Bank Size and Risk-Taking under Basel II†

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Abstract: This paper discusses the relationship between bank size and risk-taking under Pillar I of the New Basel Capital Accord. Using a model with imperfect competition and moral hazard, we find that small banks (and hence small borrowers) may profit from the introduction of an internal ratings based (IRB) approach if this approach is applied uniformly across banks. However, the banks’ right to choose between the standardized and the IRB approaches unambiguously hurts small banks, and may even lead to higher aggregate risk in the economy.

Keywords: Basel II, SME financing, IRB approach, bank competition, capital requirements.

JEL-Classification: G21, G28, L11.

This Version: November 28, 2004.

1 Introduction

Even before its coming into effect, the Basel II accord has come under fire by both academics and politicians. The critique by academics centers on the inability of the new accord to control aggregate risk because it neglects the endogeneity of risk and tends to have procyclical effects (see, e.g., Danielsson, Embrechts, Goodhart, Keating, Muennich, Renault, and Shin, 2001). In contrast, politicians are more worried about the potential consequences of the new accord for the provision of credit, most notably to small- and medium-sized enterprises (SMEs).†

Our paper describes a novel channel through which the new capital regulation (Pillar I of the new Basel accord) may harm especially small banks—and hence their

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†This actually led to an amendment of the accord, which now has special provisions for loans to SMEs.
borrowers who tend to be small as well—and thereby lead to an increase in aggregate risk. Interestingly, this result does not follow from the implementation of the internal ratings based (IRB) approach as such, but rather from the banks’ right to choose between the standardized and the IRB approaches. In fact, in our model the introduction of an IRB approach can be beneficial to small banks, if applied uniformly to all banks.

The problem arises from the implicit asymmetric treatment of small and large banks by the new regulation: The implementation of the IRB approach requires large initial investments in risk management technologies, which may deter small banks from choosing the IRB approach. In that case, only large banks profit from the reduction in capital requirements (and hence marginal costs) for safe loans in the IRB approach. This gives them a competitive advantage compared to small banks. In our model this may lead to reduced market shares and higher risk-taking at the small banks due to fiercer competition in the market for deposits. This also translates into an increase in aggregate risk in this economy. If, as is likely, small borrowers are mostly to be found at small banks, the shrinking market shares of small banks imply a cutback in the lending to these borrowers, and especially to the more creditworthy ones among them.²

The paper most closely related to ours is the one by Rime (2003) who analyzes the implications of the co-existence of the standardized and the IRB approaches on the risk choices of “sophisticated” and “unsophisticated” banks, distinguished by their eligibility for the adoption of the IRB approach. Rime shows that the sophisticated banks have a competitive advantage in the provision of low-risk loans (due to the lower capital requirement in the IRB approach), while the unsophisticated banks have a competitive advantage in the provision of high-risk loans (where the capital requirement is lower in the standardized approach). This situation leads to an sorting of borrowers in the sense that high risks tend to be financed by unsophisticated banks, and the low risks by sophisticated banks.

Our paper differs from that of Rime in several important respects. First, moral hazard effects are central to our argument. In the absence of moral hazard, regulation hardly influences bank behavior in our model. In contrast, Rime’s results are driven by cost differentials generated by differential regulation alone. Second, Rime models competition on the market for loans. We look at frictions in the deposit market, as the regulation’s impact on refinancing conditions may be crucial especially for small banks. Finally, we consider the effects of regulation on aggregate risk-taking in the economy instead of just analyzing the risk-taking of single institutions.

²It is now widely accepted that small banks have a competitive advantage in extending loans based on soft information to opaque borrowers, while large banks have an advantage in granting loans based on hard information to transparent borrowers. See Stein (2002) for a theoretical treatment and Haynes, Ou, and Berney (1999), Berger, Miller, Petersen, Rajan, and Stein (2001), Cole, Goldberg, and White (2004), and Carter and McNulty (2003) for empirical evidence.
The outline of the paper is as follows: In the next section, we describe the features of the New Basel Capital Accord that are relevant for our theoretical model. Section 3 contains the setup of the model. In section 4, we analyze a banking sector where all banks are regulated according to the standardized approach. Section 5 turns to the IRB approach. We first show what happens when all banks are required to adopt the internal ratings based approach; we then analyze the case where banks can choose between the standardized and the IRB approaches. Section 6 concludes.

2 The New Basel Capital Accord

Our analysis focuses on one particular—and arguably the most important—aspect of the New Basel Capital Accord: the enhancement of risk sensitivity of capital requirements for credit risk.\(^3\) Instead of the broad risk categories defined in the 1988 Basel Accord, the new accord envisions that capital requirements should depend directly on the debtors’ ratings, both external and internal. However, the information requirements are so high that only a subset of banks will be able to provide the necessary information in a reliable way. Therefore, the new accord offers banks the right to choose between a Standardized Approach and an Internal Ratings Based (IRB) Approach.\(^4\)

As in the old accord, banks are required to have a capital ratio of at least 8 percent. The capital ratio is defined as the regulatory capital divided by risk-weighted assets. The modifications in the new accord mostly affect the definitions of risk weights in the denominator of the capital ratio. In the model, we will not distinguish between regulatory capital and equity. Also instead of defining risk weights, we will use the effective capital requirements implied by such weights. For example, a risk weight of 75 percent would translate into an effective capital requirement of 6 percent.

The Standardized Approach is very similar to the old Basel Accord. Assets are grouped into different supervisory categories, giving rise to different risk weights. In contrast to the old accord, the standardized approach recommends the use of external ratings, if they exist, and specifies different risk weights for different rating classes; in most other cases, the risk weight is 100 percent. For a large part of corporate loans, especially to SMEs, there hardly exist any external ratings, so the 100 percent weight applies to them (as it did in the old accord). Similarly, there exist no external ratings for retail exposures; however, these loans are now subject to reduced risk weights of only 75 percent. In our model, we will assume that no

\(^3\)A detailed description of the new accord can be found in Basel Committee on Banking Supervision (2004).

\(^4\)Within the IRB Approach, banks can opt for a Foundation or Advanced IRB Approach, differing with respect to the extent that internal information is fed into the risk weight functions specified by the Accord.
external ratings are used in case of the standardized approach.\(^5\) Also we will not distinguish between corporate and retail exposures. Hence, the minimum capital requirement is flat with regard to the riskiness of loans in our model. Because of the similarity of the standardized approach and the old regulation, we will treat them as identical.

In the \textit{IRB Approach}, risk weights depend directly on external and internal assessments of asset risk. Banks estimate risk characteristics, such as the probability of default, on the basis of their internal data. These estimates then serve as inputs for the risk weight formulas specified by the Basel Committee. Retail exposures carry much smaller risk weights than corporate exposures. In our model, we define different capital requirements for different risk classes of assets, where the requirement for safe assets is below, and the one for risky assets above the flat requirement in the standardized approach. This is in line with the objective of the Basel Committee to broadly maintain the aggregate level of minimum capital requirements.\(^6\)

Note that both approaches contain special provisions with respect to SME lending: First, loans to SMEs can under certain conditions be categorized as retail loans in both approaches, benefitting from smaller capital requirements. In addition, the IRB Approach allows for a firm-size adjustment for exposures to SMEs, which also reduces capital requirements.\(^7\) Hence, SME lending is favored especially in the IRB approach, which reinforces the asymmetric treatment of large and small banks in the new accord.\(^8\)

Finally, the New Basel Accord contains a long list (51 paragraphs!) of minimum requirements that a bank has to fulfill to be eligible for the IRB Approach. Hence, the introduction of the IRB Approach requires high fixed costs, which may deter smaller and less sophisticated banks from using the IRB Approach. In that case, small banks would not benefit from the decrease in capital requirements for relatively safe exposures. This paper analyzes how this asymmetric treatment of large and small banks affects banks’ risk-taking and performance, as well as the aggregate risk in the economy. Note that our results do not hinge on the specific modelling details of the regulation. The main effect is driven by the combination of fixed costs and reduced marginal costs in the new regulation. Our specification is meant to model these features in the most simple way.

