft, non-market, and low-frequency data. This point will be discussed in more detail in Section 3.

The safe banks have a gross rate of return on assets $1 + x$. The risky banks' return

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[6]On the opaqueness of banks, see Morgan (2002).

[7]By assuming deposit insurance, we abstract from issues of market discipline. For an overview of market discipline, see Flannery (2001).

[8]See Basel Committee on Banking Supervision (1996).

$\tilde{R}$ has the following distribution

$$\tilde{R} = \begin{cases} 1 + x & \text{with probability} & p \\ 1 - x & \text{with probability} & 1 - p \end{cases},$$

with $p > \frac{1}{2}$. Given this assumption, while less profitable than the safe banks, risky banks are still socially desirable in the sense that their expected return, $1 + 2px - x$, is larger than the riskfree rate. In addition, we assume that the expected return is higher than the opportunity cost of capital, c_w. This implies that risky banks are profitable at any level of capital. Note that the risky banks cannot be distinguished from the safe banks in case of success of their investment. In that case, both types of banks have the same rate of return $1 + x$.

The failure of a bank leads to social costs C. These costs include contagion effects and disruptions of the payments system. Furthermore, contractions in the amount of available credit due to a banking crisis have a negative impact on economic growth and lead to costs in the form of reduced real output.[9] An insolvent bank does not incur any private bankruptcy costs. Furthermore, due to limited liability the bank owners cannot be forced to cover any losses.

2.1 No Regulation

To demonstrate the potential benefit of capital regulation in this setup, we first examine the banks' financing decision in the absence of any restrictions. The safe banks' (non-random) profits π^s are given by

$$\pi^s = (1 + x)(D + W) - D - c_w W.$$

Using the balance sheet identity, $D + W \equiv 1$, this can be rewritten as

$$\pi^s = x - (c_w - 1)W. \tag{1}$$

Since $c_w > 1$, these profits are maximized, if capital W is minimized, i.e., if $W = 0$.[10] The safe banks' maximum profits are therefore $\pi^s = x$.

[9]On the costs of banking problems, see Hoggarth and Saporta (2001) or Boyd, Kwak, and Smith (2005).

[10]The first derivative of (1) with respect to W is $1 - c_w$, which is always negative.

Due to the possibility of insolvency, the risky banks' expected profit function π^r is slightly more complicated:

$$\pi^r = p[(1+x)(D+W) - D] + (1-p)\max\{(1-x)(D+W) - D, 0\} - c_w W. \quad (2)$$

With probability p, a high return is realized and the payoff is the same as for the safe banks. With probability $(1-p)$, a low return is realized. In that case, limited liability protects the banks from incurring a loss. This is represented by the $\max\{.\}$ expression in the second term of (2), which ensures a minimum payoff of zero to the risky banks. The risky banks' expected profits are also maximized if the amount of capital W is set to zero[11], i.e.,

$$\pi^r = px. \quad (3)$$

To sum up, without any regulation both types of banks will finance their assets with deposits exclusively. Because capital is more costly than deposits and because there is no (private) benefit to holding capital, banks do not hold any capital at all.

For the safe banks, no capital corresponds to the first-best allocation. By minimizing capital, the financing costs are minimized and hence the total surplus is maximized. Since these banks are riskless, no capital buffer is needed to prevent any insolvencies.

In contrast, the unregulated capital structure of risky banks may not be socially efficient. Specifically, if the social costs of insolvency are high, the risky banks' profit-maximizing financing choice may not be maximizing social surplus. To see this, note that risky banks without any capital cause expected insolvency costs of $(1-p)C$. In order to prevent bankruptcy, they have to hold an amount of capital x, which has an opportunity cost of $c_w x$. Therefore, if $(1-p)C > (c_w - 1)x$, expected welfare is maximized, if risky banks hold enough capital to avoid bankruptcy. While the cost of capital has to be borne by the banks, however, the banks themselves do not benefit from the reduced insolvency costs. It is due to this externality that the banks' privately optimal capital choice may not be socially optimal.

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[11]The first derivative of (2) with respect to W is always negative, both when $W \geq x$ and when $W < x$.

In the rest of the paper we assume that the costs of insolvency are high enough to ensure that the unregulated risky banks hold too little capital, i.e.,

$$C > \frac{(c_w - 1)x}{1 - p}. \tag{4}$$

Under assumption (4), restrictions on the risky banks' capital choice may improve efficiency.

