STUDIENZENTRUM GERZENSEE
STIFTUNG DER SCHWEIZERISCHEN NATIONALBANK

The New Basel Accord: Implications of the Co-existence between the Standardized Approach and the Internal Ratings-based Approach

Bertrand Rime

Working Paper No. 03.05

The New Basel Accord: Implications of the Co-existence between the Standardized Approach and the Internal Ratings-based Approach

Bertrand Rime*

Head of Systemic stability section
Banque nationale suisse
Boersenstrasse 15
CH-8022 Zurich
Bertrand.rime@snb.ch
phone: +41 1 631 34 19
fax: +41 1 631 81 09

Abstract

We examine the prudential implications of the co-existence between the standardized approach and the internal ratings-based (IRB) approach, as defined in the new Basle Accord. We consider a model in which sophisticated banks, eligible for the IRB approach, and unsophisticated banks, eligible for the standardized approach, allocate their loan portfolio between high-risk and low-risk borrowers. We find that the co-existence between the two regimes may induce sophisticated banks to decrease risk-taking, but encourage unsophisticated banks to increase risk-taking. The risk reallocation effects are stronger when competition is more intense.

Keywords: Banking regulation, capital standards, Basel Accord
JEL classification: G2, G28

---

* The author is grateful to two anonymous referee of this journal, to Jürg Blum, Banque nationale suisse, to Myron Kwast, Federal Reserve Board, and to Joao Santos, Federal Reserve Bank of New York, for their helpful comments. This paper was presented at the 2001 European Financial Management Association annual meeting in Lugano and at the 2001 European Finance Association conference in Barcelona.

1 Introduction

In June 1999, the Basel Committee issued a first consultative paper "A New Capital Adequacy Framework" to replace the 1988 Accord. With regard to the minimum regulatory capital requirements, the consultative paper proposes a two-layer regime for the capital treatment of credit risk, with (i) a revised standardized approach, where risk-weights would be partially based on external ratings, and (ii) a brand-new internal ratings-based approach (IRB), where risk-weights would be based on banks' own assessments of credit risk. Other important modifications of the minimum capital requirements are a revised treatment of credit risk mitigation techniques and asset securitization, and the introduction of explicit capital charges for operational risk. The document also suggests complementing the minimum capital requirements with two additional pillars: a supervisory review process and an effective use of market discipline. In January 2001 and in April 2003, the Committee issued two additional consultative papers "The New Basel Accord, Consultative paper" and "The New Basel Accord" addressing a number of issues left open in the first document, especially regarding the structure and the calibration of the IRB approach.

The Committee outlined several objectives in revising the Basel Accord: improving the risk-sensitivity of the capital requirements, reducing the scope for regulatory arbitrage, and providing more flexibility in the calculation of the capital requirements. The Basel Committee recognized that the "broad brush" nature of the current Accord (where required capital generally does not differ by the degree of risk) encourages regulatory arbitrage. The problem of regulatory arbitrage has been largely studied in the theoretical literature on capital requirements (see below).

The two–layer capital framework proposed for credit risk implies that in the segment of corporate borrowers, banks eligible for the standardized approach will face very different capital requirements than those eligible for the IRB approach. For banks using the standardized approach, the capital requirements for claims on corporate borrowers will still look like a risk-insensitive leverage ratio: only a minor fraction of corporate borrowers dispose of an external rating and the new risk-weighting framework for that kind of borrower deviates from the traditional 100% risk-weight only for very high or low ratings. By contrast, banks eligible for the IRB approach will face risk-sensitive capital requirements: the internal rating coverage is large for all types of corporate borrowers and the risk-weighting scheme for that regime will be fine-tuned, as indicated in the second consultative document. The transition to a two-layer capital framework for credit risk is important, as this type of risk constitutes the core of regulatory capital requirements: for the average G-10 international bank, credit risk makes up about 95% of total capital requirements.

The higher degree of risk-sensitivity provided by the IRB approach is certainly welcome, in particular when we consider the extensive literature arguing that uniform capital requirements can induce banks to increase risk-taking and result in a higher default probability (Kim and Santomero, 1988, Gennotte and Pyle, 1991, Rochet, 1992 and Blum, 1999, Repullo, 2002).[1] At the same time, however, the co-existence of the IRB approach with the standardized approach can raise concerns regarding the risk behavior of the banks that will still have to comply with the second – much less risk-sensitive – regime. In most countries, large sophisticated banks (the more likely to be eligible for the IRB approach) still compete with smaller and less sophisticated banks (the more likely to be eligible for the standardized approach) in important segments of the domestic loan market. With the two-layer capital requirement framework, this means that sophisticated and unsophisticated banks will have to comply with a different capital requirement when competing for the same borrower. When capital requirements are binding, this can affect the competitiveness of sophisticated banks and unsophisticated banks in the various risk segments and distort the portfolio allocation by the two categories of banks.

The Basel Committee's proposals have stimulated an intense academic research. A large number of paper have been dedicated to credit risk modeling, with a particular focus on the consistency between the IRB risk-weighting framework and the empirical evidence on credit risk. Frey and McNeil (2002) address the non-coherence of VaR as a risk measure in the context of portfolio credit risk. They show that VaR is not subadditive, which questions its use for the definition of capital requirements, as is proposed under the new Basel Accord. Jackson, Perraudin and Saporta (2002) compare the solvency standard implied by the new Accord to the solvency standard banks choose by their own capital setting decision. They conclude that for large international banks, the minimum regulatory capital requirement would not be binding. A smaller number of papers look at the new Basel Accord from an incentive perspective. Décamps, Roger and Rochet (2002) examine the optimal mix between the three pillars. They show that market discipline can reduce the minimum capital requirement needed to prevent moral hazard. Altman and Saunders (2001) compare the capital charges under the Standardized Approach to those obtained under the foundation Internal Ratings-Based (IRB). They argue that for banks with an average quality portfolio, there is no incentive to shift from the standardized to the foundation IRB approach. Finally, Kirstein (2002) examines whether banks have an incentive to reveal the quality of their loan portfolio under the IRB approach. He comes to the conclusion that this is the case only if

[1] Furlong and Keeley (1989) and Santos (1999) find the opposite result. For a survey of this literature, see Berger,

the regulator validates the internal ratings and imposes a fine on the banks that overestimated the quality of their loans.

