BANK OF FINLAND
DISCUSSION PAPERS

9/96

Vesa Vihriälä

Research Department
2.4.1996

Bank Capital, Capital Regulation and Lending

SUOMEN PANKIN KESKUSTELUALOITTEITA • FINLANDS BANKS DISKUSSIONUNDERLAG

Suomen Pankki
Bank of Finland
P.O.Box 160, FIN-00101 HELSINKI, Finland
☎ + 358 0 1831

Vesa Vihriälä

Research Department
2.4.1996

Bank Capital, Capital Regulation and Lending

ISBN 951-686-501-1
ISSN 0785-3572

Suomen Pankin monistuskeskus
Helsinki 1996

Bank Capital, Capital Regulation and Lending

Bank of Finland Discussion Papers 9/96

Vesa Vihriälä
Research Department

Abstract

The paper analyzes bank loan supply in a simple value maximizing partial equilibrium framework. The focus is on the role of bank capital, capital regulation and the pricing of bank liabilities. The model is constructed so as to resemble the situation of the Finnish local banks in the late 1980s and the early 1990s, particularly with regard to capital regulation which changed subtantially during this period. While equity capital is assumed exogenous, the bank may choose the amount of subordinated debt which also counts as regulatory capital. The model shows that bank characteristics matter for loan supply, when the bank is penalized for bank failure (capital insufficiency relative to a regulatory requirement). When this penalty is positive, fair or excessive pricing (lemons premium) of bank liabilities makes bank lending depend positively on bank capital but underpricing results in a negative relationship. A negative relationship may also emerge if the bank anticipates "perverse" bank support policies ie. that capital insufficiency will be rewarded with transfers from the authorities. Thus both a credit crunch due to lack of capital and "excessive" risky lending due to moral hazard can obtain in a single model, depending on the circumstances. The precise nature of capital regulation is not important, provided a failure to meet the requirement is sufficiently penalized. The model suggests that the mutually exclusive hypotheses of credit crunch / excessive lending due to moral hazard can be tested not only by examining the relationship between bank lending on the one hand and bank equity and bank costs on the other hand, but also by examining the relationship of subordinated debt with bank lending and the capital ratio.

Keywords: bank lending, capital, capital regulation, moral hazard, credit crunch

Tiivistelmä

Paperissa analysoidaan pankin luotontarjontaa yksinkertaisessa arvon maksimointiin perustuvassa osittaisen tasapainon kehikossa. Päähuomio kiinnitetään pankin oman pääoman, pääomasääntelyn ja pankin velkojen hinnoittelun vaikutuksiin. Malli on rakennettu pitäen silmällä suomalaisten paikallispankkien tilannetta 1980-luvun lopulla ja 1990-luvun alussa, erityisesti tällöin voimakkaasti muuttuneen pääomasääntelyn osalta. Pankin varsinainen oma pääoma oletetaan eksogeeniseksi, mutta pankki voi valita pääomasäännöstelyssä pääomaksi luettavan vastuudebentuurirahoituksen määrän. Malli osoittaa, että pankin ominaisuudet vaikuttavat luotontarjontaan, kun pankin pääoman riittämättömyydestä seuraa rangaistus. Kun tämä rangaistus on positiivinen, pankin velkojen reilu hinnoittelu tai ylihinnoittelu (riskipreemio) johtaa positiiviseen relaatioon pankin oman pääoman ja luotonannon välillä ja alihinnoittelu johtaa negatiiviseen riippuvuuteen. Negatiivinen riippuvuus voi syntyä myös, jos pankki odottaa viranomaisten "palkitsevan" pääomavaatimuksen alittamisen varallisuuden siirtoa merkitsevällä pankkituella. Yksi ja sama malli tuottaa siten olosuhteista riippuen pääoman puutteesta aiheutuvan luottolaman ja moral hazardista aiheutuvan riskipitoisten luottojen liiallisen myöntämisen. Pääomasääntelyn muodolla ei ole suurta merkitystä edellyttäen, että pääomavaatimuksen alittamisesta seuraa riittävä rangaistus. Keskenään ristiriitaisia hypoteeseja pääoman puutteesta aiheutuvasta luottolamasta ja moral hazardin aiheuttamasta liiallisesta luotonannosta voidaan mallin perusteella testata paitsi suoraan tutkimalla luotonannon ja pankin pääoman sekä kustannusten välisiä yhteyksiä myös tarkastelemalla yhteyksiä vastuudebentuurien ja pankin luotonannon laajuuden sekä pääomasuhteen välillä.

Avainsanat: Avainsanat: luotontarjonta, oma pääoma, pääomasääntely, moral hazard, luottolama

Contents

1 Introduction

The general objective of this paper is to explore theoretical reasons for bank behaviour that may have contributed to the credit cycle of the Finnish Economy since the mid-1980s. By contribution is meant the role of banks' credit supply behaviour which may have made supply of credit in some sense "excessive" in the aftermath of financial liberalization in the late 1980s and "too small" in the the early 1990s. The benchmark is a situation in which credit growth is determined simply by the return of the projects to be financed and "the rate of interest" ie. a situation where bank behaviour or bank characteristics do not play any role. In this benchmark situation banks are simply a passive veil.