2.2 Simple Leverage Ratio Restriction

The simplest and historically oldest form of capital regulation is a lower bound to the ratio of capital to total assets – a leverage ratio restriction. In the context of this model with normalized assets of size one, a leverage ratio restriction is equivalent to requiring a minimum amount of capital $W_{\min}$.

By setting $W_{\min} = x$, the risky banks' capital buffer is big enough to prevent any insolvencies. While such a crude leverage ratio restriction solves the externality problem of risky banks, it has the downside that it imposes an undue cost on safe banks. Since the supervisor is not able to identify the banks' types *ex ante*, the safe banks also have to hold a positive amount of capital – even though they would be safe enough without any capital. In effect, the distortion of excessive risk taking is removed at the expense of introducing another distortion in the form of raising the financing costs of safe banks above their first-best level.

An important motivation for Basel II is to solve this dilemma. The goal is to make required capital dependant on each bank's level of risk. To achieve such risk sensitivity, the main innovation vis-à-vis Basel I is the so-called Internal Ratings Based Approach. Under this approach, the banks determine the risk of their assets themselves and report this risk to the supervisor. The supervisor in turn sets the required capital on the basis of this report. The following section formalizes this approach.

2.3 Basel II: The IRB Approach

Under the Internal Ratings Based Approach (IRB Approach), a bank determines important risk parameters of its credit portfolio based on its own internal calculations. The bank then reports these parameters to the supervisor, who in turn sets the bank's required capital based on these reports.[12] In this paper, we model this approach as follows. In the first step, a bank announces its type. In the second step, the supervisor sets the bank's minimum capital conditional on the announced type.

In order to implement the first-best allocation, the supervisor requires the risky banks to hold capital $W_{\min}(risky) = x$ and the safe banks to hold no capital, $W_{\min}(safe) = 0$. The safe banks' decision is trivial, as they never have an incentive to pretend to be of the risky type. They always correctly report their type. The risky banks in contrast may choose whether to announce their type correctly or not. If risky banks claim to be safe, they do not have to hold any capital and their payoff is the same as in the absence of any regulation, $\pi^r(safe) = px$ (see equation 3). If they truthfully announce to be risky, due to the capital requirement $W = x$ their payoff is

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\begin{aligned}
\pi^r(risky) &= p[(1+x)(D+W) - D] + (1-p)\max\{(1-x)(D+W) - D, 0\} - c_w W \\
&= p[2x] - c_w x.
\end{aligned} \tag{5}
$$

Recalling that $p < 1 < c_w$, it becomes directly evident that the expected payoff of being honest is smaller than the payoff of being dishonest. This leads to the following sobering result.

Result 1 *Risk-sensitive capital requirements that rely on banks' voluntary disclosure of their risk profiles do not work.*

Anticipating the supervisor's behavior, the risky banks have a strong incentive to lie about their true type. By announcing their type as 'safe' they don't have to hold any capital, which corresponds to their preferred capital structure in the absence of any regulation. As a result, all banks announce that they are of the safe type, *independent* of

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[12]See Basel Committee on Banking Supervision (2006a) for details on this approach and on Basel II in general.

their actual type. In other words, capital adequacy rules that simply rely on the banks' own announcements of their risk do not work. This, of course, is not really surprising. Banking regulation only makes sense in the first place, if banks do not always behave in a socially efficient manner on a voluntary basis. If they always did act in a welfare maximizing way, there wouldn't be any need to regulate banks. Relying on the banks' own announcement of their risk, however, is equivalent to letting them directly choose their required capital themselves. Since unregulated risky banks have a tendency to hold too little capital, a mechanism that is based on the *voluntary* disclosure of banks' types will not correct this tendency.

Risky banks are not truthful about their type because they would incur a 'penalty' in the form of higher financing costs, if they were honest. In contrast, lying about their type does not affect their payoff. A possible solution to this problem consists in imposing sanctions on banks and, hence, reducing the dishonest banks' expected payoffs, whenever the supervisor finds out that a bank was lying *ex post*. This enhanced mechanism is analyzed in the next section.

2.4 Basel II: The IRB Approach Plus Sanctions

As in the previous section, banks first announce their type and, second, the supervisor imposes capital requirements based on these announcements. In a new, third step the supervisor examines banks after the returns have been realized. If a bank is not insolvent, the supervisor learns with probability q whether a bank has been dishonest.[13] Fourth, if a bank is detected as having misstated its type, the supervisor imposes a penalty F on the bank. This penalty consists of confiscating a fraction s of the bank's capital after profits, W_1, i.e., $F = sW_1$.