\(^5\)This is similar to the simplified standardized approach as described in Annex 9 of the new accord, Basel Committee on Banking Supervision (2004).

\(^6\)See Basel Committee on Banking Supervision (2004, paragraph 14). It is not clear, however, whether this statement refers to the initial portfolio structure or to the one after portfolio adjustments in reaction to the new accord.

\(^7\)The illustration in the official documentation suggests that the firm-size adjustment reduces capital requirements by 20 to 25 percent.

\(^8\)For an extensive discussion of this issue, see Berger (2004).
3 Model Setup

Banks Consider an economy with \( n + 1 \) chartered banks and no entry of new banks. The banks have limited liability and are risk neutral. They collect deposits and equity, and can invest these funds in a risky project. There are two types of projects that each bank can choose from. The safe project yields \( y_1 \) with probability \( p_1 \), and zero otherwise. The risky project returns \( y_2 \) with probability \( p_2 \), and zero otherwise. Assume that \( p_1 y_1 > p_2 y_2 \); hence, an investment in the safe project is efficient. Assume also that \( y_2 > y_1 \), so that there is scope for the typical risk-shifting problem à la Stiglitz and Weiss (1981).

There are two types of banks, large banks (\( L \)) and small banks (\( S \)). For simplicity we assume that there is only one large bank.\(^9\) It competes with all small banks for deposits, whereas the small banks compete only with the large bank, but not with other small banks. This is to capture the idea that small banks operate in isolated local markets where they compete with large banks maintaining a branch at the same location, but not with small banks from other locations. This structure simplifies the calculations considerably, because one can analyze each local market separately.

There is imperfect competition in the deposit market. Specifically, the supply of deposits takes the following form,\(^10\)

\[
d_L = D_L + n \sigma (r_L - r_S) \quad \text{and} \quad d_S = D_S/n + \sigma (r_S - r_L). \tag{1}
\]

The deposit volume \( d_j \) supplied to a bank of type \( j \) depends on the expected (gross) returns for depositors, \( r_j \), relative to the expected returns of its competitor bank.\(^11\) We implicitly assume that depositors are risk neutral and care about expected returns only. If, for example, depositors expect a bank to invest in the safe project, the relationship between the expected and the nominal rate is \( r_j = p_1 r_j^{\text{nom}} \), or equivalently \( r_j^{\text{nom}} = r_j/p_1 \).

\( D_L \) and \( D_S/n \) can be thought of as the banks’ clienteles. If two competing banks set identical interest rates, they collect their clienteles. The parameter \( \sigma \) measures depositors’ interest rate sensitivity. If \( \sigma \) is small, depositors are reluctant to switch

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\(^9\)Introducing more than one large bank would weaken the competitive position of the large bank, but would leave the general structure of the model unchanged.

\(^10\)This function is similar to the ones used in models of monopolistic competition, such as in Hart (1985). Note, however, that in our setup there is no free entry. The supply function could be motivated by a model with spatial competition à la Hotelling (1929), with transportation costs \( t \) that are inversely proportional to \( \sigma \). Because parameters for all small banks are identical, we do not have to distinguish between them (as long as they play pure strategies).

\(^11\)We ignore the depositors’ participation constraints. If deposit rates are low, depositors may choose to stay at home (and save on transportation costs) rather than to bring their money to the bank. We implicitly assume that depositors have to invest their money at a bank, they can only choose which bank to go to.
Figure 1: Time Structure

- Nature chooses banks’ clienteles, $D_j$ ($j = L, S$).
- The regulator sets the parameters $\alpha$, $\beta_1$, and $\beta_2$ (if applicable).
- Banks choose regulatory approach (if applicable).
- Banks announce their deposit rates, $r_j$.
- Banks first collect deposits, $d_j$, then equity, $k_j$. The depositors and the shareholder anticipate the project choices of banks.
- Banks choose a project and invest.
- Projects mature. If the project is successful, banks repay debt and equity; otherwise, they default and repay nothing.

banks even in the presence of relatively big interest rate differentials, and banks nearly enjoy monopolies with respect to their clienteles. If $\sigma$ is large, depositors are very sensitive to interest rates, and the deposit market is rather competitive. Note that the aggregate supply of deposits is completely inelastic and equal to $D_L + D_S$. Interest rates determine only how the aggregate supply is distributed among banks; they do not affect the aggregate supply. This means that any amount of deposits gained by one bank must be lost by another. Without loss of generality, we set $D_L + D_S = 1$, so that we can interpret $d_L$ and $d_S$ not only in absolute terms (deposit volumes), but also in relative terms (market shares). Furthermore, assume that $D_L > D_S$; the clientele of the large bank is larger than that of small banks.

In addition to deposits, banks can finance their lending activities through equity, $k_j$. Equity is provided by a single shareholder who demands an expected return of $r_k > p_1 y_1$. Equity finance is inefficient, but it may be used for regulatory purposes. We assume that depositors cannot observe the amount of equity taken in by their bank, so that banks cannot use their equity as a signal for project quality.\(^{12}\)

**Capital Adequacy**  We analyze two different regulatory approaches.

1. The *standardized approach* does not distinguish between projects with different risk levels. A fraction of at least $\alpha$ of a bank’s assets must be financed by equity. Hence, a bank’s balance sheet must satisfy the regulatory constraint

   \[ k_j \geq \alpha (d_j + k_j), \quad (2) \]

   where $d_j + k_j$ is the amount invested in risky assets.

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\(^{12}\)If depositors could observe $k_j$, a bank would have an incentive to take enough equity to convince depositors that it will take the safe project. As a consequence, there would be no reason for banking regulation. Assuming that $k_j$ is unobservable is a consistent way to leave some scope for regulation.
2. The internal ratings based (IRB) approach distinguishes between different risk classes. The regulatory constraint is

\[ k_j \geq \beta_1 (d_j + k_j), \quad (3) \]

if the bank chooses the safe project, and

\[ k_j \geq \beta_2 (d_j + k_j), \quad (4) \]

if the bank chooses the risky project, where \( \beta_2 > \alpha > \beta_1 \). This specification implicitly assumes that the regulator can observe the riskiness of banks’ assets. Finally, the IRB approach requires a sophisticated internal risk management, entailing a non-monetary fixed cost of \( C \).

Figure 1 displays the time structure of the model. In the following, we will characterize the equilibria of the model under different types of capital regulation.

4 The Standardized Approach

In this section, we assume that all banks must take the standardized approach.

4.1 Risk Choice of Banks

In this model there is a simple decision rule concerning banks’ project choices. A bank will choose the risky project if and only if expected returns on deposits exceed a critical interest rate, \( r^{\text{crit}} \). If a bank collects \( d \) units of deposits and \( k \) units of equity, it can invest \( d + k \) in risky assets. If the bank offers an expected return of \( r \), the bank’s nominal debt amounts to \( dr/p_1 \), given that depositors anticipate the bank to take the safe project. Since equity cannot be used as a signal, regulatory constraints will always bind, \( \alpha = k/(d + k) \) and \( 1 - \alpha = d/(d + k) \).