Several broad stories exist in the literature to explain why bank behaviour may matter, and in particular why it may vary in such a way as observed in the Finnish credit cycle. Most of them give a central role for bank capital or net worth.

As discussed in Vihriälä (1996), a large literature based on asymmetric information argues that the firm net worth affects the cost and availability of external financing of any firm. Thus weak bank capital may force banks to restrain lending as re-financing becomes increasingly expensive or cannot be found at all due to lemons premia. Bankruptcy costs or "costs of financial distress" may also have the same effect even under symmetric information, although the size of such costs probably cannot be assumed high in the absence of informational asymmetries. These "market-based" capital effects may be reinforced by capital regulation imposed by the authorities. As a consequence, depleation of bank capital, say due to credit losses, may lead to a "credit crunch" or more specifically "capital crunch", which has been claimed to have contributed to the credit slowdown in several countries, particularly in the United States in the early 1990s. Bank lending thus turns out too small relative to a frictionless Modigliani-Miller world.

Bank capital playes an important but rather different role also in one of the leading explanations for potential excessive risky lending by the banks. Under limited liability the value of bank equity can be increased by increasing the riskiness of bank assets provided the cost of bank liabilities does not respond sufficiently to the increased credit risk. Starting with Merton (1977), flat-rate deposit insurance has been considered an important source of underpricing of bank funding and therefore of "moral hazard" incentives. The smaller bank capital or net worth to begin with, the greater are these incentives. Thus although underpricing of bank liabilities is the fundamental cause of excessive risk taking, the amount of capital greatly affects the size of the problem. Many accounts of the savings and loan crisis of the 1980s in the United States name moral hazard as a reason for the rapid growth of the – ex post highly unprofitable – thrift lending to real estate businesses.

Another widely cited cause for variation in the banks' loan supply behaviour is competition. Fear for excessive competition which would threaten the survival of individual banks and the stability of the financial system as a whole has in fact motivated much of the regulation (including the aforementioned deposit insurance and restrictions on entry) applied to financial institutions since the 1930s. In part change in the degree of competition is seen to work through the moral hazard mechanism noted above. When competition in the financial markets increases, margins in financial intermeadition decrease, lowering the net worth of financial institutions. Keeley (1990) among others argues that the banks' "charter value" ie. the economic rent associated with banking licence decreased as a result of increased competition in the 1980s among different types of financial institutions and that this led to increased risk taking by many American banks.

But competition may affect loan supply behaviour in other ways as well. One idea is that competition may lead the banks to pay too little attention to borrower quality. Banks' efforts to screen borrowers may be reduced by increased competition as the benefits from screening decline with more competition. But it is not at all clear that less information gathering necessarily means more risky lending. As Broecker (1990) shows, the lesser profitability of screening due to increased competition may in fact make lenders more conservative in their lending policies in fear of what is called the "winner's curse".

Some further ideas about the role of bank competition pay no explicit attention to credit risk but rely on changes in strategic behaviour. In particular, it has been claimed that liberalization of financial regulation induces additional competition, as the banks attempt to capture market shares early on in the expanding market, see e.g. Vives (1991). It has been also argued that independently of any regulatory changes, monopolistic competition can lead to price wars in times of high demand, as the benefits from aggressive pricing relate to a larger-than-average overall demand while the retaliation of the competitors will have an effect at a later stage of more normal demand.[1]

Conflicts of interest between bank management and bank owners may also result in excessive risk taking which can take the form of highly expansionary risky lending. Managers of poor ability may be induced to take excessive risks in order to keep their positions. Gorton and Rosen (1995) provide a model in which such incentives are strongest when external conditions are adverse, just a as in the standard moral hazard case, where weakening profitability increases gains from a gamble for resurrection. But it may be argued that lending may exceed the value maximizing level also in buoyant market conditions, when displaying bad profitability would more likely be interpreted as a proof of managent inability than in more difficult circumstances.[2]

A totally different view from all arguments above is to emphasize the potential "irrationality" or "bounded rationality" of economic agents. Most prominently Minsky (1977) and Kindleberger (1982) argue that the actions of economic agents including bankers are to a large extent determined by such psykological factors as "optimism", "euphoria" and "pessimism". Herd behaviour also may be characteristic for decision making in such situations. Thus it may be argued that the rapid growth of lending following liberalization was at least partly fuelled by highly optimistic – and in retrospect false – expectations about asset prices etc., and similarily the contraction of credit later on was at least partly due to pessimism. However, these types of arguments are extremely difficult if not impossible to test with any real economy data: suitable assumptions about expectations may rationalize all kinds of patterns of observed variables.

This paper focuses on the role of bank capital, capital regulation and pricing of bank liabilities. On the one hand, the aim is to illustrate how bank lending can be both too expansionary and too small relative to a Modigliani–Miller situation within a simple model depending on the precice assumptions about the pricing of bank

[1] Rotemberg and Saloner (1986).