The case of safe banks again is trivial, because they always honestly announce their true type and are never detected as liars. Hence, their payoff is not affected by this enhanced IRB Approach. The risky banks' decision, however, is affected as the potential sanctions influence their profits. If a risky bank is honest, it has to hold

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[13]If the bank is insolvent, it has been dishonest with certainty. Due to limited liability, however, the supervisor cannot impose any sanctions in that case.

capital $W_{\min}(risky) = x$. In return, the bank is never sanctioned. Therefore, the honest risky bank's expected payoff $\pi^r(risky)$ is the same as before (see equation 5),

$$\pi^r(risky) = p[2x] - c_w x. \tag{6}$$

If the risky bank is dishonest, it is not required to hold any capital ($W = 0$ and $D = 1$). However, with probability q it will incur a penalty F. Therefore, the dishonest risky banks' expected payoff $\pi^r(safe)$ is now

$$\pi^r(safe) = p\left[(1+x)D - D - qF\right] \tag{7}$$

Using $F = sW_1 = s[(1+x)(D+W) - D] = sx$ yields

$$\pi^r(safe) = p\left(1 - qs\right)x. \tag{8}$$

Comparing (6) and (8), the risky bank's expected payoff of being honest is higher than the expected payoff of being dishonest, if and only if

$$qs > \frac{c_w - p}{p}. \tag{9}$$

As the right-hand side of condition (9) is always positive, risky banks can only be induced to be truthful if the supervisor's ability both to detect (q) and to punish (s) dishonest banks is sufficiently high. Note that both of these abilities, detection *and* punishment, are necessary to induce truth telling by risky banks. For instance, if the supervisor had perfect knowledge of banks' types ($q = 1$), but no powers to enforce any sanctions ($s = 0$), all risky banks would still lie about their type. The same is true for a tough ($s = 1$), but completely uninformed ($q = 0$) supervisor. This is summarized in the following result.

Result 2 *If the supervisor detects dishonest banks only with low probability or if the supervisor is weak (i.e., cannot enforce high penalties), risky banks misrepresent their type as 'low risk'.*

If condition (9) is violated, the IRB Approach does not work as intended. Risky banks fare better if they lie about their type than if they disclose their type correctly. This observation directly suggests a potential remedy for the problem: If one manages to raise the relative profitability of being honest, the incentive compatibility condition (9) may be relaxed in such a way as to render the truthful revelation of types the dominant strategy for all banks. The next section demonstrates that this can indeed be achieved by imposing an additional leverage ratio restriction on banks.

2.5   Basel II: The IRB Approach Plus Leverage Ratio Restriction

We extend the model by introducing a simple leverage ratio restriction. Independent of the announced type, all banks have to hold some minimum amount of capital $\hat{W}_{\min} \leq x$. Whether this additional constraint is actually binding or not depends on the type announced by each bank. If banks claim to be high-risk banks, the risk-weighted capital rule requires them to hold enough capital to avoid insolvency, i.e., $W_{\min} = x$. These banks have to hold at least as much capital as the leverage ratio restriction requires anyway. Hence, for them the leverage ratio restriction is not binding. It is binding, however, for banks that announce the type 'safe'. Based on the risk-weighted rules alone, they don't have to hold any capital. Therefore, for these banks the leverage ratio restriction represents the binding constraint.

Because the leverage ratio restriction is not binding for an honest risky bank, the expected payoff in this modified framework is the same as before (see equation 6). The expected payoff of a dishonest risky bank (equation 7), however, is altered due to the binding leverage ratio restriction:[14]

$$
\begin{aligned}
\hat{\pi}^r(safe) &= p \left[1 + x - (1 - \hat{W}_{\min}) \right] (1 - qs) - c_w \hat{W}_{\min} \\
&= p \left(1 - qs \right) \left(x + \hat{W}_{\min} \right) - c_w \hat{W}_{\min}. \quad (10)
\end{aligned}
$$

A comparison of (8) and (10) shows that a dishonest risky bank's expected payoff is

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[14]Recall the balance sheet identity $D + W \equiv 1$. Therefore, $D = 1 - \hat{W}_{\min}$.

lower in the presence of a leverage ratio restriction, $\hat{\pi}^r(safe) < \pi^r(safe)$. Furthermore, the expected payoff $\hat{\pi}^r(safe)$ is decreasing in the leverage ratio requirement $\hat{W}_{\min}$.