If the shareholder obtains a fraction \( \delta \) of profits, the expected profits of the bank are, net of repayments to the debt and equity holders,

\[ \Pi^1 = (1 - \delta) p_1 (y_1 (d + k) - r d/p_1), \quad (5) \]

\[13\] At first sight, this assumption may seem unappealing. Why, then, does the regulator not simply prohibit banks from taking risky (inefficient) projects? This apparent inconsistency can be resolved by assuming that some banks have access to a third asset that yields \( y_3 \gg y_2 \) with probability \( p_2 \), with \( p_2 y_3 \gg p_1 y_2 \). Hence the third project is still risky, but highly profitable. Now if the regulator would ban risky projects, he would force all banks to take the safe (and for many banks inefficient) project.

\[14\] The index \( j \) is omitted when there is no danger of confusion.
given that the bank chooses the safe project as anticipated by their depositors. If, however, depositors anticipate the bank to choose the safe project, whereas the bank opts for the risky project, expected profits are

\[ \Pi_2 = (1 - \delta) p_2 (y_2 (d + k) - r d/p_1). \] (6)

The critical expected return that equalizes \( \Pi_1 \) and \( \Pi_2 \) is

\[ r_{\text{crit}} = \frac{d + k}{d} p_1 \frac{p_1 y_1 - p_2 y_2}{p_1 - p_2} = \frac{p_1}{p_1 - p_2} \frac{p_1 y_1 - p_2 y_2}{1 - \alpha}. \] (7)

If the shareholder anticipates that the bank takes the safe project, the expected payment to him amounts to

\[ k r_k = \delta (p_1 y_1 (d + k) - r d), \]

yielding an expected return of \( r_k \) if the bank indeed chooses the safe project. Solving for \( \delta \) and substituting into (5), we get

\[ \Pi_1 = (d + k) p_1 y_1 - r d - k r_k. \]

Considering further that \( k = d \alpha / (1 - \alpha) \) implies

\[ \Pi_1 = d \left( \frac{p_1 y_1 - \alpha r_k}{1 - \alpha} - r \right), \]

Following the same procedure for the case of the risky project and combining the two profit functions, we get expected profits of

\[ \Pi = d \left( \frac{p_1 y_i - \alpha r_k}{1 - \alpha} - r \right), \] (8)

with \( i = 1 \) (safe project) for \( r \leq r_{\text{crit}} \) and \( i = 2 \) (risky project) for \( r > r_{\text{crit}} \).

Note that capital adequacy has two effects on the profitability of banks. First, for a given project choice, it deteriorates profitability, because the bank is forced to refinance itself through expensive equity.\(^{15}\) Second, a higher \( \alpha \) increases the critical interest rate \( r_{\text{crit}} \). If this induces a bank to take the efficient project where it otherwise would have chosen the inefficient one, profitability is enhanced.

### 4.2 Reaction Function of Banks

We start with the analysis of a single bank (without loss of generality, the large bank) in a specific local market. The bank takes market conditions (here the deposit rate of the competing small bank) as given.

\(^{15}\)In general, part (but not necessarily all) of this cost is going to be shifted to depositors in the form of reduced interest rates.
If competition is weak and interest rates are low, moral hazard is not a problem and the large bank will choose the safe project. We will establish constraints on $\sigma$ afterwards. Substituting (1) into (8) yields

$$\Pi^1_{L} = (D_{L} + n \sigma (r_{L} - r_{S})) \left( \frac{p_{1} y_{1} - \alpha r_{k}}{1 - \alpha} - r_{L} \right).$$

The first order condition implies

$$r_{L} = \frac{1}{2} \left( \frac{p_{1} y_{1} - \alpha r_{k}}{1 - \alpha} + r_{S} - \frac{D_{L}}{n \sigma} \right). \quad (9)$$

The bank’s expected profits are then

$$\Pi^1_{L} = \frac{n \sigma}{4} \left( \frac{p_{1} y_{1} - \alpha r_{k}}{1 - \alpha} - r_{S} + \frac{D_{L}}{n \sigma} \right)^2,$$

and its market share is

$$d_{L} = \frac{n \sigma}{2} \frac{p_{1} y_{1} - \alpha r_{k}}{1 - \alpha} + \frac{D_{L} - n \sigma r_{S}}{2}.$$

When the competitor’s rate $r_{S}$ rises, the bank reacts by also offering higher rates (see (9)). At some point $r_{S}^{\text{kink}}$, it reaches the critical rate with $r_{L} = r_{L}^{\text{crit}}$,$^{16}$

$$r_{S}^{\text{kink}} = 2 r_{L}^{\text{crit}} + \frac{D_{L}}{n \sigma} - \frac{p_{1} y_{1} - \alpha r_{k}}{1 - \alpha}. \quad (10)$$

When $r_{S}$ rises further, the bank does not immediately offer higher deposit rates, but it continues to offer $r_{L}^{\text{crit}}$ (hence the kinks in Figure 2). Otherwise, depositors would anticipate that the bank will choose the risky project and demand a higher risk spread. The bank’s market share is now simply $d_{L} = D_{L} + n \sigma (r_{L}^{\text{crit}} - r_{S})$.

However, at some point $r_{S}^{\text{jump}}$, market rates are so high that the bank prefers to raise its rate, thereby admitting that it will take the risky project, but “regaining” some volume. After this point, the bank sets a deposit rate of

$$r_{L} = \frac{1}{2} \left( \frac{p_{2} y_{2} - \alpha r_{k}}{1 - \alpha} + r_{S} - \frac{D_{L}}{n \sigma} \right). \quad (11)$$

$^{16}r_{S}^{\text{kink}}$ is the competitor’s critical rate $r_{S}$ such that $r_{L}$ has a kink, not vice versa.
The thick curve is the reaction function of the large bank, the thin curve is that of small banks.

The nominal rate is then $r_L/p_2$. The regime switch occurs when expected profits of the bank are equal in both regimes,

$$(D_L + n\sigma (r_{crit} - r_S)) \left( \frac{p_1 y_1 - \alpha r_k}{1 - \alpha} - r_{crit} \right) = \frac{n \sigma}{4} \left( \frac{p_2 y_2 - \alpha r_k}{1 - \alpha} - r_S + \frac{D_L}{n \sigma} \right)^2.$$

At the critical $r_S^{jump}$, the deposit volume of the bank must jump up: An infinitesimal increase in the deposit rate leads to a strictly positive deterioration in refinancing conditions, hence the benefit must also be strictly positive. This can only be achieved by a jump of expected deposit rates (illustrated in Figure 2).

Summing up, the large bank’s reaction function is

$$r_L = \begin{cases} \frac{1}{2} \left( \frac{p_1 y_1 - \alpha r_k}{1 - \alpha} + r_S - \frac{D_L}{n \sigma} \right) & : r_S \leq r_S^{kink}, \\ r_{crit} + r_S - \frac{D_L}{n \sigma} & : r_S^{kink} < r_S \leq r_S^{jump}, \\ \frac{1}{2} \left( \frac{p_2 y_2 - \alpha r_k}{1 - \alpha} + r_S - \frac{D_L}{n \sigma} \right) & : r_S^{jump} < r_S. \end{cases} \quad (12)$$

The reaction functions of small banks have an analogous form. Figure 3 depicts the reaction functions of both bank types for a numerical example.

### 4.3 Equilibrium

The equilibrium lies at the intersection of the reaction functions. Given the geometric structure of those functions, there is at least one equilibrium. However, as is also clear from the picture, the intersection may not be unique. For example, all banks may take the safe project (with deposit rates below the jump) in one equilibrium, whereas they may all take the risky project (with deposit rates above the jump) in
another equilibrium. In such cases, we pick the Pareto-superior equilibrium with the lower deposit rates.

Banks’ behavior can be characterized by a number of regimes, differing with respect to the banks’ risk-taking and interest rate policies. It depends on the intensity of competition in which regimes the banks find themselves. In our discussion, we start from a regime with low competition (small $\sigma$) and then consider what happens if $\sigma$ is increased. Figure 4 illustrates the effects of competition on banks’ deposit rates, volumes, profits, and on welfare. Figure 5 displays the areas of the different regimes for different parameter constellations.