The present paper belongs to the literature focusing on the incentives created by the new Basel Accord. We try to assess the impact of the co-existence between the standardized approach and the IRB approach on the portfolio allocation by sophisticated and unsophisticated banks. We also examine how competition intensity and the degree of risk-differentiation of the capital requirements affect sophisticated banks' preference for the IRB approach. While the model combines the traditional ingredients of the literature on capital requirements, it is the first to analyze the competitive interaction between banks eligible for the different regulatory regimes defined in the new Accord. The setup of the model is the following. Banks are risk-neutral and have limited liability. They can allocate their loan portfolio between a high-risk borrower segment and a low-risk borrower segment, which differ in their sensitivity to the state of nature. Banks fund themselves through deposits and equity, and they have to comply with a minimum capital requirement. Bank deposits are fully insured at a zero premium. The two-layer capital requirement framework proposed in the consultative paper is approximated as follows. Unsophisticated banks have to comply with a simple minimum ratio between capital and total assets – the standardized approach. For sophisticated banks, the capital requirements reflect the bank’s portfolio allocation between high-risk and low-risk borrowers – the IRB approach.

Using this modeling framework, we find that the introduction of the two-layer approach for credit risk may lead sophisticated banks to decrease risk-taking, but induce unsophisticated banks to increase risk-taking. The intuition for this result is that unsophisticated banks enjoy a competitive advantage in the high-risk segment, where they have to hold less capital than the

Herring, and Szegö (1995).

sophisticated bank, while they suffers a competitive disadvantage in the low-risk segment, where they have to hold more capital than their sophisticated competitors. Another finding is that sophisticated banks' preference for the IRB approach is positively related to competition intensity and to the degree of risk-differentiation of the IRB capital requirement. A third finding is that the introduction of the two-layer approach makes low-risk borrowing cheaper compared to high-risk borrowing.

The remainder of the paper is organized as follows. Section 2 describes the model. In sections 3 and 4, we assess the impact of the introduction of the two-layer capital framework on bank portfolio allocation and on lending interest rates. In section 5, we look at the conditions under which sophisticated banks voluntarily apply for the IRB approach. Section 6 summarizes the results and draws implications for the new capital adequacy framework and its implementation.

2 The model

2.1 Main features of the model

We use a two-period model with two possible futures states of nature ("good" and "bad") to analyze portfolio and leverage decisions of risk-neutral banks facing high-risk and low-risk borrowers. Banks differ in their degree of sophistication and are eligible in different regulatory regimes: unsophisticated banks can only apply for the standardized approach while sophisticated banks can apply for the IRB approach. We consider two basic types of competitive environments: perfect competition and Cournot oligopoly.

2.2 Representative borrowers

The loan market is divided into two segments, represented by a low-risk and a high-risk borrower. The two types of borrowers differ in their sensitivity to the state of nature.

The low-risk representative borrower, indexed by l, can invest in a project whose return per unit of investment is $(1+U)$ in the state "good" and $(1-U)$ in the state "bad". U is the return of the project, before operating costs. The investment generates a quadratic operating cost for the borrower, equal to Q_l^2, where Q_l is the amount invested. The loan contract specifies the repayment of a fixed interest rate r_l plus principal in the state "good" and the bank's seizing of the residual value $(1-U)Q_l$ of the investment in the state "bad". With limited liability, the maximization program for the low-risk borrower is

$$\max_{Q_l} W_l = p_G(U - r_l)Q_l - Q_l^2,$$

where p_G is the probability of the state "good".

Differentiating with respect to Q_l and solving for r_l, we obtain the inverse loan demand function for the low-risk representative borrower

$$r_l = U - 2Q_l / p_G.$$

The high-risk representative borrower, indexed by h, can invest in a project whose return per unit of investment is $(1+kU)$ in the state "good" and $(1-kU)$ in the state "bad", with $k>1$. The inverse loan demand function for the representative high-risk borrower is

$$r_h = kU - 2Q_h / p_G.$$

We use a linear specification of (inverse) loan demand as this improves the tractability of the model, in particular with regard to the expression of the interest rates and quantities prevailing at equilibrium. In the competitive model, the predictions of the model would hold for any downward sloping demand function.[2] The inverse loan demand functions imply that the level of interest rate in each borrower segment is a decreasing function of the amount of loans granted to this segment.

2.3 Banks

All banks have the same size, measured by their total assets A.[3] In the derivation of the results, A is normalized to unity without any loss of generality.

Banks fund their loans through deposits D and equity. Banks' deposits are fully insured at a zero premium. Accordingly, the depositors do not care about banks' risk or capital adequacy. They are ready to supply an unlimited amount of deposits at the risk-free interest rate, set to zero for simplicity. The assumption that banks deposits are fully insured at a zero or flat premium is quite standard.[4]

Banks choose the allocation of their total assets between the two borrower segments. A proportion p is invested in loans to low-risk borrowers, a proportion 1- p is invested in loans to high-risk borrowers. In the state "good", banks receive $1+r_l$ per unit of loans granted to low-risk

---

[2] In a Cournot oligopoly, the use of a non-linear demand function would require the imposition of additional conditions on its convexity (loan demand must not be too convex). Otherwise, the profit function is not necessarily concave. Tirole (1993) p. 225.

[3] We assume that A is fixed in order to focus the analysis on banks' portfolio allocation between high-risk and low-risk borrowers. A can, for example, be defined as the cost efficient level of activity in the presence of economies of scale.

[4] See Merton (1977), Furlong, and Keeley (1989), Gennotte and Pyle (1991), Rochet (1992), Boot, Dezelan and Milbourn (2000) and Hellmann, Murdock and Stiglitz (2000).

borrowers and $1+r_h$, per unit of loans to high-risk borrowers. In the state "bad", banks receive $1-U$, respectively, $1-kU$ per unit of loan.

We assume that in the state "good", all banks meet their obligations to the depositors and that in the state "bad", all banks default. The assumption that banks default in at least one state of nature is standard.[5] Otherwise, the presence of deposit insurance would be of no value for the banks and for its depositors. The combination of banks' limited liability and of deposit insurance imply that banks (i) prefer to collect deposits than to raise capital and (ii) prefer high-risk to low-risk loans (see also Keeley and Furlong, 1989). These two ingredients traditionally serve as a motivation for banking regulation.

2.4 Capital requirement under the current Accord

Under the current Accord, only the standardized approach is available for credit risk. For corporate and retail borrowers, it specifies a unique risk-weight of 100%. Accordingly, we proxy the capital requirement with the simple capital ratio $C = c \cdot A$. Both sophisticated banks and unsophisticated banks have to comply with this capital requirement.