Since the honest banks' payoff is not affected, changes in the leverage ratio restriction directly affect the relative profitability of being honest and of being dishonest. The leverage ratio restriction $\hat{W}_{\min}(qs)$ that makes risky banks indifferent between lying and telling the truth can be determined by equating (6) and (10). Doing so yields the minimal, truth-inducing leverage ratio requirement

$$\hat{W}_{\min}(qs) = \frac{p(1-qs) - (2p - c_w)}{c_w - p(1-qs)}x. \tag{11}$$

This means that given the supervisor's abilities qs, the leverage ratio restriction $\hat{W}_{\min}(qs)$ defined by (11) in combination with the risk-sensitive capital requirement ensures that risky banks report their risks honestly:

Result 3 *If the supervisor imposes a leverage ratio restriction $\hat{W}_{\min}(qs)$ in addition to the risk-sensitive capital requirement, all banks announce their type truthfully.*

To better understand the mechanism that leads to this result, it is useful to rewrite the dishonest risky banks' payoff (10) as

$$\hat{\pi}^r(safe) = \left\{ p\left[1 + x - (1 - \hat{W}_{\min})\right] - c_w\hat{W}_{\min} \right\} - pqF, \tag{12}$$

where the sanction $F = s[1 + x - (1 - \hat{W}_{\min})] = s[x + \hat{W}_{\min}]$. Introducing or raising the capital ratio $\hat{W}_{\min}$ has two effects: First, as can be seen from the expression in curly brackets in equation (12), the banks' expected payoff excluding any potential sanctions is reduced. The higher the amount of capital that the banks have to hold, the more of the downside risk they have to bear themselves. In other words, the put option value of limited liability[15] is reduced. Second, the expected sanction increases as the leverage

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[15]In this model, the put option value of limited liability corresponds to the expected loss, which does not have to be borne by the bank owners, $(1 - p)(x - W)$. This is the absolute value of the limited-liability term in equation (2).

ratio is raised. This corresponds to the second term in equation (12). As the bank owners have to invest more of their own funds, there is a higher net worth of banks that the supervisor may confiscate. Both of these effects reduce the risky banks' expected payoff of understating their risks. Hence, by choosing a sufficiently high level of the leverage ratio, the supervisor can reduce the payoff of understating risks by enough to ensure that risky banks voluntarily choose to announce their risk type truthfully.

Furthermore, equation (11) reveals some interesting comparative statics. The lower the supervisor's ability to detect banks' true types (q) or the lower the supervisor's ability to enforce sanctions (s), the higher is the necessary leverage ratio restriction to ensure truth telling (i.e., $\partial \hat{W}_{\min}/\partial qs < 0$). In this sense, a simple leverage ratio restriction is a substitute for supervisory knowledge and power. If the supervisor can never detect banks' true types $(q = 0)$ or if the supervisor cannot enforce any sanctions $(s = 0)$, the capital regulation reduces to the simple leverage ratio restriction discussed in Section 2.2. In this case, the risk-sensitive capital requirement is irrelevant. At the other extreme, if the supervisor's abilities (qs) are high enough, an additional leverage ratio restriction is not needed: If condition (9) is fulfilled, $\hat{W}_{\min}(qs) = 0$.[16] For intermediate values of qs, some leverage ratio restriction $\hat{W}_{\min}(qs) > 0$ in addition to the risk-sensitive capital requirement is necessary to ensure truthful revelation of banks' risk types. The relationship between the supervisor's abilities qs and the minimum leverage ratio restriction $\hat{W}_{\min}(qs)$ is summarized in Figure 1.

Two comments on the analysis' robustness are in order. First, it has been assumed that there are only two types of banks. However, this is without any consequence for the results. As long as the leverage ratio is set in such a way that the riskiest type will behave honestly, any other, less risky types are also induced to reveal their risks truthfully. Since the threat of sanctions and the reduction in the put option value of limited liability are strong enough for the riskiest type – who gain the most from understating their risk –, they are sufficient to deter the less risky types from