[2] Rajan (1994).

liabilities and the penalties associated with bank default. On the other hand, the aim is to develope testable implications of the "excessive lending due to moral hazard" and "credit crunch due to capital insufficiency" hypotheses applicaple to Finnish banking since 1985.

The analysis will be conducted in a simple static framework which assumes value maximization as the objective of the banking firm. The simplicity of the framework allows using a relatively rich liability structure and incorporating a reasonably realistic capital regulation while keeping the comparative statics largely unambiguous. The assumptions of the model are made with regard to the characteristics of the Finnish savings and cooperative banks in the late 1980s and early 1990s, as data on these banks will be used in the subsequent empirical analyses.

The paper is organized as follows. The basic assumptions of the model are laid down and discussed in sections 2. In section 3 the returns of the relevant financial claims for the optimization problem are computed. The case of fair pricing of marginal funding with a liability side capital regulation is analyzed in section 4 while the cases of underpricing or overpricing are analyzed in section 5. Section 6 shows how the model works with an asset side capital regulation. Finally the main results are summarized in section 7. In that last section we also present some specific implications of the model for explaining the Finnish credit cycle.

2 The basic assumptions of the model

We take as the point of departure the so-called Klein–Monti model of bank behaviour augmented with credit risk (Klein 1971). Such a model has been used eg. by Dermine (1984, 1986). It is thus assumed that the bank (owner/manager) maximizes the value of equity or expected end-of-period net worth. Also the providers of funds to the bank are assumed risk-neutral.

The asset and liability structure is constructed so as to embody the essential features of the Finnish savings and cooperative banks.

The basic assumptions are as follows:

(i) Bank balance sheet: $L + B = K + D + S + M$,

where L = loan(s) to risky investment project(s)
B = riskless bonds
K = equity capital (exogenous)
S = subordinated debt
D = (core) deposits (exogenous)
M = money market debt or other senior debt

Assuming equity capital to be exogeneous in the static setting is a very close approximation of the situation of the Finnish saving and cooperative banks. Until 1991, the savings banks had in practice no instruments to augment equity capital, equity could be added only through retained earnings.[3] Since 1991, the savings banks have been allowed to issue "basic fund shares" and the cooperative banks "investment shares" which are counted as equity. Their importance has been miniscule, however.

Instead, the banks have been able to issue freely subordinated debt, which functions as a cushion vis-á-vis any senior debt in the case of insolvency. Up to a limit, as will explained later, subordinated debt also counts as regulatory capital.

Senior debt is divided here into exogenous "deposits" and endogenous "money market debt" (or other senior debt). The former is assumed to represent the retail deposits that the banks may obtain, owing eg. to tax priviledges and full deposit insurance, at so low rates that all such deposits are accepted under all circumstances. Although the Finnish regulations have varied over time, the rates on tax-exempt transactions and time deposits have been constrained clearly below market rates by law. The underpring of these so-called core deposits represents a priviledge given for the banking firms by legislation. It can be said to create "charter value" to the firms licenced to do banking business.

In contrast, the rest of senior debt is assumed to be available at posted rates or posted marginal cost at or above the bond rate. Such funds are denoted by M and called money market debt. In the Finnish context this item contains, apart from true money market debt in the form of certificates of deposits (CD's), interbank borrowing and possibly also taxable time deposits.

It is assumed that D is senior to M in the case of bankruptcy. This is not strictly according to the Finnish legislation but simplifies the analysis somewhat without distorting the qualitative results.

(ii) Interest rates and returns:

L: $R(L) = 1 + r(L)$ is the contract rate. It is assumed that the marginal contractual revenue $MR \equiv \partial(R(L)L)/\partial L$ is diminishing in L due to local or temporary monopoly power. This rather standard assumption in this type of models can be rationalized for example by the monopoly power created by informational advantages of customer relationships, see eg. Rajan (1992).

a is a stochastic return on the fixed-size project financed by the bank loan, with d.f. f(a) and c.d.f F(a) known by all agents. The lower and upper bounds of the return distribution are denoted by a^{min} and a^{max}.

The structure implies that the bigger L, the larger the set of the realizations of the project returns, where the firm does not meet the contractual commitment and the bank incurs a credit loss. In particular the ratio of credit losses over the contractual commitment increases with loan volume, mimicing the empirical findings of Solttila and Vihriälä (1994).

---

[3] The significance of cooperative capital as a source of equity was very small also for the cooperative banks; furthermore, the right of the members of a cooperative to withdraw their share of cooperative capital under certain circumstances makes that instrument questionable as equity that could be used to cover losses.

Rather than interpreting the project outcome literally it might be better regarded as the value of the loan customers' collaterizable wealth.

B: R^B is exogenous constant

K: residual claim

S: R^S is determined so as to make the expected return on an investment in S, $E(R^S S)$, equal to the return on an investment of the same size in the safe asset B. The posted rate, which is greater than or (in a degenerated case) equal to the bond rate, is thus fair from the point of view of a risk neutral investor.