2.5 Capital requirement under the new Accord: two-layer framework

Under the new Accord, two main approaches are available: the standardized approach and the IRB approach. Unsophisticated banks, indexed by u, are unable to credibly communicate to the regulating authority how they have allocated their loan portfolio between the two borrower segments. This means that the regulator cannot observe the shares of the portfolio p_u and 1-p_u

[5] Furlong and Keeley (1989), Hellmann, Murdock and Stiglitz (2000) and Repullo also consider a model with two states of the nature, where banks default in one state. Merton (1977) and Gennotte and Pyle (1991) consider a continuous distribution of portfolio returns. For some realizations of the return, the bank defaults.

allocated by the bank to low-risk and high-risk borrowers. As a result, unsophisticated banks have to comply with the standardized approach that imposes a minimum capital requirement derived from a simple capital ratio $C_u = c \cdot A$. This regime is a fair approximation of the standardized approach proposed in the consultative paper, since most corporate borrowers have no external rating and thus fall in the 100% risk-weighted category.

Sophisticated banks, indexed by s, can credibly communicate to the regulator their portfolio allocation through their internal rating system, and are therefore eligible for the IRB approach. Assuming that sophisticated banks voluntarily apply for the IRB approach[6], they are subject to a capital requirement that reflects the risk profile of their loan portfolio. The capital requirement for sophisticated banks is equal to $C_s = p_s(c-b)A + (1-p_s)(c+b)A$, where b is a risk-differentiation factor, and $(c-b)$ and $(c+b)$ can be seen as the risk-weights applicable to low- and high-risk-borrowers respectively. The rationale for the differentiation of the capital requirement is that the recovery values of loans to low- and high-risk borrowers in the state of nature "bad" are different. This is consistent with the IRB framework, where the risk-weight is a function of the loss given default as well as of the probability of default. [7]

Our definition of the two-layer capital requirement implies that sophisticated banks are allowed to hold less capital than unsophisticated banks for low-risk borrowers, but are required to hold more capital for high-risk borrowers. This is a reasonable assumption, if we consider that the 100% risk-weight should cover the risk of an average-quality loan portfolio.

---

[6] In section 4, we examine the conditions under which sophisticated banks voluntarily apply for the IRB.
[7] The case where borrowers differ in their probability of default is examined in appendix B.

Throughout the paper, we assume that banks' degree of sophistication is exogenous. Today, we observe significant differences between banks in their ability to model credit risk. In that context, it seems justified to consider that in the short and medium term, a large number of small unsophisticated banks will have to use the standardized approach, while large sophisticated institutions will be eligible for the IRB approach. In the long run, however, banks will certainly adjust their investment in risk management techniques to the new regulatory framework, so that their degree of sophistication becomes endogenous.

2.6 Bank maximization program under the current Accord

Banks maximize the expected value of their equity, net of the initial investment. They have to determine the allocation p of their portfolio between the two borrowers segments and their liability structure D under the constraint imposed by the capital requirement $D \leq A - C$.

Because we assume that banks always default in the state of nature "bad" and that their deposits are fully insured by the deposit insurance scheme, the profit maximization program considers only the pay-off for the state of nature good.[8] The maximization program is

$$\max_{p,D} V(p,D) = p_G \cdot [pA(1+r_l) + (1-p)A(1+r_h) - D] - (A - D) \qquad (2.1)$$

such that

$$D \leq A - C.$$

Under the current Accord, the capital requirement for the two types of banks implies

[8] Formally, this program is obtained by defining the value of the bank as the NPV of the bank's assets minus the NPV of its liabilities, plus the NPV of the put issued "for free" by the deposit insurance scheme (Furlong and

$$D \leq A - C = A - cA \tag{2.2}$$

The maximization program is increasing in D, which implies that the capital requirement constraint (2.2) is binding. We can therefore redefine our problem as an unconstrained maximization program by substituting the capital requirement constraint as an equality in (2.1). The only remaining decision variable is the bank's portfolio allocation p between the two borrower segments.

The maximization program for the two types of banks can be rewritten as

$$\max_p V(p) = \pi_G \cdot [pA(1+r_l) + (1-p)A(1+r_h) - (A - cA)] - cA$$

or

$$\max_p V(p) = \pi_G \cdot A[p \cdot r_l + (1-p)r_h] - (1-\pi_G)cA \tag{2.3}$$

2.7 Bank maximization program under the new Accord

Under the new Accord, the capital requirements imply

$D_u \leq A - C_u = A - cA$ for unsophisticated banks and (2.4)

$D_s \leq A - C_s = A - \left(\pi_s(c-b)A + (1-\pi_s)(c+b)A\right)$ for sophisticated banks. (2.5)

Since the capital requirements are binding, the maximization program for an unsophisticated bank can be written as

Keeley, 1989). The put has a strike price equal to the full repayment of the deposits guaranteed by the deposit insurance scheme (Merton, 1977).

$$\max_{p_u} V(p_u) = p_G \cdot A[p_u r_l + (1 - p_u) r_h] - (1 - p_G) cA \qquad (2.6)$$

and the maximization program for a sophisticated bank can be written as

$$\max_{p_s} V(p_s) = p_G \cdot A[p_s r_l + (1 - p_s) r_h) - (1 - p_G) A[c + (1 - 2 p_s) b]\,. \qquad (2.7)$$

3 Equilibrium under the old Accord and under the new Accord: perfect competition

A proper assessment of the effects of the new Accord requires that we define a benchmark. This benchmark is the competitive equilibrium prevailing under the current Accord. The results in this section are derived under the assumption that there is an infinitely elastic supply of capital. In appendix A, we show that relaxing this assumption does not affect the predictions of the model.

3.1 Equilibrium under the current Accord: standardized approach only

Under the current Accord, all banks have the same maximization program (2.3). The first-order condition is

$$p_G(-r_h + r_l) = 0\,. \qquad (3.1)$$

With perfect competition, banks make zero profits. Combining this condition with the first-order condition, we find that the equilibrium interest rates on the two segments are identical[9] and given by

[9] This reflects the assumption that banks always default in the state of nature "bad", i.e. they do not care about the recovery value of their loans. We could add an "intermediate" state of nature, where banks do not default, although they lose money on their loans. Assuming that high-risk loans have a lower recovery value than low-risk loans in the state of nature "intermediate", they would pay a higher interest rate at equilibrium. But the interest rate differential would not compensate for the differences in loan recovery values corresponding to the state of nature "bad".

$$r_l = r_h = c\left(-1 + \frac{1}{p_G}\right). \quad (3.2)$$

Accordingly, lending by the banking industry to each borrower segment is given by

$$Q_l = \frac{-c + cp_G + p_G U}{2} \quad (3.3)$$

and

$$Q_h = \frac{-c + cp_G + kp_G U}{2} \quad (3.4)$$

Because we have $k > 1$, (3.3) and (3.4) imply that $Q_h > Q_l$, i.e., there is more lending to the high-risk segment than to the low-risk segment.