**Regime 1: All banks below the kink**  When both types of banks are below the kink, moral hazard is not a problem, and all banks choose the safe project. Equilibrium deposit rates are

$$r_L = \frac{p_1 y_1 - \alpha r_k}{1 - \alpha} - \frac{D_L}{n\sigma} + \frac{D_L - D_S}{3n\sigma},$$

$$r_S = \frac{p_1 y_1 - \alpha r_k}{1 - \alpha} - \frac{D_S}{n\sigma} - \frac{D_L - D_S}{3n\sigma}.$$  

As equilibrium deposit volumes, we obtain

$$d_L = D_L - \frac{D_L - D_S}{3},$$

$$d_S = D_S + \frac{D_L - D_S}{3n},$$

and expected profits are

$$\Pi_L = \frac{1}{9n\sigma} (2D_L + D_S)^2 \quad \text{and} \quad \Pi_S = \frac{1}{9n\sigma} (2D_S + D_L)^2.$$  

In equilibrium, small banks set deposit rates more aggressively than large banks ($r_S > r_L$) in order to attract market share. When competition increases ($\sigma$ rises), both types of banks increase their deposit rates.

**Regime 2: Small banks above the kink**  At some point the small banks, offering the higher rate, are going to reach the critical rate $r_{\text{crit}}$. They know that if they raised deposit rates further, depositors would anticipate that the bank chooses the inefficient project and demand an additional default premium. Therefore, small banks optimally leave their rates unchanged, foregoing some market share. This weakens competition for the large bank, who now sets a lower rate than it would in the absence of the moral hazard problem. However, as long as its interest rate is below $r_{\text{crit}}$, the large bank increases its interest rate as $\sigma$ rises, albeit less strongly than before. Formally, interest rates are given by

$$r_L = \frac{1}{2} \left( \frac{p_1 y_1 - \alpha r_k}{1 - \alpha} + r_{\text{crit}} - \frac{D_L}{n\sigma} \right),$$

$$r_S = \frac{1}{2} \left( \frac{p_1 y_1 - \alpha r_k}{1 - \alpha} - r_{\text{crit}} + \frac{D_L}{n\sigma} \right).$$
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\[ r_S = r_{\text{crit}}, \]  

and market shares by

\[
\begin{align*}
  d_L &= \frac{D_L}{2} + \frac{n \sigma}{2} \left( \frac{p_1 y_1 - \alpha r_k}{1 - \alpha} - r_{\text{crit}} \right), \\
  d_S &= \frac{D_L + 2 D_S}{2 n} - \frac{\sigma}{2} \left( \frac{p_1 y_1 - \alpha r_k}{1 - \alpha} - r_{\text{crit}} \right).
\end{align*}
\]

**Regime 3: All banks above the kink**  At some point, large banks also reach the critical rate \( r_{\text{crit}} \). In this case, both types of banks offer the same expected rate

\[ r_L = r_S = r_{\text{crit}}. \]

The nominal rate is also identical because all banks take the safe project. Hence no bank can attract any customers from another bank, and deposit volumes are simply equal to the respective clienteles,

\[ d_L = D_L \quad \text{and} \quad d_S = D_S. \]

**Regime 4: Small banks above the jump**  At some point, it becomes profitable for small banks to raise deposit rates and opt for the risky project. Depositors at these banks now anticipate the risky project. Therefore, nominal rates must jump up to include the higher default premium. However, the small banks raise interest rates even further to gain market shares. The large bank sticks to the lower deposit rate, thereby accepting a sharp decrease in its market share. So equilibrium rates are

\[
\begin{align*}
  r_L &= r_{\text{crit}}, \\
  r_S &= \frac{1}{2} \left( \frac{p_2 y_2 - \alpha r_k}{1 - \alpha} + r_{\text{crit}} - \frac{D_S}{n \sigma} \right),
\end{align*}
\]

yielding the deposit volumes

\[
\begin{align*}
  d_L &= \frac{2 D_L + D_S}{2} - \frac{n \sigma}{2} \left( \frac{p_1 y_1 - \alpha r_k}{1 - \alpha} - r_{\text{crit}} \right), \\
  d_S &= \frac{D_S}{2 n} + \frac{\sigma}{2} \left( \frac{p_1 y_1 - \alpha r_k}{1 - \alpha} - r_{\text{crit}} \right).
\end{align*}
\]

\[17\]If small and large banks are sufficiently asymmetric \((D_L \gg D_S)\), or if the moral hazard problem is small \((p_1 y_1 \approx p_2 y_2)\), it may happen that the small banks reach \( r_{\text{jump}} \) before the large bank reaches \( r_{\text{crit}} \). This would give rise to an additional regime. We do not explicitly treat this regime in the paper because it does not provide any additional insights, but just makes the discussion more cumbersome.
The increase in small banks’ interest rates may be so large that the large bank also finds it beneficial to raise its rate. In this case, regime 3 may directly be followed by regime 5.\(^\text{18}\)

**Regime 5: All banks above the jump** Finally, even the large bank finds it profitable to raise deposit rates sharply and signal that it will take the risky project. From this point on, all banks take the risky project. The small banks react by raising interest rates as well, but not as sharply as the large bank. Therefore, the small banks will lose some of the market share they had gained before. However, the small banks’ rate continues to exceed the rate at the large bank. Similar to (13) and (14), we obtain

\[
\begin{align*}
    r_L &= p_2 y_2 - \alpha r_k \frac{D_L}{n \sigma} + D_L - D_S \frac{D_L - D_S}{3 n \sigma}, \\
    r_S &= p_2 y_2 - \alpha r_k \frac{D_S}{n \sigma} - D_L - D_S \frac{D_L - D_S}{3 n \sigma}.
\end{align*}
\]

The expressions for deposit volumes and expected profits are the same as in regime 1 (but profits are much lower in this case due to higher competition and, hence, interest rates).

We now discuss how banks’ profits are affected by the different regimes (see the bottom left panel of figure 4). In general, increasing competition decreases profits. The reason is that banks have to offer higher interest rates to prevent their depositors from switching to another bank. Thereby they exert a negative externality on their competitors.\(^\text{19}\) However, in some regimes, the moral hazard problem prevents some banks from raising rates, which implies a drop in their market shares and profits if the competitor bank continues to raise rates. In those cases, the deposit rate is a suboptimal response to the rate of the competitor bank, and the bank’s profits decrease not only in absolute terms, but also relative to the competitor bank. If both large and small banks are unwilling to raise rates (regime 3), an increase in \(\sigma\) leaves volumes, rates and profits unaffected. However, at some point, small banks find it profitable to increase deposit rates sharply. Even though this reduces their margins, it may boost profits due to the gains in market shares. Hence, in regime 4, small banks may actually profit from an increase in competition.\(^\text{20}\) Similarly, the large bank’s profits may rise with competition in regime 2 for certain parameter constellations.

Finally, we want to analyze the effects of competition on welfare. In our model, welfare consists of only two components: the proceeds from the project, and the

\(^{18}\)See Figure 5 for an illustration.

\(^{19}\)In our model, the negative externality is very strong because of the inelastic aggregate supply of deposits. The qualitative result would still hold if the supply of deposits was elastic (but not perfectly).

\(^{20}\)See figure 4 for an example of this phenomenon.
opportunity costs from (inefficient) equity finance. Interest payments are welfare-neutral. Hence, the welfare function is

$$W = \sum_j [(p_j y_j) d_j - (r_k - p_j y_j) k_j]$$

$$= \sum_j d_j \frac{p_j y_j - \alpha r_k}{1 - \alpha}.$$  \hfill (26)

The aggregate opportunity costs from equity finance ($r_k \alpha/(1 - \alpha)$) do not depend on $\sigma$. Hence, welfare is affected by the banks’ project choices alone. Welfare is highest (and constant) in regimes 1 to 3 when all banks choose the safe project, and lowest (and constant) in regime 5 when all banks choose the risky project. In regime 4, the banks choosing the risky project expand, such that welfare decreases in this regime. Welfare jumps discretely between the regimes 3 and 4, and 4 and 5, respectively, because at that point, one type of banks switches its entire portfolio from the safe to the risky project. Overall, welfare decreases in competition in our model.

**4.4 The Impact of Capital Regulation**

So far, we have been holding capital regulation constant. Now we ask how the banks respond to a tightening in capital adequacy. We first consider what happens within
the regimes described in the preceding section. Then we discuss regime switches triggered by the tightened regulation.