D: $R^D < R^M$ is exogenous constant. Apart from representing the average cost of the exogenous cheap funds, R^D may be interpreted as any exogenous cost element that is independent of other liabilities.

M: The posted rate R^M is assumed to be equal to or greater than the bond rate. In one version of the model, R^M is assumed to determined just as R^S ie. to make the expected return on an investment in M equal to that of a bond portfolio of the same size. Apart from this fair pricing of M, also the version is analyzed where $R^M(.)$ is a fixed non-decreasing function of M. The fixed cost schedule can reflect rather different underlying assumptions. On the one hand, a relatively flat such schedule could be consistent with an assumption of an implicit creditor protection (or if M is interpreted as time deposits also flat rate explicit deposit insurance). On the other hand, a steeply rising cost schedule could stand in for a rapidly rising lemons premium associated with (unmodelled) asymmetric information about bank behaviour.

(iii) Capital adequacy regulation:

Prior to 1991, the Finnish banks were required to have capital equal to at least 4 per cent (commercial banks) or 2 per cent (savings banks and cooperative banks) of total liabilities (excluding some specific items) and half of the off-balance sheet commitments. Subordinated debt was among the items subtracted from the liability base and could be counted as capital up to 50 per cent of the proper capital. Since 1991 the regulations have required (along the lines of the BIS recommendations) the banks to have capital at least 8 per cent of the risk-weighted assets and off-balance-sheet commitments. Again certain types of debt instruments, including subordinated debt, can be counted as regulatory capital. Risk-weighting was tightened and some other adjustments were made as of 1994.

There are in principle several ways of introducing capital constraints into the analysis. The simplest thing is to set an ex ante constraint in the form $K > k(D + M)$ or $K > kL$. That is what for instance Peek and Rosengren (1994) do in their credit crunch analysis. This is nevertheless rather unsatisfactory, as it does not take into account the possibility that banks may sometimes fail to fulfil the requirement and the regulation is enforced with different degrees of strictness.

A more natural way of introducing the capital regulation is to postulate a non-pecuniary cost to the bank (owners/managers) in the case of non-fulfilment of the requirement. Direct empirical counterparts of such penalties could be the costs associated with law suits for negligence and prohibition of further banking activities on the part of the management, and exclusion of the owners from a potentially privileged banking market (with a positive charter value). Here it is assumed that this cost is proportional (coefficient $c \leq 1$) to the shortfall of the regulatory bank capital (the sum of net worth and subordinated debt) from the required level (fraction k of the base). Thus with the pre-1991 rules the cost of non-fulfilment of the requirement can be written: $c(k(R^D D + R^M M) - (a + R^B B - R^D D - R^M M - R^S S + R^S S))$. The capital with which the bank meet the requirement consists thus of bank net worth and the value of subordinated debt which will be counted towards regulatory capital up to a given maximum S^{max}. This regulatory cost is incurred when the project outcome a falls short of $a^k \equiv (1 + k)(R^D D + R^M M) - R^B B$.

The cost c can be interpreted as the product of the probability of inspection of capital adequacy and the penalty imposed in the case of non-performance. The value $c = 1$ would correspond unlimited liability in the sense that the cost would be equal to a capital injection sufficient to make the bank just meet the regulatory constraint in every state of world. The value $c = 0$ represents the case of no effective capital regulation. Finally, one may even contemplate a perverse case with $c < 0$, if a failure to meet the capital requirement is rewarded by government bank support say in the form of subsidized loans, purchaces of assets at inflated prices, injection of capital etc.

The above formulation corresponds to that of Dermine (1984). However, in his model the treshold for the project return is set at the point where the bank is just able to meet its contractual commitments ($k = 0$), and Dermine gives these costs the interpretation of bankruptcy costs. If by bankruptcy cost is meant administrative costs and the reduction of the value of a firm's assets in liquidition, such costs should reduce the value of the claims of the creditors, ie. the costs ought to be pecuniary rather than non-pecuniary, as here. In that sense a bankruptcy cost interpretation would seem somewhat questionable.

Here the penalty is interpreted in the first place as a regulatory punishement by the authorities. As such the non-pecuniary nature of the penalty would seem quite appropriate.[4] On the other hand, sticking strictly to a regulatory cost interpretation may be unnecessarily narrow. The banks which fail to meet the capital adequacy standards may in fact be penalized also by the "market" even in the absence of a bankruptcy. For managers loss of reputation may be a significant factor. Uncertainty about the value and fate of the bank failing a capital requirement may temporarily hamper the

[4] Also Passmore and Sharpe (1994) utilize the idea of non-pecuniary costs imposed on the owners to introduce capital constraints. However, in their model the cost is made proportional to the loan stock rather than the amount of capital shortfall, as would seem natural.

bank's possibilities to conduct business and make the equity stake illiquid for a while even if the bank need not in the end be reorganized in a way which creates dead weight costs.

One can postulate an analogous cost of capital insufficiency to depict the current (as of 1991) capital regulation. In this case the threshhold for the project return is $a^k \equiv kRL + R^D D + R^M M - R^B B$.