We now have our benchmark. Under the current Accord, i.e., when only the standardized approach is available, and with perfect competition, our model predicts that the interest rate prevailing on the two segments are equal. The two bank categories are indifferent regarding their portfolio allocation between the two borrowers segments. The share of the portfolio allocated to the low-risk segment by the average bank is equal to $p = Q_l / (Q_h + Q_l)$, with 0< p <0.5.

3.2 Equilibrium under the new Accord: two-layer capital framework

With the two-layer regime, the maximization program is given by (2.6) for unsophisticated banks and (2.7) for sophisticated banks.

The first-order condition for sophisticated banks is

$$-2b(-1 + p_G) + p_G(-r_h + r_l) = 0$$

The first-order condition for unsophisticated banks is

$$p_G(-r_h + r_l) = 0.$$

The first-order conditions cannot be satisfied at the same time for the two categories of banks. This means that for at least one bank category, the optimal portfolio allocation is a corner solution characterized by p =0 or p =1.[10]

We look for a competitive equilibrium where each bank category operates at least in one segment with non-negative profits. This unique equilibrium is obtained when sophisticated banks specialize in the low-risk segment while unsophisticated banks specialize in the high-risk segment. With this configuration, competition between sophisticated banks specializing in the low-risk segment drives interest rates down to a level such that this category makes zero profits, i.e., $r_l^*[V_s(p_s = 1)] = \frac{(c-b)(1-p_G)}{p_G}$. (3.5)

On the high-risk segment, competition between unsophisticated banks drives interest rates down to a level such that this bank category makes zero profits, i.e.,

$$r_h^*[V_u(p_u = 0)] = c\left(-1 + \frac{1}{p_G}\right). \tag{3.6}$$

With the levels of interest rates given in (3.5) and (3.6), an unsophisticated bank cannot enter the low-risk segment without making losses, i.e., $V_{u,i}\left(r_h^*, r_l^*, p_{u,i} > 0\right) = bp_{u,i}(-1 + p_G) < 0$, while a

[10] The possibility of corner solutions can be taken into account by writing the Kuhn-Tucker first-order conditions. Define $m_{s,0}$, $m_{s,1}$, $m_{u,0}$ and $m_{u,1}$ as the Kuhn-Tucker multipliers for the inequality constraints $p_s \geq 0$, $p_s \leq 1$, $p_u \geq 0$ and $p_u \leq 1$. The Kuhn-Tucker first-order conditions are $m_{s,0} - m_{s,1} - 2b(-1 + p_G) + p_G(-r_h + r_l) = 0$ for the sophisticated bank and $m_{u,0} - m_{u,1} + p_G(-r_h + r_l) = 0$ for the unsophisticated bank. If there were an interior

sophisticated bank cannot enter the high-risk segment without making losses i.e., $V_{s,i}\left(r_h^*, r_l^*, p_{s,i} < 1\right) = b\left(-1 + p_G + p_{s,i}(1 - p_G)\right) < 0$. Consistently, for these levels of interest rates, the first-order condition for sophisticated banks is always positive, i.e., $\frac{\partial}{\partial p_{s,i}} V_{s,i}\left(r_h^*, r_l^*\right) = b\left(1 - p_G\right) > 0$, indicating that perfect specialization in the low-risk segment is optimal for this bank category. At the same time, the first-order condition for unsophisticated banks is always negative $\frac{\partial}{\partial p_{u,i}} V_{u,i}\left(r_h^*, r_l^*\right) = b\left(-1 + p_G\right) < 0$, indicating that perfect specialization in the high-risk segment is optimal for this bank category.

Hence, with perfect competition, the zero profit condition for the banks belonging to the category facing the lower capital requirement on a given borrower segment ensures that banks from the other category cannot enter that segment without making losses. For this reason, the other configurations (specialization of the two bank categories in the same segment; specialization of sophisticated banks in the high-risk-segment and of unsophisticated banks in the low-risk segment; specialization of one bank category, with the other category indifferent between the two segments) cannot be an equilibrium.

3.3 Assessing the impact of the new Accord

By comparing the competitive equilibria in section 3.1 (old Accord) and section 3.2 (new Accord), we obtain the following result for portfolio allocation. First, while the two bank categories would be indifferent with regard to their portfolio allocation between the two segments under the current Accord, the introduction of the two-layer capital requirement would

solution for the two bank categories, all the Kuhn-Tucker multipliers would be zero. But with the Kuhn-Tucker multipliers set equal to zero, at least one of the first-order conditions would be violated.

induce unsophisticated banks to perfectly specialize in the high-risk segment, and sophisticated banks to perfectly specialize in the low-risk segment. From a prudential point of view, this specialization is an issue of concern for two main reasons. First, it seems highly undesirable that high-risk borrowers be concentrated in the portfolios of the banks with less expertise in credit risk management and measurement. Second, because of the lack of risk-sensitivity of the standardized approach, the possible increase in risk-taking by unsophisticated banks would not be compensated by higher capital charges, and it could thus lead to a deterioration of the capital adequacy in this bank category.

When comparing the equilibrium interest rates prevailing under the current Accord and under the New Accord, we also see that the introduction of the two-layer capital requirement reduces the level of interest rates on the low-risk segment, while the level of interest rates on the high-risk segment remains unchanged. This is because the risk-differentiation of the IRB capital requirement makes low-risk lending cheaper for sophisticated banks, while it does not affect the cost of high-risk lending, the latter activity being performed solely by unsophisticated banks.

4 Impact of the introduction of the new Accord: oligopoly

In many countries, the banking sector is characterized by a high degree of concentration. Moreover, banking activity requires different types of investment (reputation, screening of the borrowers, branch network) that reduce market contestability. For these reasons, we examine how departing from the assumption of perfect competition affects the prediction of the model. We model imperfect competition using a Cournot oligopoly. This provides us with a convenient way for varying the degree of competition intensity. In its original form, the Cournot equilibrium characterizes competition in quantities. As shown by Kreps and Scheinkman (1999), the Cournot equilibrium can also be used to characterize competition in capacities followed by competition in prices. A recent application of the Cournot oligopoly model to the banking industry can be found in Boot, Dezelan and Milbourn (2000).