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[16]If $(c_w - p)/p > 1$, i.e., if the cost of capital is very high and the probability of success is low, even a perfect supervisor $(qs = 1)$ is not sufficient to induce risky banks to be honest. In that case a leverage ratio restriction is indispensable.
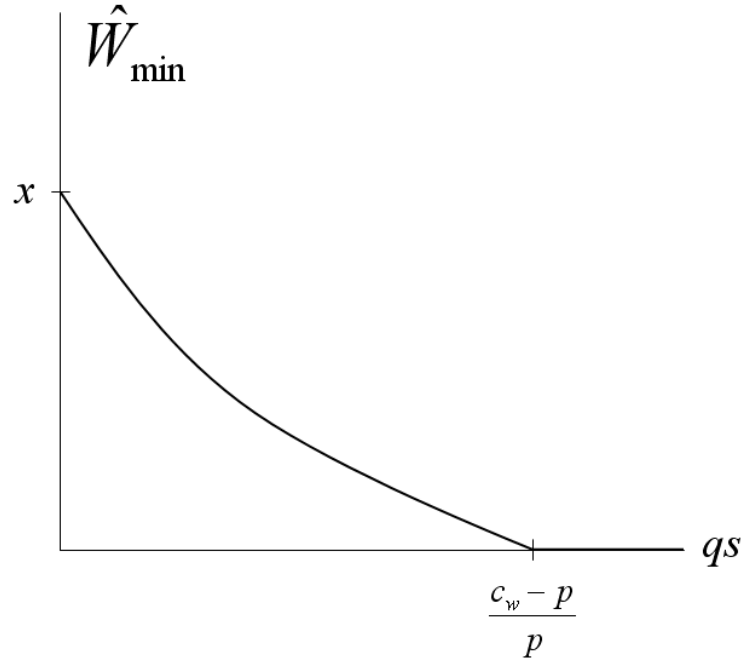
Figure 1: Relationship between the supervisor's ability and the leverage ratio restriction

understating their risks. Formally, this can be seen from equation (11): The required minimum level of capital $\hat{W}_{\min}(qs)$ is decreasing in the banks' success probability p. Safer banks, i.e., banks with a higher p, require a less strict leverage ratio restriction to be induced to reveal their type truthfully. Hence, if the leverage ratio is tight enough to align the riskiest banks' incentives, all other types will be honest, too.

The second comment on robustness concerns the modelling choice of viewing capital regulation as a problem of adverse selection. This may seem restrictive as the level of risk is generally under the control of banks. But the implications of the analysis would be unchanged, if banks could choose their levels of risk in a moral hazard setting. For the analysis to still be plausible and sensible, an underlying reason why banks choose different levels of risk would need to be modelled. Furthermore, to retain the opaqueness of banks, this reason must not be observable to the supervisor. For instance, bank owners or managers could differ with respect to their risk aversion. As the degree of risk aversion is not observable, the supervisor could not deduce the banks' levels of risk. In such a setting, as discussed in the previous paragraph, the supervisor

only needs to know the distribution of potential risk levels or, more generally, of the underlying characteristics. Once the leverage ratio restriction is set in such a way as to keep the riskiest banks honest, the same reasoning as in the adverse selection setup applies.

3   Discussion

A simple leverage ratio restriction is a rather blunt tool that does not take into account any differences between banks. In particular, it ignores any potential differences in risk profiles. Independent of the level of risk, all banks have to meet the same minimum capital ratio. As a consequence, some banks may be too safe, i.e., they have to hold more capital than would be socially optimal, while other banks may hold too little capital relative to the risks they incur. Risk-sensitive capital requirements for banks intend to reduce this regulatory distortion. Since banks by the nature of their business are highly opaque, however, the assessment of their risk by outsiders presents a major problem. Under Basel II, this problem is solved by delegating the risk assessment to the banks themselves. As this analysis demonstrates, however, this solution may be illusory.

Delegating the risk assessment to the banks, under Basel II using the Internal Ratings Based Approach, assumes that somehow the banks will have an incentive to truthfully reveal their risk. But this assumption violates the main reason why banks need to be regulated in the first place: They may not always have the incentive to behave in a socially efficient manner. Accordingly, if banks have a tendency to hold too little capital, why should banks be honest when reporting their risk to the supervisor, knowing precisely how this reporting translates into a minimum level of required capital? This paper shows that simply relying on banks' own announcement of their risk does not lead to adequate capital levels at risky banks. Risky banks have a strong incentive to hide the fact that they are risky in order to economize on costly capital.