In regimes 1 and 5, tightened capital adequacy leaves deposit volumes and profits unaffected, but leads to the same decrease in deposit rates at small and large banks,

\[
\frac{\partial r_L}{\partial \alpha} = \frac{\partial r_S}{\partial \alpha} = -\frac{r_k - p_1 y_1}{(1 - \alpha)^2} < 0.
\]

This implies that the costs of equity finance are shifted entirely to the depositors in this regime, whereas the banks’ profits are not affected by the regulation.

If only the small banks are above the kink (regime 2), tightened capital adequacy implies higher rates and volumes for the small banks,

\[
\frac{\partial r_S}{\partial \alpha} = \frac{\partial r_{\text{crit}}}{\partial \alpha} = \frac{p_1}{p_1 - p_2} \frac{p_1 y_1 - p_2 y_2}{(1 - \alpha)^2} > 0
\] and

\[
\frac{\partial d_S}{\partial \alpha} = \sigma \frac{p_1 (r_k - p_2 y_2) + p_2 (r_k - p_1 y_1)}{2 (p_1 - p_2)(1 - \alpha)^2} > 0.
\]

The reason is that an increase in \(\alpha\) raises \(r_{\text{crit}}\), thereby relaxing the constraints on the small banks. By raising rates to the new \(r_{\text{crit}}\), the small banks can attract more deposits and may increase their profits. Given the inelastic aggregate supply of deposits, the large bank must shrink. The effect on the large bank’s deposit rate is ambiguous. On the one hand, the rate increase by the small banks induces the large bank to raise its rate as well. On the other hand, the investment becomes less profitable due to higher equity costs, which reduces competition for deposits and induces the large bank to decrease its rate. In both cases, the large bank’s profits may fall.
When both types of banks are above the kink, but below the jump (regime 3), a tightened regulation raises deposit rates for both types of banks,

\[ \frac{\partial r_L}{\partial \alpha} = \frac{\partial r_S}{\partial \alpha} = \frac{\partial r_{\text{crit}}}{\partial \alpha} > 0. \]  \hspace{1cm} (28)

As before, the rise in the critical rate relaxes the constraints on banks. However, in this case the relaxation is not beneficial to the banks because they cannot attract any deposits from their competitors. Volumes remain unchanged, and profits of both types of banks decrease. The constancy of deposit volumes is a result of our somewhat extreme assumption that deposit volumes are constant at the aggregate level. If we relaxed this assumption, aggregate volumes would actually increase in the presence of tightened regulation.\(^{21}\) This result is interesting because it implies that a tightening of regulation may have an expansionary effect on the banking sector. The reason is that higher capital adequacy attenuates the moral hazard problem. Therefore, let us state the following remark.

**Remark 1** \(\text{Tightened capital regulation may raise deposit rates for all types of banks.}\)

When markets are so competitive that small banks prefer to take the risky projects (regime 4), the effects of tightened capital regulation are the same as in regime 2, with reverse roles. The large bank will expand at the expense of small banks; the large bank will gain, the small banks will lose.

The preceding discussion suggests that a tightening of capital requirements may lead to an expansion of one type of bank in certain cases. Of particular interest is regime 2, where small banks may expand in the face of tightened regulation. If one assumes that small banks are specialized in financing small and medium enterprises (SMEs), this result implies that the financing of SMEs is not necessarily choked by capital adequacy. In fact, the opposite may be true. This observation is summarized in the following remark.

**Remark 2** \(\text{Higher capital requirements may induce small banks to expand.}\)

Note that in our model, a tightening of capital regulation always reduces welfare in the absence of regime switches. The reason is that higher capital adequacy increases the inefficiencies arising from equity finance, while leaving the aggregate level of deposits unchanged. In the presence of a very elastic aggregate supply of deposits, welfare increases would be conceivable.

Within our model, welfare increases can only be obtained if the tightening of capital regulation induces a regime switch, rendering banks less likely to take the risky

\(^{21}\)However, profits may decrease even in the presence of an elastic aggregate supply of deposits.
Bank Size and Risk-Taking under Basel II

projects. Figure 5 illustrates this effect for a numerical example: Starting from a regime where some banks opt for the risky project (regimes 4 or 5), an increase in $\alpha$ may lead to a switch into a regime where both types of banks opt for the safe project (holding competition $\sigma$ constant). The higher $\alpha$, the smaller is the range of $\sigma$, for which at least one type of banks opts for the risky project (regimes 4 and 5). The following proposition confirms this conjecture for any parameter constellation.\footnote{The proofs of all propositions are found in the Appendix.}

**Proposition 1** Higher capital requirements raise the critical levels of competition, above which one or both types of banks opt for the risky project.

In other words, higher capital requirements reduce the set of parameters where risky projects are chosen. Graphically, this proposition implies that, in figure 5, the border between the area where all banks choose the safe projects (regimes 1, 2, and 3) and the remaining area (regimes 4 and 5) is strictly increasing. The same is implied for the border between the regimes 4 and 5. In fact, higher capital requirements “move” all borders towards higher competition.\footnote{The proofs for the other borders are straightforward.}

We can conclude that regulation is always welfare-decreasing in our model within regimes. However, tightened regulation may increase welfare because it may induce banks to switch from the risky to the safe project. The stricter regulation, the more competitive markets must be to induce banks to take risky projects. If the net effect of higher inefficiencies from equity finance and lower risk-taking on welfare is positive, one may say that the capital regulation achieves its goal.

## 5 The IRB Approach

Up to now, we have discussed an economy in which all banks use the standardized approach. Now we turn to the IRB approach. We first consider what happens if all banks must adopt the IRB approach (Section 5.1). Then, we analyze the implications of banks’ right to choose between the two approaches, as envisioned by the new Basel accord (Section 5.2).

### 5.1 Compulsory IRB Approach

In this section, we assume that the IRB approach according to (3) and (4) is compulsory for all banks. What are the implications of switching from the standardized to the IRB approach? Clearly, the answer depends on whether regulation has become stricter or looser. We assumed above that banks need less capital if they choose
the safe project, compared to the standardized approach, and more capital if they choose the risky project, i.e. \( \beta_1 < \alpha < \beta_2 \).

Using the same procedure as in section 4.1, we derive the critical rate \( \dot{r}_{\text{crit}} \). Here the assumption of a single shareholder becomes crucial. It implies that the equity investor can infer the bank’s project choice from the amount of equity that the bank raises. Let \( \Pi^1 \) again denote the expected profits of a bank that chooses the safe project as anticipated by the depositors, and \( \Pi^2 \) the profits of a bank that deviates by taking the risky project. We then get

\[
\Pi^1 = (1 - \delta_1) p_1 (y_1 (d + k_1) - r d/p_1) \quad \text{with} \quad k_1 = \delta_1 p_1 (y_1 (d + k_1) - r d/p_1)/r_k \\
\Pi^2 = (1 - \delta_2) p_2 (y_2 (d + k_2) - r d/p_1) \quad \text{with} \quad k_2 = \delta_2 p_2 (y_2 (d + k_2) - r d/p_1)/r_k
\]

if the bank takes the safe project, and

\[
\Pi^1 = d \left( \frac{p_1 y_1 - \beta_1 r_k}{1 - \beta_1} - r \right), \quad \text{and} \quad \Pi^2 = d \left( \frac{p_2 y_2 - \beta_2 r_k}{1 - \beta_2} - \frac{p_2}{p_1} r \right).
\]

The critical deposit rate is then

\[
\dot{r}_{\text{crit}} = \frac{p_1}{p_1 - p_2} \left( \frac{p_1 y_1 - r_k}{1 - \beta_1} - \frac{p_2 y_2 - r_k}{1 - \beta_2} \right).
\] (29)

One can check that for \( \beta_1 = \beta_2 = \alpha \), the critical rate is the same as in the standardized approach (see (7)). Comparative statics are \( \partial \dot{r}_{\text{crit}} / \partial \beta_1 < 0 \) and \( \partial \dot{r}_{\text{crit}} / \partial \beta_2 > 0 \). Raising \( \beta_1 \), while holding \( \beta_2 \) constant, lowers the relative costs of risk-shifting; raising \( \beta_2 \), while holding \( \beta_1 \) constant, increases them. Given our assumptions on \( \beta_1 \) and \( \beta_2 \), \( \dot{r}_{\text{crit}} \) is strictly larger than \( r_{\text{crit}} \). In contrast to the standardized approach, the critical rate also depends on the cost of equity \( r_k \), with \( \partial \dot{r}_{\text{crit}} / \partial r_k > 0 \). Higher costs of capital make risk-shifting less attractive.