We consider that the banking industry consists of a Cournot oligopoly of N sophisticated banks and N unsophisticated banks of size A/N [11]. It is natural to consider a symmetric solution, where all unsophisticated banks and all sophisticated banks choose the same allocation of their portfolio between the two borrower segments. Define $p_{s,n}$ as the portfolio choice by the representative sophisticated bank and $p_{u,n}$ as the portfolio choice by the representative unsophisticated bank.

The maximization program for the sophisticated bank is

$$\max_{p_s} V(p_{s,n}) = p_G \cdot A/N[p_{s,n}r_l + (1-p_{s,n})r_h] - (1-p_G)A/N[c+(1-2p_{s,n})b] \tag{4.1}$$

The maximization program for the unsophisticated bank is

$$\max_{p_{u,n}} V(p_{u,n}) = p_G \cdot A/N[p_{u,n}r_l + (1-p_{u,n})r_h] - (1-p_G)cA/N \tag{4.2}$$

For a Cournot oligopoly with N sophisticated and N unsophisticated banks, the inverse loan demand function of section 2.2 need to be rewritten as

$$r_l = U - 2\left(p_{u,n}\frac{A}{N} + \sum_{m\neq n} p_{u,m}\frac{A}{N} + p_{s,n}\frac{A}{N} + \sum_{m\neq n} p_{s,m}\frac{A}{N}\right)/p_G \tag{4.4}$$

for the low-risk segment and

[11] See Freixas and Rochet, 1997, for a generalization of the Cournot oligopoly to N banks.

$$r_h = kU - 2\left((1 - p_{u,n})\frac{A}{N} + \sum_{n \neq m}(1 - p_{u,m})\frac{A}{N} + (1 - p_{s,n})\frac{A}{N} + \sum_{m \neq n}(1 - p_{s,m})\frac{A}{N} \right) / p_G \qquad (4.5)$$

for the high-risk segment.

For a sophisticated bank, the first-order condition is

$$\frac{-2bN(p_G - 1) + U(1-k)p_G N - 2(-3 + 4p_s + 2p_u + 2\sum_{m \neq n}(p_{u,m} + p_{s,m} - 1))}{N^2} = 0 \qquad (4.6)$$

For an unsophisticated bank, the first-order condition is

$$\frac{U(1-k)p_G N - 2(-3 + 4p_u + 2p_s + 2\sum_{m \neq n}(p_{u,m} + p_{s,m} - 1))}{N^2} = 0 \qquad (4.7)$$

The second-order conditions for a maximum are satisfied since (4.1) is concave, i.e., we have $\partial^2 V_{s,n} / \partial p_{s,n}^2 = \partial^2 V_{u,n} / \partial p_{u,n}^2 = -8/N^2 < 0$.[12]

Using the symmetry conditions $p_{s,n} = p_{s,m \neq n}$ and $p_{u,n} = p_{u,m \neq n}$, (4.6) and (4.7) can be rewritten as a system of two equations with two unknowns: the portfolio allocations chosen by each representative bank. Solving, we obtain

$$p_{s,n}^* = \frac{2b(N + N^2)(1 - p_G) + Np_G U - kNp_G U + 2 + 4N}{4 + 8N} \qquad (4.8)$$

[12] We assess the stability of the equilibrium by considering a duopoly with one sophisticated bank and one unsophisticated bank, i.e., we set N =1. A sufficient condition for stability is $\frac{\partial^2 V_u}{\partial p_u^2} \cdot \frac{\partial^2 V_s}{\partial p_s^2} - \frac{\partial^2 V_u}{\partial p_u \partial p_s} \cdot \frac{\partial^2 V_s}{\partial p_s \partial p_u} > 0$ (see Varian, 1992, p. 288). Using our specification, we obtain $(-8) \cdot (-8) - (-4) \cdot (-4) = 48 > 0$>, i.e., the stability condition is satisfied for a duopoly.

$$p^*_{u,n} = \frac{-2bN^2(1-p_G) + Np_GU - kNp_GU + 2 + 4N}{4+8N} \qquad (4.9)$$

Equations (4.8) and (4.9) indicate that the optimal proportion p^* invested in the low-risk borrowers segment is an increasing function of the differentiation factor b for the sophisticated bank, but a decreasing function of b for the unsophisticated bank. Moreover, the sensitivity of the portfolio allocation to the differentiation factor increases with N, i.e., with competition intensity. When N tends to infinity, we have a perfect specialization of unsophisticated banks in the high-risk segment and of sophisticated banks in the low-risk segment. These two results are consistent with those obtained for perfect competition.

Note that the risk reallocation also affects the equilibrium interest rates on the two borrowers segments. The interest rate prevailing on the low-risk borrower segment is given by

$$r_l = \frac{-bN(1-p_G) + (1+N+kN)p_GU - 2 - 4N}{p_G + 2Np_G}, \qquad (4.10)$$

while the interest rate prevailing on the high-risk borrower segment is given

$$r_h = \frac{bN(1-p_G) + (k+N+kN)p_GU - 2 - 4N}{p_G + 2Np_G}. \qquad (4.11)$$

From (4.10) and (4.11), it is easy to see that the interest rate on the low-risk segment is a decreasing function of the risk-differentiation factor b, while the interest rate on the high-risk segment is an increasing function of the risk-differentiation factor. This means that the introduction of a two-layer capital requirement makes borrowing cheaper for high-risk borrowers and more expensive for low-risk borrowers, compared to the situation where all banks had to comply with the simple capital ratio (i.e. where b =0), as under the current Accord. The reason for this is that for sophisticated banks, the IRB approach increases the cost of lending to high-risk borrowers and decreases the cost of lending to low-risk borrowers.

Overall, the predictions of the oligopoly model with regard to the impact of the introduction of the two-layer capital requirement on portfolio allocation and on interest rates are consistent with those of the competitive model. Appendix B generalizes the results to the case where high-risk borrowers have a higher probability of default than low-risk borrowers.

5 Do sophisticated banks prefer the IRB approach?

Until now, we have simply assumed that sophisticated banks voluntarily apply for the IRB approach. This is consistent with the fact that banks leading the pace in credit risk modeling have been supporting the development of a risk-sensitive capital requirement. Still, it is important to examine whether in our model, the banks having the choice between the two regimes would prefer to be subject to a risk-sensitive capital requirement (like the IRB) rather than to a simple leverage ratio (like the standardized approach).

5.1 Perfect competition

Consider the situation where all banks use the standardized approach, regardless of their degree of sophistication. With perfect competition, equilibrium implies equality between the interest rates in the two borrowers segments, as given by condition (3.2). Both sophisticated banks and unsophisticated banks make zero profit and they are indifferent with respect to their portfolio allocation between the two segments.