To make a system of banks' reporting their own risk work, a mechanism to detect

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and to sanction untruthful banks is a necessary condition. Only the threat of being exposed and punished may induce risky banks to be honest about their risk assessment. Interestingly, the whole Basel II framework is completely silent about this question. It seems clear that a coordination of regulatory sanctions is a politically difficult matter. Nevertheless, it is essential for Basel II to work and to create a so-called level playing field. If supervisors either lack the ability to detect dishonest banks or are unable to enforce drastic sanctions, the new elaborate capital rules may be ineffective and in that sense may be inferior to a simple, risk-independent leverage ratio restriction.

The main message of this paper is that even if supervisors do have some ability to detect and sanction banks, an additional leverage ratio may be needed to enhance this ability. First, a minimum level of capital restricts the banks' put option value of limited liability. Imposing a minimum capital ratio ensures that at least some fraction of the negative consequences of incurring higher risks are borne by the bank owners themselves.[17] Second, a higher level of capital expands the possibility of supervisors to sanction banks. If the banks' net worth is higher, the supervisors are able to make banks pay higher penalty fees without jeopardizing the banks' solvency. This in turn makes the threat of sanctions more powerful *ex ante*. Together, these two effects reduce the banks' incentives to be dishonest about their type, as the difference in expected payoffs between lying and telling the truth is reduced or even eliminated.

The informational requirement to set the optimal leverage ratio restriction are very modest. The supervisor only needs to know the potential risk types of banks, but does not need to know the type of any particular bank. Unfortunately, the benefit of setting the incentives of risky banks correctly does not come without any costs. Since the risk-independent leverage ratio restriction has to be fulfilled by all banks, the costs of this additional measure have to be borne by the safe banks. They have to hold more capital than would be socially efficient and they become 'too safe'. In terms of keeping required capital as low as possible while ensuring banks' holding

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[17]Furthermore, but not modelled in this paper, this helps to reduce the most severe forms of excessive risk taking, which occur when banks have no or even negative capital. See Rochet (1992), for instance, for a rigorous presentation of this point, or Kane's (1989) account of the 'zombie banks' that were 'gambling for resurrection' during the Savings & Loans crisis in the 1980s in the United States.

an appropriate minimum amount of capital, however, the combination of risk-sensitive capital requirements and a leverage ratio restriction is superior to the alternative where all banks are subject to a simple leverage ratio which is appropriate for the riskiest type. For the riskiest banks, the complementary use of risk-sensitive capital requirements and a leverage ratio does not distort their capital structure. These banks end up holding exactly the first-best level of capital.

It may seem surprising at first sight that capital requirements based on banks' own risk assessments may not be effective. After all, under Basel I banks' internal models are used to measure and to report their market risks of their trading books. The amount of required capital is a direct function of the reported risks. And as in this paper's model, the supervisors use backtesting procedures to detect banks that were understating their risks. All in all, this mechanisms is working very well. So why might it not work when applied to whole banks? The big difference is precisely that under Basel I, the self-assessment of banks is limited to a fraction of their balance sheets. As a consequence, if an understatement of risks is detected, the supervisors is able to impose sanctions on the remaining, still solvent part of the banks. However, if the self-assessment is extended to the whole balance sheet, the supervisors may not be able to sanction banks because in many cases the banks will be insolvent when it will become obvious that they took higher risks than reported. Another important difference is that in the case of market risk in the trading books, there is daily data on exposures and returns, whose plausibility is readily verifiable as it is market data. As a result, the detection of dishonest banks is relatively easy. In other bank activities, in particular in the lending business, however, there is only very low-frequency data, whose quality is difficult to verify due to the banks' opaqueness. This renders the job of supervisors to detect dishonest banks extremely challenging.

4 Summary

In a model where unregulated banks hold too little capital relative to first best and where supervisors know the potential risk types of banks, but not the actual type

of each bank, the combination of a risk-sensitive requirement and a simple leverage ratio restriction represents the second-best capital regulation. The risk-sensitive requirement, where banks assess their own risks and report these assessments to the supervisors, makes sure that the banks' private information is taken into account when determining required capital. Since reporting a high level of risk results in a high level of (costly) required capital, however, risky banks have an incentive to understate their risks. In order to induce truthful revelation of their risks, the supervisors need some ability to detect and to punish dishonest banks. The threat of potential sanctions reduces banks' incentives to misrepresent their risks. To compensate for the limited ability of supervisors to detect dishonest banks and to enforce sanctions, the leverage ratio restriction may be necessary. Imposing a minimum capital ratio reduces the banks' benefit of understating their risks, as the potential savings in required capital are reduced, and it enhances the supervisors' threat of sanctions, as the higher net worth allows the supervisor to charge higher penalty fees.

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