The introduction of the IRB approach has two effects: First, it decreases the capital requirements for safe projects and increases them for risky projects. The effects

\[\text{\textsuperscript{24}}\text{For distinction, we put a dot on variables that refer to the compulsory IRB approach.}\]

\[\text{\textsuperscript{25}}\text{The fact that } \dot{r}_{\text{crit}} \text{ lies above (and possibly well above) } r_{\text{crit}} \text{ is critical for the model when we introduce the right to choose between different regulatory approaches. If, for example, banks’ deposit rates are constrained by } r_{\text{crit}} \text{ (as in regime 3), they have an incentive to implement the IRB approach in order to overcome this constraint and raise rates, but not farther than } \dot{r}_{\text{crit}}.\]
are similar to the ones from a loosened or tightened capital regulation in the stan-
dardized approach. Second, it raises the critical rate. The qualitative properties of 
banks’ reaction functions are just as under the standardized approach (see Figure 3). 
As a result, we again have five regimes, depending on whether banks are below or 
above the kinks and the jumps of their reaction functions.

We start again by describing the behavior of banks within regimes, before discussing 
regime switches. If both types of banks are below the kink (regime 1), they will 
offer higher deposit rates. Lower capital requirements make the investment more 
profitable, hence the competition for deposits becomes more severe. The opposite 
is true when all banks are above the jump (regime 5). Here, because both types of 
bank take the risky project, capital adequacy is tightened, and deposit rates drop.

In regime 2, all banks raise their rates. Small banks raise their rates because the 
increase in the critical rate (from $r^{\text{crit}}$ to $\dot{r}^{\text{crit}}$) relaxes the constraints on their interest 
rates policies. This allows them to “recapture” some market share from the large 
bank. Remarkably, this may even lead to increased profits. The large bank raises 
its rate for two reasons: First, because the small banks raise their rates, and second, 
because investing becomes more profitable. Since the large bank shrinks at the same 
time, its profits are always decreased compared to the standardized approach. These 
observations lead us to the following remark.

**Remark 3** Small banks may benefit from the transition from the standardized to 
the IRB approach in the form of increased volumes and profits.

This result is interesting because it appears to contradict the conventional wisdom 
that small borrowers are bound to suffer from the IRB approach. We see that 
small banks may actually gain relative to large banks from implementing the IRB 
approach. If we believe that small banks serve primarily small borrowers, our results 
suggest that the IRB approach may actually have an expansionary effect on SME 
borrowing.

In regime 3, all banks raise rates after the transition to the IRB approach because 
of the increase in the critical rate. This results in lower profits for both bank types. 
Finally, in regime 4, the large bank raises its rate because of the increase in the 
critical rate. The reaction of small banks is ambiguous. On the one hand, they 
want to raise rates in reaction to the large bank’s rate increase. On the other hand, 
they want to cut rates because they are subject to a stricter capital requirement, $\beta_2$, rendering investment less attractive.

As before, we are most interested in whether the transition from the standardized 
to the IRB approach can deter banks from choosing the risky project. In graphical 
terms (see Figure 5), this would again imply a move of the borders between the 
regimes 3, 4, and 5 towards higher competition. Figure 6 illustrates this for a 
numerical example. The left panel shows equilibrium interest rates in the IRB
Figure 6: Equilibrium Deposit Rates and Regime Switches, IRB Approach

In the left panel, the thick line denotes the large bank, the thin line the small banks. Dashed vertical lines mark the regime switches in the standardized approach; the dashed horizontal line is the critical rate in the standardized approach. The right panel plots the critical $\sigma$'s of the regime switches for varying $\Delta \beta = \beta_2 - \beta_1$. The thick line refers to the switch between regime 3 and regimes 4 and 5. The dashed vertical line refers to the parameter constellation of the left panel.

approach for different levels of competition. For comparison, it also shows the levels of competition at which regime switches occurred in the standardized approach. Apparently, the regime switches move towards more competition. In the right panel, the critical $\sigma$'s of the regime switches are plotted for varying $\Delta \beta = \beta_2 - \beta_1$, measuring the degree of differentiation by the IRB approach. The thick curve denotes the critical $\sigma$, above which the small banks, and possibly also the large banks, choose the risky project. The curve increases monotonically; hence, a more pronounced IRB approach reduces the set of parameters where banks take excessive risk.

The following proposition claims that these results are true for any parameter constellation. As before, the other borders move as well towards higher competition. The proofs are analogous.

**Proposition 2** A transition to the IRB approach raises the critical levels of competition, above which one or both types of banks opt for the risky project.

Small banks will reach the point, at which they are unwilling to raise the rate, at a more competitive stage. The same applies for the large bank. Also, because switching to the risky project is more costly than under the standardized approach, small banks will start to raise the rates (and signal that they will take the risky project) at a more competitive stage. Again, the same applies for the large bank.

Let us shortly discuss the effects of the transition on welfare. Within the regimes, welfare is increased relative to the standardized approach if banks choose the safe project (regimes 1 to 3) because capital requirements are reduced. The opposite is true when both banks take the risky project (regime 5). In regime 4, the effect is ambiguous because capital requirements increase for one bank, but decrease for
the other. In addition, welfare is increased relative to the standardized approach because the IRB approach is better at deterring banks from choosing the risky project than the standardized approach. If the regulation is designed in a way that induces all bank types to opt for the safe project, the IRB approach is superior to the standardized approach in terms of welfare because it economizes on capital.

5.2 The Right to Choose

In the preceding section, we assumed that all banks have to adopt the IRB approach. However, the new Basel accord does not make such a prescription. Instead it allows banks to choose between the standardized and the IRB approaches. We will see that this right to choose fundamentally changes our assessment of the regulation.

Banks will opt for the IRB approach if they can increase their profits, given the choice of their competitor banks. If fixed costs $C$ are so high that neither small nor large banks choose the IRB approach, we are back in the case of section 4. The regulatory amendment is then irrelevant. If fixed costs $C$ are so low that all bank types opt for the IRB approach, we are back in the case of section 5.1. The interesting case is the intermediate situation where switching to the IRB approach is profitable only for the large bank.

In that case, the large bank never takes the risky project. If it did, regulation would become stricter because of the IRB approach; hence the investment $C$ could not be profitable. As a result, competition must be relatively low. Furthermore, the IRB approach will allow the large bank to offer higher deposit rates. If the large bank has not yet reached the critical interest rate, it will raise rates because investment becomes more profitable. If it has reached the critical rate, it will raise rates because the critical rate rises. As a consequence, competition for small banks increases. Since small banks stick to the standardized approach, their capital requirement is $\alpha$. For the large bank, the requirement is reduced to $\beta_1$ because the large bank chooses the safe project.

Let us consider first what happens within the regimes. Note that regime 5 need not be considered here because it would imply that the large bank takes the risky project, rendering the choice of the IRB approach unprofitable.