Starting from this configuration, it is optimal for an isolated sophisticated bank to apply for the IRB approach and to allocate its whole portfolio to the low-risk segment. The intuition is the following. With perfect competition, the portfolio reallocation by a single bank does not affect the equilibrium interest rates in the two segments. By applying for the IRB approach and by switching its entire portfolio to the low-risk segment, the sophisticated bank is able to generate the same expected interest income with a lower capital requirement. This strategy brings an expected profit that is larger than the (zero) profit corresponding to an application for the standardized approach.

To get the formal proof of this proposition, we now solve the maximization program (2.7) for the sophisticated bank, and we check that this bank makes a positive profit when applying for the IRB approach, while all other banks stick with the standardized approach. We define p_s^{IRB} as the portfolio allocation chosen by the bank applying for the IRB approach. Since all other banks stick with the standardized approach, the equilibrium interest rates on the two segments are given by (3.2) and they are unaffected by a change in the portfolio allocation by a single bank.

Under these conditions, the derivative of the maximization program (2.7) with respect to p_s^{IRB} is

$$2b(1-p_G),$$

which is positive, implying that the bank using IRB chooses perfect specialization in the low-risk segment.

The expected profit of the bank applying for IRB with p_s^{IRB} =1 and the interest rates levels given by (3.2) is equal to

$$V\left(p_s^{IRB}=1\right)=b\left(1-p_G\right),$$

which is larger than zero.¦

This strategy is optimal for any sophisticated bank. This means that with perfect competition, all sophisticated banks voluntarily apply for the IRB approach and specialize in the low-risk segment.[13]

5.2 Oligopoly

We now examine how imperfect competition can affect sophisticated banks' preference for the IRB. Again, we start from a situation where all banks use the standardized approach, and we determine the conditions under which a sophisticated bank will deviate and apply for the IRB approach. We define $p_{s,n}^{STD}$ as the portfolio allocation of a sophisticated bank using the standard approach.

When all banks use the standardized approach, they choose the same portfolio allocation, regardless of their degree of sophistication

$$p_{s,n}^{STD*}=p_{u,n}=\frac{Np_G U-kNp_G U+2+4N}{4+8N}.$$

Accordingly, the two bank categories make the same profits, i.e., we have $V\left(p_{s,n}^{STD*}\right)=V\left(p_{u,n}^{*}\right)$.

Consider now that one sophisticated bank, indexed i, applies for the IRB approach. This bank will choose the portfolio allocation

[13] Note that at the competitive equilibrium, sophisticated banks using IRB again make zero profits. But no sophisticated bank has an interest to deviate from this equilibrium, i.e., to apply for the standardized approach.

$$p_{s,i}^{IRB*} = \frac{4bN^2(1-p_G) + Np_G U - kNp_G U + 2 + 4N}{4+8N} \qquad (5.4)$$

while all other banks choose

$$p_{u,n}^{*} = p_{s,n\neq i}^{STD*} = \frac{-2bN(1-p_G) + Np_G U - kNp_G U + 2 + 4N}{4+8N}. \qquad (5.5)$$

We define the profits of the sophisticated bank using IRB as $V\left(p_{s,i}^{IRB*}\right)$. The difference between the profits obtained by the sophisticated bank when it applies for the IRB and when it applies for the standardized approach is equal to

$$V_{s,i}\left(p_{s,i}^{IRB*}\right)\text{-}V_{s,i}\left(p_{s,i}^{STD*}\right)=\frac{2bN\left(-1+p_G\right)\left(2bN\left(-1+p_G\right)+\left(-1+k\right)p_G U\right)}{\left(1+2N\right)^2} \qquad (5.6)$$

Expression (5.6) indicates that the sophisticated bank prefers to apply for the IRB when the risk-differentiation factor is large enough, i.e., we need

$$\underline{b} > \frac{\left(-1+k\right)p_G U}{2N\left(1-p_G\right)}.$$

Note that the degree of risk-differentiation necessary for a sophisticated bank to choose the IRB approach decreases with competition intensity. As N tends to infinity, $\underline{b}$ tends to zero. This indicates that with market conditions close to perfect competition, a small - but positive - risk-differentiation factor is sufficient to induce a bank to apply for the IRB. This is consistent with the results in section 5.1.

Of course, as other sophisticated banks choose the same strategy, the attractiveness of an IRB application decreases. For the N sophisticated banks to prefer the IRB approach, we need

$$\underline{\underline{b}} > \frac{(-1+k)p_G U}{2(1-p_G)},$$

which is larger than $\underline{b}$.

5 Conclusion

In this paper, we assessed the prudential implications of the two-layer capital requirement framework proposed in the new Accord by looking at the competitive interaction between sophisticated and sophisticated banks. Our main finding is that the introduction of a two-layer capital requirement framework may encourage sophisticated banks (eligible for the IRB) to decrease risk-taking, and induce unsophisticated banks (eligible for the standardized approach) to increase risk-taking. The pressure for a specialization of sophisticated banks on low-risk borrowers and of unsophisticated banks on high-risk borrowers would be especially strong in a highly competitive environment. From a prudential point of view, this specialization is an issue of concern for two main reasons. First, it seems highly undesirable that high-risk borrowers be concentrated in the portfolios of the banks with less expertise in risk management and measurement. Second, because of the lack of risk-sensitivity of the standardized approach, the possible increase in risk-taking by unsophisticated banks would not be compensated by higher capital charges, and it could thus lead to a deterioration of the capital adequacy in this bank category. This looks like a high price to pay against the advantage of having risk-sensitive capital requirements for sophisticated banks.

The purpose of this paper is not to propose an alternative to the minimum capital requirement defined in the new Basel Accord. Rather, it is to highlight that any regulatory capital requirement - regardless of its degree of sophistication - may produce some undesirable effects when implemented in a strictly mechanical way. This suggests that the two other pillars of the new Accord - the supervisory review process and market discipline - have an important role to play as complements to the minimum capital requirement. Under the supervisory review process, supervisors are supposed to conduct an extensive analysis of each bank's risk management techniques and risk profile and they have the possibility to require banks to hold more capital than the regulatory minimum. Under the market discipline pillar, banks will have to comply with higher disclosure requirements regarding capital, risk and risk management. In that context, supervisors and market participants should be in a better position to impose penalties - in the form of additional capital requirements, increased scrutiny or higher risk premiums – on banks using obsolete credit risk management techniques or reallocating their portfolio towards riskier borrowers following the introduction of the new Basel Accord.