It is reasonable to assume that the bank must meet the capital requirement always ex ante ie. that the supervisors would not allow a bank to operate if the contractual loan rate were so small that the bank were sure to fail the capital regulation.

(iv) Simplifying assumptions: ignorance of the reserve requirement and the premium for deposit insurance

In order to simplify the presentation, two typical features of this type of models are left out: the reserve requirement and deposits insurance premium. The former would in our setting be a tax on reservable deposits, and their effects can be analyzed by altering the exogenous cost of such funds.

Similarly the existing flat-rate deposit insurance premium levied on the balance sheet total would be very easy to incorporate by simply postulating that the bank has to pay an ex ante tax of the size p(L + B). However, as long as it is flat rate (as in Finland) it does not have any interesting implications, and it left out of the analysis.

3 The returns on various claims

Given the seniority structure of the various claims on the bank, the returns contingent on the project outcome a are with the pre-1991 capital regulation as follows:

<u>Return on S</u>

$$\begin{cases} R^S S, \text{ when} & a \geq a^s \equiv R^S S + R^D D + R^M M - R^B B \\ a + R^B B - R^D D - R^M M, & a^s > a \geq a^M \equiv R^D D + R^M M - R^B B \\ 0, & a < a^M \end{cases} \tag{1}$$

Return on M

$$\begin{cases} R^M M, \text{ when} & a \geq a^M \\ a + R^B B - R^D D, & a^M > a \geq a^D \equiv R^D D - R^B B \\ 0, & a < a^D \end{cases} \tag{2}$$

Return on D

$$\begin{cases} R^D D, \text{ when} & a \geq a^D \\ a, & a < a^D \end{cases} \tag{3}$$

Return on K

$$\begin{cases} RL + R^B B - R^S S - R^M M - R^D D, \text{ when} & a \geq RL \\ a + R^B B - R^S S - R^M M - R^D D, & RL > a \geq a^k \equiv \\ & (1+k)(R^D D + R^M M) - R^B B \\ a + R^B B - R^S S - R^M M - R^D D - c(a^k - a), & a^s \leq a < a^k \\ -c(a^k - a), & a < a^S \end{cases} \tag{4}$$

Note that $a^s < a^k$ is equivalent to the requirement that $R^S S < k(R^D D + R^M M)$, i.e. that subordinated debt never can meet the capital requirement alone. Given the constraint that subordinated debt can be counted as regulatory capital only up to 50 per cent of the core capital K, this condition is always fulfilled when subordinated debt is needed for capital adequacy reasons.

Expected returns

The expected return of subordinated debt is

$$E(R^S S) = \int_{a^s}^{a^{max}} R^S S f(a) da + \int_{a^M}^{a^s} (a + R^B B - R^D D - R^M M) f(a) da. \tag{5}$$

Adding and subtracting $R^S S \int_{a^M}^{a^s} f(a)da$ and integrating by parts allowes (5) to be written as

$$E(R^S S) = R^S S - \int_{a^M}^{a^S} F(a)da. \tag{6}$$

Equating (6) with the return on a safe investment of the same size yields the condition for the fair pricing of subordinated debt

$$R^S S = R^B S + \int_{a^M}^{a^S} F(a)da. \tag{7}$$

In (7) the second term of the RHS is the required default premium, which is a highly nonlinear function of the portfolio composition.

Similarily one obtains the rule for the fair pricing of money market debt

$$R^M M = R^B M + \int_{a^D}^{a^M} F(a)da. \tag{8}$$

It is easy to see that (7) and (8) imply the following bounds for the fair posted rates

$$\frac{R^B}{1 - F(a^M)} \leq R^S \leq \frac{R^B}{1 - F(a^S)} \tag{9}$$

$$\frac{R^B}{1 - F(a^D)} \leq R^M \leq \frac{R^B}{1 - F(a^M)} \tag{10}$$

As one would expect, the fair posted rate is higher for subordinated debt than for money market debt. If there is no risk that the bank defaults on money market debt or subordinated debt ie. $F(a^M) = F(a^S) = 0$, the posted rates naturally collapse into the safe bond rate.

In the same fashion the expected value of equity K

$$\begin{aligned} E(V) = &\int_{RL}^{a^{max}} (RL + R^B B - R^S S - R^M M - R^D D)f(a)da \\ &+ \int_{a^S}^{RL} (a + R^B B - R^S S - R^M M - R^D D)f(a)da \\ &- \int_{a^{min}}^{a^k} c(a^k - a)f(a)da \end{aligned} \tag{11}$$

can be written after some manipulation as

$$E(V) = RL + R^B B - R^S S - R^M M - R^D D - \int_{a^S}^{RL} F(a)da - c \int_{a^{min}}^{a^k} F(a)da. \tag{12}$$

4 Maximization of bank value with fair pricing of subordinated debt and money market debt

Consider first the benchmark case where all endogenous funding takes place at a fair rate ie. that the risk neutral investors require an expected return R^B on both subordinated debt and money market debt. At that expected rate the supplies are fully elastic. Later we take a look at the situation when the price for money market debt deviates from the fair pricing.