\footnote{The set of possible parameter settings is not empty: If $C$ were negligible, all banks would (individually) benefit from switching to the IRB approach, except for the case that they take the risky project even after a switch to IRB. Now because of the assumed structure of competition, if we set $\sigma \sim 1/n$, the large bank’s profits are independent of $n$, whereas the small banks’ profits are inversely proportional to $n$. Therefore, for each $C$ (and other parameters of the model), we must only choose $n$ large enough to render the IRB approach unprofitable for small banks.}
In regime 1, the equilibrium interest rates are\footnote{We put double dots on parameters that refer to the regulatory setting where banks have the right to choose between the two approaches.}

\[
\begin{align*}
\ddot{r}_L &= r_L + \frac{2(\alpha - \beta_1)(r_k - p_1 y_1)}{3(1 - \alpha)(1 - \beta_1)}, \\
\ddot{r}_S &= r_S + \frac{(\alpha - \beta_1)(r_k - p_1 y_1)}{3(1 - \alpha)(1 - \beta_1)},
\end{align*}
\]

yielding the deposit volumes

\[
\begin{align*}
\ddot{d}_L &= d_L + \frac{n \sigma (\alpha - \beta_1)(r_k - p_1 y_1)}{3(1 - \alpha)(1 - \beta_1)}, \\
\ddot{d}_S &= d_S - \frac{\sigma (\alpha - \beta_1)(r_k - p_1 y_1)}{3(1 - \alpha)(1 - \beta_1)}.
\end{align*}
\]

Hence in regime 1, deposit rates of all banks rise. The large bank raises its rate because investment becomes more profitable, and the small banks raise their rates in reaction to the large bank. However, the rate increase of the large bank is much larger, such that the large bank increases its market share at the expense of the small banks. The large bank’s profits increase, those of the small banks decrease.

In regime 2, small banks have reached the critical rate. Because \( r_{\text{crit}} \) is independent of competition, we have \( r_S = r_{\text{crit}} \), as defined in (7). The switch to the IRB approach induces the large bank to increase its deposit rate. Because the rates of small banks are constrained, small banks shrink, and the large bank grows. Also, profits of small banks decrease, whereas those of the large bank increase.

In regime 3, interest rates were \( r_S = r_L = r_{\text{crit}} \) (as defined in (7)) when both types of banks were using the standardized approach. Now \( r_L \) goes up to \( \dot{r}_{\text{crit}} \). As a consequence, the large bank gains market share, whereas small banks loose market share. Again the profits of the small bank decrease, whereas those of the large bank increase.

In regime 4, the large bank’s deposit rate rises to \( \dot{r}_{\text{crit}} \). The rates of the small banks are as in (21), replacing \( r_{\text{crit}} \) by \( \dot{r}_{\text{crit}} \). Hence, deposit rates of all banks rise. However, the large bank’s rate rises more strongly, increasing the large bank’s market share. As before, the profits of the large bank go up, those of small banks drop.

It is clear that the large bank weakly benefits (i.e. never suffers) from the right to choose: If it does not opt for the IRB approach, nobody else does, and the option is irrelevant. What is more surprising is that small banks always suffer from an adoption of the IRB approach by the large bank. These results are summarized in the following remark.
Remark 4 Within each regime, a switch of the large bank to the IRB approach is detrimental to small banks’ volumes and profits. The large bank (weakly) benefits from the right to choose between regulatory approaches.

Remark 4 yields a political economy rationale for why certain interest groups may lobby the regulatory authorities towards a highly sophisticated IRB approach. The more sophisticated the approach, the higher the fixed costs, and the more likely it is that smaller banks will not be willing to adopt the new approach. The potential benefits from the IRB approach for large banks are largest when only a small number of banks switches to the new approach. The small banks, whose interests are less well organized, suffer from the introduction of the IRB approach because its use is only optional. However, given the degree of sophistication of the IRB approach, an adoption by all banks is impossible in the absence of subsidization.

In the above discussion, we have only considered changes within each of the five regimes. Additionally, a regime change may occur when the large bank switches to the IRB approach. This is particularly problematic if small banks now switch to the risky project, i.e., the regime switches from 3 to 4. Such a regime switch would increase aggregate risk in the economy, and market rates would jump up.\footnote{It is not possible that the large bank also takes the risky project because of the jump in deposit rates (the regime switches to 5). This would have been anticipated by the large bank, which would not have opted for the IRB approach in the first place.}

In fact, this situation may be very realistic if we assume that regulators fix the regulatory variables $\alpha$, $\beta_1$, and $\beta_2$ to maximize social welfare. In this case, $\alpha$ is likely to be fixed such that all banks opt for the safe project, because choosing the risky project entails a welfare loss. Also, the regulator is likely to set $\alpha$ at the minimum level that achieves this goal because equity finance is inefficient. This means that $\alpha$ would be set such that small banks are indifferent between the safe and the risky project (this would be true at the border between regimes 3 and 4, or 5).\footnote{Even if the regulator has only noisy information about the parameters in the economy, he may try to set $\alpha$ close to the border.} In that case, we get the following proposition.

**Proposition 3** Assume that $\alpha$ is set such that small banks are indifferent between the safe and the risky project under the standardized approach. If banks get the option to switch to the IRB approach, and fixed costs $C$ are so high that switching pays off only for the large bank, small banks take the risky project, and aggregate risk in the economy increases.

The proposition is illustrated by Figure 7. The left panel displays equilibrium interest rates if there is a right to choose between the two approaches. We see that the border between regimes 3 and 4 is actually moved towards lower competition,
Curves are as in Figure 6. This curve falls monotonously (see Proposition 3), hence a more pronounced IRB approach makes small banks more likely to take risk—if banks are allowed to choose between approaches.

compared to the standardized approach, implying that risk-taking is increased by the regulation. At the former border between regimes 3 and 4, the small banks now strictly prefer to increase rates. The same result can be found in the right panel. Above the thick curve, small banks take the risky project. In contrast to Figure 6, the curve separating the regimes with and without risk-taking falls monotonically. Hence, if banks are allowed to choose between approaches, a more pronounced IRB approach expands the sets of parameters where small banks take risk.

The increase in risk-taking by the small banks leads to an increase in aggregate risk. This implies that the regulation does not achieve its goal of deterring risk-taking. It appears that the advantages of the IRB approach are destroyed by the right to choose.

6 Conclusion

Our paper has presented a novel channel of how the New Basel Capital Accord may harm small banks and lead to an increase in aggregate risk in the economy. We started from the observation that the new accord implicitly treats small and large banks in an asymmetric way: Due to the high fixed costs from implementation, it is very likely that only large banks opt for the IRB approach. In that case, small banks cannot benefit from the lower capital requirements for safe loans. This distorts competition to the benefit of the larger banks whose capital requirements, and hence marginal costs, are reduced when adopting the IRB approach. Large banks are induced to increase deposit rates to attract more deposits and exploit the higher profitability of investments. Fiercer competition for deposits forces small banks to raise their deposit rates as well to recapture some of their market shares. At this higher rate, small banks may prefer a risky investment strategy over a safe one. Starting from a situation where all banks choose a safe investment strategy, this
implies an increase in aggregate risk. Hence, the new accord may actually destabilize the banking system, contrary to the regulators’ intention.

Note that our results do not follow from the introduction of the IRB approach as such, but rather from the implicit asymmetric treatment of banks if they are given the right to choose between the standardized and the IRB approach. If the IRB approach is applied uniformly across banks, banking stability is improved as intended. Small banks may even profit from the introduction of the IRB approach relative to the old Basel accord.

We believe that our main result (Proposition 3) is robust to the specific modelling choice. The only important modelling ingredients seem to be moral hazard, some type of imperfect competition among banks, and the fact that equity is more expensive than deposit refinance. Let us give some examples for possible generalizations of the model. First, assume that there are several large banks competing with each other. Still, as long as they are larger than small banks, there is a range of fixed costs $C$ so that only large banks implement the IRB approach. Marginal costs of lending decrease for large banks, and small banks suffer because of the fiercer competition, making a switch to riskier projects likely. Second, we have modelled price competition à la Hotelling (1929). Different types of competition, such as competition in capacities à la Cournot, would not alter our results—as long as banks suffer from the lower marginal costs of their competitors. Third, the aggregate supply of deposits (which we have assumed to be perfectly inelastic) may depend on deposit rates. Also in this case, our main propositions hold true. One difference would be that aggregate deposits would depend on regulation: In the third regime, tightened regulation or a transition to the IRB approach would lead to an expansion of volume.