The paper also has an implication for the Committee's proposal in the second and third consultative papers to divide the IRB approach into two sub-regimes, an "advanced" approach and a "foundation" approach, for which part of the eligibility criteria is less demanding. At first sight, the introduction of the foundation IRB should reduce the proportion of banks still having to comply with the standardized approach and thus mitigate the risk reallocation effects analyzed in this paper. The problem, however, is that only a minority of unsophisticated banks dispose of the historical data on their loan portfolio performance that is necessary to comply with the data requirements imposed for the foundation IRB. A systematic pooling of the data among banks could solve the data problem faced by individual banks. The regulators and the various banks' associations have certainly a role to play in the creation of these data pools, for example by acting as intermediaries that guarantee the confidentiality of data.

Appendix A: Relaxing the assumption of an infinitely elastic supply of capital in the competitive model

We assume that raising capital implies an opportunity cost r_c per unit of capital. The opportunity cost is an increasing function of the amount of capital raised by the banking industry C_{all}. For simplicity, we define $r_c(C_{all}) = w + z \cdot C_{all}$, with w, z >0.

With perfect competition, the maximization program including the opportunity cost of capital for a bank of type t (with $t = u$, s) is

$$\max_{p_t} V(p_t) = p_G \cdot [p_t A(1+r_l) + (1-p_t)A(1+r_h) - (A - C_t)] - C_t(1+r_c).$$

Using the capital requirement defined in section 2.5, we obtain the following first-order condition for sophisticated banks

$$-2b(-1 + p_G - r_c) + p_G(-r_h + r_l) = 0.$$

For unsophisticated banks, the first-order condition is

$$p_G(-r_h + r_l) = 0.$$

The first-order conditions cannot be satisfied at the same time for the two bank categories. Using the same approach as in section 3, we examine whether the combination of corner solutions p_u=0 and p_s=1 is an equilibrium.

The competitive equilibrium is defined by a system of six equations with six unknowns, r_l, r_h, r_c, Q_l, Q_h and C_{all}.

Equations (A.1) and (A.2) specify the inverse loan demand functions for the two borrowers segments

$$r_l = U - 2Q_l v / p_G \tag{A.1}$$

$$r_h = kU - 2Q_h v / p_G \tag{A.2}$$

Equation (A.3) specifies the opportunity cost of capital

$$r_c = w + z \cdot C_{all} \tag{A.3}$$

Equations (A.4) and (A.5) state that in a competitive equilibrium, net income just cover the opportunity cost of capital for each bank category

$$V_{u,i}\left(r_h, r_l, r_c, p_u = 0\right) = 0 \tag{A.4}$$

$$V_s\left(r_h, r_l, r_c, p_s = 1\right) = 0 \tag{A.5}$$

Equation (A.6) specifies the overall amount of capital that the banking industry must hold at equilibrium to comply with the capital requirements. Since sophisticated banks specialize on the low-risk segment and unsophisticated banks specialize on the high risk segment, the overall amount of capital can be expressed as a function of aggregate lending to each borrower segment

$$C_{all} = cQ_h + (c - b)Q_l \tag{A.6}$$

From (A.4) and (A.5), we know that at equilibrium, the interest rates levels in the two segments are such that for the two bank categories, net income just cover the opportunity cost of capital. Solving the system of equations, we find that for an unsophisticated bank entering the low-risk segment, net income would not be large enough to cover the opportunity cost of capital. Formally, we have

$$V_{u,i}\left(r_h^{\ *}, r_l^{\ *}, r_k^{\ *}, C_{all}^{*}, p_{u,i} > 0\right) = bp_{u,i}\frac{b\cdot z\cdot p_G U - c\cdot z(1+k)p_G U - 2(1-p_G + w)}{b^2 z - 2b\cdot c\cdot z + 2(c^2 z + 1)} < 0,$$

under the condition that $c \geq b$, i.e. the capital requirement for low-risk lending is not negative.

The opposite holds for a sophisticated bank. If the latter enters the high-risk segment, net income will not be large enough to cover the opportunity cost of capital. Formally, we have

$$V_{s,i}\left(r_h^{\ *}, r_l^{\ *}, r_k^{\ *}, C_{all}^{*}, p_{s,i} < 1\right) = b(1 - p_{s,i})\frac{b\cdot z\cdot p_G U - c\cdot z(1+k)p_G U - 2(1-p_G + w)}{b^2 z - 2b\cdot c\cdot z + 2(c^2 z + 1)} < 0.$$

Hence, the combination of corner solutions p_u=0 and p_s=1 is an equilibrium and no bank has interest to deviate from this equilibrium. This result is the same as the one obtained in section 3 under the assumption that the supply of capital is infinitely elastic. In the presence of the opportunity cost of capital, the two-layer capital requirement framework still implies that sophisticated banks have a comparative advantage in lending to the low-risk segment, and vice versa. The only difference with section 3, is that the presence of the opportunity cost of capital makes borrowing more expensive for the two-borrower segments. Accordingly, the amounts lent to the two borrower segments are lower.

Appendix B: Relaxing the assumption that the two borrower categories have the same default probability

We now assume that the two borrowers' projects differ in their probability of success, but that they have the same pay-off structure. The low-risk borrower's returns $(1+U)$ per unit of investment with probability p_l, and $(1-U)$ otherwise. The project of the high-risk borrower returns $(1+U)$ per unit of investment with probability p_h, and $(1-U)$ otherwise. We set $p_h < p_l$, i.e. the low-risk borrower has a lower probability of default than the high-risk borrower.

For simplicity, we assume that defaults are independent across the two borrower categories. We now have four possible states of nature: (i) with probability $p_h p_l$, none of the borrower categories is in default; (ii) with probability $(1-p_h)(1-p_l)$, the two borrower categories are in default; (iii) with probability $(1-p_l)p_h$, only the low-risk borrower category is in default; (iv) with probability $(1-p_h)p_l$, only the high-risk borrower category is in default.