4.1 The optimization problem

Given the assumption of risk neutrality, the objective of the bank (owner/manager) is to maximize bank value subject to the pricing constraints, balance sheet constraint, non-negativity contraints and the constraint $S \leq S^{max}$. The Lagrangean of this problem is

$$\begin{aligned} Z &= E(V) + \lambda_1(L + B - K - D - S - M) + \lambda_2(R^S S - R^B S - \int_{a^M}^{a^S} F(a)da) \\ &\quad + \lambda_3(R^M M - R^B M - \int_{a^D}^{a^M} F(a)da) \\ &\quad + \mu_L L + \mu_B B + \mu_S S + \mu_M M + \eta_S(S^{max} - S) \end{aligned} \tag{13}$$

The Kuhn-Tucker conditions are

$$Z^L = MR(1 - F(RL)) + \lambda_1 + \mu_L = 0, \quad MR \equiv \frac{\partial(R(L) \cdot L)}{\partial L}$$

$$\begin{aligned} Z^B &= R^B(1 - F(a^s)) + cR^B F(a^k) + \lambda_1 \\ &\quad + \lambda_2 R^B(F(a^S) - F(a^M)) + \lambda_3 R^B(F(a^M) - F(a^D)) + \mu_B = 0 \end{aligned}$$

$$Z^S = -R^S(1 - F(a^S)) - \lambda_1 + \lambda_2(R^S(1 - F(a^S)) - R^B) + \mu_s - \eta_s = 0$$

$$Z^{M} = -R^{M}(1 - F(a^{S})) - c(1+k)R^{M}F(a^{k}) - \lambda_1$$
$$- \lambda_2 R^{M}(F(a^{s}) - F(a^{M})) + \lambda_3(R^{M}(1 - F(a^{M})) - R^{B}) + \mu_M = 0$$

$$Z^{R^S} = -S(1 - F(a^{S})) + \lambda_2 S(1 - F(a^{S})) = 0$$

$$Z^{R^M} = -M(1 - F(a^{S})) + c(1+k)MF(a^{k}) - \lambda_2 M(F(a^{S}) - F(a^{M})) + \lambda_3 M(1 - F(a^{M})) = 0 \qquad (14)$$

$$Z^{\mu_L} = L \geq 0, \quad L \cdot \mu_L = 0$$

$$Z^{\mu_B} = B \geq 0, \quad B \cdot \mu_B = 0$$

$$Z^{\mu_S} = S \geq 0, \quad S \cdot \mu_S = 0$$

$$Z^{\mu_M} = M \geq 0, \quad M \cdot \mu_M = 0$$

$$Z^{\eta_S} = S^{max} - S \geq 0, \quad \eta_S(S^{max} - S) = 0$$

$$Z^{\lambda_1} = L + B - K - D - S - M$$

$$Z^{\lambda_2} = R^{S}S - R^{B}S - \int_{a^M}^{a^S} F(a)da$$

$$Z^{\lambda_3} = R^{M}M - R^{B}M - \int_{a^D}^{a^M} F(a)da.$$

Noting that $\lambda_2 = 1$ ($\Rightarrow \lambda_3 = 1 + \frac{c(1+k)F(a^k)}{1 - F(a^M)}$) and making the substitution $\lambda_1 = -MR(1 - F(RL))$ on the assumption that the portfolio always contains some amount of loans, we can restate the first-order conditious for the three free endogenous variables

$$Z^{B} = R^{B}(1 - F(a^{M}) + cF(a^{k})) + \lambda_3 R^{B}(F(a^{M}) - F(a^{D})) + \mu_B - MR(1 - F(RL)) = 0 \qquad (15)$$

$$Z^S = MR(1 - F(RL)) - R^B + \mu_S - \eta_S = 0 \tag{16}$$

$$Z^M = MR(1 - F(RL)) - R^M(1 - F(a^M) + c(1 + k)F(a^k)) + \lambda_3(R^M(1 - F(a^M)) - R^B) + \mu_M = 0 \tag{17}$$

Adding (15) and (17) yields

$$[(R^B - R^M)(1 - F(a^M)) + cF(a^k)(R^B - (1 + k)R^M) + \lambda_3(R^M(1 - F(a^M) - R^B + R^B(F(a^M) - F(a^D)))] + \mu_B + \mu_M = 0. \tag{18}$$

The term in the brackets in (18) can be shown to be negative for all $c \geq 0$, implying that $\mu_B + \mu_M > 0$. This means that if $M > 0$, then $B = 0$ and if $B > 0$ then $M = 0$.[5]

In the optimum the bank never can have simultaneously bonds and money market debt in its portfolio. This reflects the fact that the model does not have any time dimension that would make holding liquid assets (like government bonds) valuable when their posted rate is less than the marginal costs of financing such acquisitions.[6]

The solutions can thus be divided into two simple qualitatively different sets: one with positive money market debt, and the other one with no money market debt but potentially bonds in the portfolio. The first type of solution is likely to be more relevant for most "real world" banks in that it applies to a bank that actively funds itself in the market.[7] The case with no money market funding applies to banks which face such a weak demand for loans that the issue is how to allocate the cheap deposits, exogenous in the model, between risky lending and safe bonds.