Our results have important implications for the prospective provision of loans to SMEs after the implementation of the new accord. If we believe that small firms are more likely to borrow from small banks, our model predicts not only a decrease in bank lending to SMEs, but also a shift from SMEs with safer projects to those with riskier ones. Hence, the SMEs with the most efficient projects are bound to loose the most. This effect may, however, be mitigated by the preferential treatment of loans to SMEs in the IRB approach, which may induce some of the safer SMEs to switch to larger banks. however, the large banks may not be prepared to extend loans based primarily on soft information (see Stein, 2002). In addition, the unequal treatment of small and large banks may be of concern for equity reasons.

Even in the absence of such considerations, our model gives a clear policy prescription: Small banks should be subsidized to adopt the IRB approach if the social costs from an increase in aggregate risk exceed the costs from the subsidization. In reality, such a subsidization is unlikely to occur, mostly for political reason. First, the subsidization would put a lot of pressure on public budgets, which would make

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30Remember that both approaches allow certain SME loans to be treated like retail exposures. However, only the IRB approach has an additional firm-size adjustment for SMEs.
the new accord unpopular and would possibly prevent its implementation in the first place. Second, the new accord may itself be seen as a manifestation of regulatory capture by the large banks. It is unlikely that the large banks would allow their privileges to be taken away that easily.

A Appendix

Proof of Proposition 1: We consider the border between regions $1 \cup 2 \cup 3$ and $4 \cup 5$ (the proof for the border between 4 and 5 proceeds analogously). At the border, $\sigma$ is such that small banks are indifferent between the safe project (and the critical $r_{\text{crit}}$) and the risky project (and a rate above $r_{\text{crit}}$). Expected profits in both cases are

$$
\Pi_{\text{crit}} = \left( \frac{D_S}{n} + \sigma (r_{\text{crit}} - r_{\text{crit}}) \right) \left( \frac{p_1 y_1 - \alpha r_k}{1 - \alpha} - r_{\text{crit}} \right)
$$

$$
= \frac{D_S}{n} \left( \frac{p_1 y_1 - \alpha r_k}{1 - \alpha} - r_{\text{crit}} \right),
$$

$$
\Pi_{\text{above}} = \left( \frac{D_S}{n} + \sigma (r_{S} - r_{\text{crit}}) \right) \left( \frac{p_1 y_1 - \alpha r_k}{1 - \alpha} - r_{\text{crit}} \right)
$$

$$
= \frac{1}{4 \sigma} \left( \frac{D_S}{n} + \sigma \left[ \frac{p_2 y_2 - \alpha r_k}{1 - \alpha} - r_{\text{crit}} \right] \right)^2
$$

$$
= \frac{1}{4 \sigma} \left( \frac{D_S}{n} + \sigma \left[ \frac{p_1 y_1 - \alpha r_k}{1 - \alpha} - r_{\text{crit}} - \frac{p_1 y_1 - p_2 y_1}{1 - \alpha} \right] \right)^2.
$$

The relation that defines the function $\sigma_{\text{crit}}(\alpha)$ is simply $\Pi_{\text{crit}} = \Pi_{\text{above}}$.

We want to show $\partial \sigma_{\text{crit}}(\alpha)/\partial \alpha > 0$ (as documented by Figure 5). The implicit function theorem gives us

$$
\frac{\partial \sigma_{\text{crit}}(\alpha)}{\partial \alpha} = - \frac{\partial \Pi_{\text{crit}}/\partial \alpha - \partial \Pi_{\text{above}}/\partial \alpha}{\partial \Pi_{\text{crit}}/\partial \sigma - \partial \Pi_{\text{above}}/\partial \sigma} \tag{A1}
$$

It is obvious that $\partial \Pi_{\text{crit}}/\partial \sigma = 0$. Furthermore $\partial \Pi_{\text{above}}/\partial \sigma > 0$, the easier it is to lure customers away from the large bank, the more profitable it is for the small bank to raise rates. Hence the denominator of (A1) is negative. If we can show that the numerator is positive, $\partial \Pi_{\text{crit}}/\partial \alpha > \partial \Pi_{\text{above}}/\partial \alpha$, then the proof is complete. The rest of the proof will proceed in two steps. First, we define an auxiliary variable

$$
\Pi_{\text{aux}} := \frac{1}{4 \sigma} \left( \frac{D_S}{n} + \sigma \left[ \frac{p_1 y_1 - \alpha r_k}{1 - \alpha} - r_{\text{crit}} \right] \right)^2.
$$

First, we show that $\partial \Pi_{\text{crit}}/\partial \alpha > \partial \Pi_{\text{aux}}/\partial \alpha$, second that $\partial \Pi_{\text{aux}}/\partial \alpha > \partial \Pi_{\text{above}}/\partial \alpha$. (to be completed)
Figure 8: Reaction Functions near the Critical $\alpha$

Thin lines are reaction functions by small banks, thick lines those of large banks. Black lines denote the standardized approach, gray lines the IRB approach.

Proof of Proposition 2: We consider only parameters for which there is a direct changeover from regime 3 to regime 5. If there are regime switches from 3 to 4 and from 4 to 5, a similar argument must be applied twice. We must look at an individual (small) bank’s incentive to increase rates above $r_{\text{crit}}$, given that all other banks offer $r_{\text{crit}}$. If it keeps offering $\dot{r}_{\text{crit}}$, profits are $D_{S} ((p_{1} y_{1} - \alpha r_{k})/(1 - \alpha) - \dot{r}_{\text{crit}})$. (to be completed)

Proof of Proposition 3: For the proof, we build on the intuition delivered by Figure 8. Black curves denote the reaction functions of small and large banks under the old regulatory framework, i.e. if all banks use the standardized approach. We have assumed parameters ($\alpha$) is such that we are at the border between regimes 3 and 4. In other words, in equilibrium, small banks are individually indifferent between the critical deposit rate $r_{\text{crit}}$ and a higher rate (which would signal the risky project). In Figure 8, the equilibrium is given by the inner white dot. Here, indeed, the equilibrium $r_{L}$ is low enough to ensure that small banks offer $r_{\text{crit}}$ and take the safe project. Also the large bank offers $r_{\text{crit}}$. However, it has some “reserves”: Even if small banks raised deposit rates, the large bank would not react by raising rates, too (in the figure, the reaction function of the large bank “overlaps” the critical point).

Now we have assumed that a switch to the IRB approach is profitable only for the large bank. As a result, the large bank implements the IRB approach, and the critical deposit rate for the large bank goes up from $r_{\text{crit}}$ to $\dot{r}_{\text{crit}}$. The large bank raises deposit rates. Consequently, small banks now individually prefer offering a higher deposit rate (and signalling the risky project). Before the introduction of the IRB approach, all banks took the safe project, now all small banks take the risky project. Aggregate volume remains unchanged, hence aggregate risk in the economy has gone up.

There are two reasons why small banks may be indifferent between $r_{\text{crit}}$ and a higher rate, but still the situation is different from that in Figure 8. First, small and large
banks may be so asymmetric that at the indifference point of small banks, the large
bank offers a rate below $r_{\text{crit}}$ (regime 2). From deriving (9), one proves that for given
$r_S$, deposit rates of the large bank rise if regulation for large banks softens. Again,
this leads small banks to raise rates and pick the risky project.

Second, banks may be so symmetric, and the the capital privileges of the IRB
approach so small ($\beta_1 \approx \alpha \approx \beta_2$) that the introduction of IRB at the large bank
and the ensuing upward jump of market rates would make also the large bank take
the risky project. This, as already discussed, leads to a contradiction, because large
banks would not have implemented IRB in the first place.

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