Assume now that banks default only in the state of nature where the two borrower categories are in default. In a Cournot oligopoly with N sophisticated and N unsophisticated banks, the maximization programs for the two representative banks are

$$\begin{aligned}\max_{p_{s,n}} V(p_{s,n}) = {} & p_l p_h A/N[p_{s,n} r_l + (1-p_{s,n})r_h] - (1-p_l p_h)A/N[c + (1-2p_{s,n})b] \\ & + p_l(1-p_h)A/N[p_{s,n} r_l - (1-p_{s,n})\cdot U] - (1-p_l(1-p_h))A/N[c+(1-2p_{s,n})b] \\ & + (1-p_l)p_h A/N[-p_{s,n}U + (1-p_{s,n})r_h] - (1-(1-p_l)p_h)A/N[c+(1-2p_{s,n})b]\end{aligned}$$

$$\max_{p_{u,n}} V(p_{u,n}) = p_l p_h A/N[p_{u,n} r_l + (1-p_{u,n}) r_h] - (1-p_l p_h) A/Nc$$
$$+ p_l (1-p_h) A/N[p_{u,n}(r_l) - (1-p_{u,n})U] - (1-p_l(1-p_h))A/Nc$$
$$+ (1-p_l) p_h A/N[-p_{u,n}U + (1-p_{u,n}) r_h] - (1-(1-p_{,l})p_h)A/Nc$$

Solving, we obtain the following portfolio allocations for each representative bank

$$p^*_{s,n} = \frac{b(N+N^2)(-1+p_h)(-1+p_l) - Np_hU + Np_lU + 1 + 2N}{2+4N} \tag{B.1}$$

$$p^*_{u,n} = \frac{-bN^2(-1+p_h)(-1+p_l) - Np_hU + Np_lU + 1 + 2N}{2+4N} \tag{B.2}$$

(B.1) and (B.2) indicate that the optimal proportion p^* invested in the low-risk borrowers segment is an increasing function of the differentiation factor b for the sophisticated bank, but a decreasing function of b for the unsophisticated bank. This result is the same as the one obtained in section 4 under the assumption that the two borrower categories have the same probability of default. With a larger b, the sophisticated bank has a larger comparative advantage in lending to low-risk borrowers. Whether low-risk borrowers are characterized by a lower probability of default or by a lower loss given default is irrelevant.

Alternatively, we could have assumed that banks are able to avoid a default only in the state of nature where the two borrower categories do not default. In this case, the optimal portfolio allocations would be

$$p^*_{s,n} = \frac{b(N+N^2)(1-p_l p_h) + p_l(1+2N)}{(1+2N)(p_l + p_h)} \tag{B.3}$$

$$p^*_{u,n} = \frac{-bN^2(1-p_l p_h) + p_l(1+2N)}{(1+2N)(p_l + p_h)} \tag{B.4}$$

(B.3) and (B.4) have the same implications as (B.1) and (B.2) with regard to the impact of the risk-differentiation factor on portfolio allocation by the two bank categories. As long as banks default in at least one state of nature, the number of states where they do not default do not affect the predictions of the model.

References

Altman, E., Saunders, A., 2001, An Analysis and Critique of the BIS Proposal on Capital Adequacy and Ratings, *Journal of Banking and Finance,* 25(1), pages 25-46.

Basel Committee, 1999, A New Capital Adequacy Framework, Consultative paper, June 1999.

Basel Committee, 2000, Range of Practice in Banks' Internal Ratings Systems, January 2000.

Basel Committee, 2001, The New Basel Accord, Consultative paper, January 2001.

Basel Committee, 2003, The New Basel Accord, April 2003.

Berger, Allen N., Herring, Richard J., Szegö, Giorgio P., 1995, The Role of Capital in Financial Institutions, *Journal of Banking and Finance,* 19(3-4), June 1995, pages 393-430.

Blum, Jürg, 1999, Do Capital Adequacy Requirements Reduce Risks in Banking?, *Journal of Banking and Finance,* 23(5), May 1999, pages 755-71.

Boot, Arnoud, Dezelan, Silva and Milbourn, Todd., 2000, Regulatory Distortions in a Competitive Financial Services Industry, *Journal of Financial Services Research* 17(1), pages 249-259.

Décamps, Jean-Paul, Rochet, Jean-Charles and Roger, Benoît, 2002, The Three Pillars of Basel II: Optimizing the Mix in a Continuous-Time Model, Paper presented at the BIS Conference "Basel 2: an Economic Assessment", May 2002.

Freixas, Xavier, Rochet, Jean-Charles, 1997, Microeconomics of banking, The MIT Press.

Frey, Rudiger; McNeil, Alexander J., 2002, VaR and Expected Shortfall in Portfolios of Dependent Credit Risks, *Journal of Banking and Finance,* 26(7), pages 1317-34.

Furlong, Frederick T., Keeley, Michael C., 1989, Capital Regulation and Bank Risk-Taking: A Note, *Journal of Banking and Finance,* 13(6), December 1989, pages 883-91.

Gennotte, Gerard, Pyle, David, 1991, Capital Controls and Bank Risk, *Journal of Banking and Finance,* 15(4-5), September 1991, pages 805-24.

Hellmann, T.F., Murdock, K.C. and Stiglitz, J.E., 2000, Liberalization, Moral Hazard in Banking, and Prudential Regulation: Are Capital Requirements Enough?, *American Economic Review,* 90, pages 147-165.

Jackson, Patricia, Perraudin, William and Saporta, Victoria, 2002, Regulatory and 'Economic' Solvency Standards for Internationally Active Banks, *Journal of Banking and Finance,* 26(5), pages 953-76.

Kim, Daesik, Santomero, Anthony M., 1988, Risk in Banking and Capital Regulation, *Journal of Finance,* 43(5), December 1988, pages 1219-33.

Kirstein, Roland , 2002, The New Basle Accord, Internal Ratings, and the Incentives of Banks, *International Review of Law and Economics,* May 2002, 21(4), pages 393-412.

Kreps, David M., Scheinkman, Jose A., 1999, Quantity Precommitment and Bertrand Competition Yield Cournot Outcome, Jean-J. Thisse, and Jacques-Francois, eds. Microeconomic theories of imperfect competition: Old problems and new perspectives. Elgar Reference Collection. International Library of Critical Writings in Economics, vol. 102, pages 105-16.

Merton, Robert C., 1977, An Analytic Derivation of the Cost of Deposit Insurance and Loan Guarantees, *Journal of Banking and Finance,* 1, June 1977, pages 3-11.

Repullo, Rafael, 2002, Capital Requirements, Market Power, and Risk-Taking in Banking, Paper presented at the BIS Conference "Basel 2: an Economic Assessment", May 2002.

Rochet, Jean-Charles, 1992, Capital Requirements and the Behaviour of Commercial Banks, *European Economic Review,* 36(5), June 1992, pages 1137-70.

Santos, Joao A. C., 1999, Bank Capital and Equity Investment Regulations, *Journal of Banking and Finance*, 23(7), July 1999, pages 1095-1120.

Tirole, Jean, 1993, The Theory of Industrial Organization, The MIT Press Cambridge, Massachusetts, 479 pages.

Swiss National Bank, nor does it imply the policy views, nor potential policy of those institutions.