---

[5] In the perverse capital regulation with $c < 0$, the separation of the solutions obtains only for sufficiently small c's in absolute value.

[6] Here the model differs clearly from that of Passmore and Sharpe, in which "liquidity costs" motivate simultaneous holdings of loans and bonds even under risk neutrality.

[7] The assumption that banks issue money market debt certainly applies to "a representative Finnish deposit bank" since the mid-1980, when a true money market was established. For example at the end of 1990 the banks had certificates of deposits (the primary money market instrument) outstanding of the order of FIM 70 billion or some 25 per cent of the markka loans outstanding. Of the Finnish cooperative and savings banks only 11 percent had debts to other banks and "the market" less than 10 percent of their lending at the same point of time.

4.2 Solution with strong loan demand (M > 0, B = 0)

Substituting MR(1 - F(RL)) in (17) from (16) yields

$$-(1-\lambda_3)(R^M(1-F(a^M)-R^B)-c(1+k)R^MF(a^k)-\mu_S+\eta_S+\mu_M=0 \qquad (19)$$

With c > 0, all other terms than η_S in (19) are negative so that η_S must be positive implying $S = S^{max}$. Bank having money market debt must therefore have the balance sheet $L = K + D + S^{max} + M$. This is so because the investors require the same expected rate of return on both S and M, and for the bank the former is always more profitable because it helps meet the capital requirement and thereby avoid the non-pecuniary costs associated with failing to do so. If there is no effective capital regulation, c = 0, no specific amount of subordinated debt is implied, as then subordinated debt is equivalent to senior debt for both the investors and the bank. In the perverse case of c < 0, the optimal amount of subordinated debt is zero.

The relevant first order condition for the determination of L and M is thus (17), which after substituting λ_3 obtains the form

$$MR^* \equiv MR(1-F(RL)) = R^B\left(1+\frac{c(1+k)F(a^k)}{1-F(a^M)}\right) \equiv MC^M \geq R^B \qquad (20)$$

or

$$\frac{MR(1-F(RL))}{1-F(a^M)+c(1+k)F(a^k)} = \frac{R^B}{1-F(a^M)} \qquad (20')$$

Given the assumption that MR is decreasing in L, it is easy to see by differentiation that the first order condition indeed defines a maximum, provided c ≥ 0. If c < 0, then its is required that the expected marginal revenue declines faster than the expected marginal cost of money market debt.

(20) says that the expected marginal revenue from loans must equal the expected marginal cost of money market debt including the cost associated with capital requirement. No penalty for failing to meet the capital requirement, c = 0, would imply a straight equalization of the expected marginal revenue on loans with the required expected return on money market debt, which is the bond rate. The optimal loan volume does not depend in any way on bank characteristics. The bank balance sheet in inconsequential in sense of Modigliani-Miller. As already noted, in this no penalty case, the bank would make no difference between subordinated debt and money market debt.

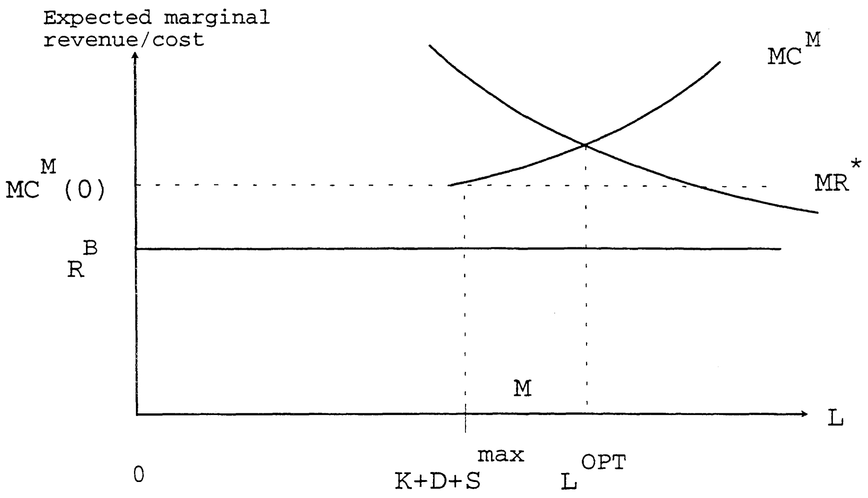
However, with a positive c, the marginal cost for the bank exceeds the expected return to the holders of M by a factor which in fact is the shadow value of the pricing constraint on M, λ_3. The denominator term in this factor, $1 - F(a^M)$, reflects the fact that every unit of M increases the posted rate of M (or the posted liability of the bank vis-á-vis the holders of M). Therefore also the capital requirement is increased by more than what would happen if R^M would not react to increased indebtedness.

(20') says the same thing somewhat differently. It equals the marginal revenue on loans adjusted for capital requirement with the posted marginal cost of money market debt. In this form the adjusted marginal revenue on loans depends not only on the revenue net of credit losses from the loan contract but on the benefit of not needing to pay out to the creditors in the case of default and the effect of increased borrowing on the expected penalty from not meeting the capital requirement. On the other hand, the investors in money market debt require a full compensation for the default risk but are unaffected by the capital regulation: the posted marginal cost of money market debt is thus $R^B/(1 - F(a^M))$.

Moreover, even in the absence of capital regulation (c=0), the assumed fair pricing of money market debt eliminates the possibility of exploiting the money market investors: however large expected benefit to the owners from default, the default premium compensates it exactly.

The optimum can be described graphically by drawing the MR^* and MC^M schedules based on equation 20 (Figure 1).

Figure 1. **Solution with high demand for loans, M > 0**



$$MC^M(0) = \lim_{M \to 0} R^B \left(1 + \frac{c(1+k)F(a^k)}{1 - F(a^M)} \right)$$

The reactions of M and L to changes in various exogenous factors can be obtained by differentiating (20) implicitely. The exogeneous factors examined are apart from the already introduced capital regulation parameters c and k, equity capital K, the cost of exogeneous deposits R^D, the volume of exogeneous deposits D, also a demand shift variable x and a borrower quality variable z. An increase in the demand shift variable x is assumed to have a positive impact on the willingness to pay ie. the derivative of MR w.r.t x is assumed positive. An increase in the borrower quality variable z (eg. an increase of asset values) is assumed to shift the distribution function F(a) to the right.

The deposit rate R^D can be interpreted both literary as the cost of deposit funding and as a general exogenous cost variable reflecting eg. operation costs.

The comparative statics are shown not only for the "normal" case of positive penalties for capital insufficiency (c > 0), but also for the case of no such penalties (c=0) and the perverse case of negative penalties for capital inadequacy. The derivatives are reported in Appendix 1. Their signs are shown in Table 1.

Table 1. **Comparative statics when M > 0**

Penalty param.	End. var.	Exogenous variables R^B	c	k	K	R^D	D	x	z
c > 0	M	–	–	–	–	–	–	+(-)	+
	L	–	–	–	+	–	+	+(-)	+
c = 0	M	–	..	0	–	0	–	+(-)	+
	L	–	..	0	0	0	0	+(-)	+
c < 0	M	–	–	+	–	+	–	+(-)	+(-)
	L	–	–	+	–	+	–	+(-)	+(-)

x = increase in loan demand: $\partial MR/\partial x > 0$
z = improvement of borrower quality: $\partial F(a,z)/\partial z \leq 0$, $\partial f(a,z)/\partial z < 0$ for small a and $\partial f(a,z)/\partial z > 0$ for large a.
+(–): both possible but + more likely

The effect of the bond rate R^B is unambiguously negative on lending (and money market funding), as the bond rate is the opportunity cost for the investors in subordinated debt and money market debt. A rise in this cost increases the expected marginal cost of funds and thus the required expected marginal revenue on loans.

The effects of capital regulation depend critically on whether there indeed is a positive penalty for non-performance. If there is, then both the size of the penalty and the requirement as such affect negatively lending. With no penalty, the requirement obviously has no bearing on lending, and with a negative penalty higher requirement leads to more lending as a failure to meet the requirement gets rewarded.

Similarily, the effects of equity capital and the deposit rate (other exogeneous costs) depend on the stiffness of capital regulation. More equity capital implies with unchanged lending less money market debt. As long as the penalty for a failure to meet the capital requirement is positive, the smaller amount of M reduces the expected penalty and thus the expected marginal cost for the bank as well. This facilitates increasing lending, which is subject to decreasing returns. In the absence of capital regulation the marginal cost of money market debt is the constant bond rate R^B required by the investors. In this case lending does not respond to equity capital at all but all changes are compensated by an equal negative change in money market debt. By the same token, the exogenous cost element R^D affects the marginal condition for lending only to the extent it changes the expected cost for not meeting the capital requirement.

The effect of exogeneous deposits resembles very much that of equity capital. It lowers the use of money market debt in every case. The marginal condition is only affected to the extent the expected capital insufficiency penalty is affected. Quantitatively the positive effect of deposits on lending, in the case of a positive c, is nevertheless weaker than that of bank capital as deposit funding is subject to capital requirement itself.

Change in loan demand in the sense of customers' willingness to pay for any given loan stock has in principle an ambiguous effect on loan volume. The reason is simple. Although the marginal revenue increases in the case of no borrower default, a higher liability of the borrower also implies ceteris paribus a higher likelihood of default. However, when the density of the project return is small at the level of the contract commitment RL ie. the change in the default probability small, then a higher contract rate also implies a higher expected marginal revenue and a higher loan stock.

But also the distribution of the return on the project for which finance is demanded or the value of the collateral assets may change. The effects of such changes depend crucially on how the distribution function F(a) changes; they are difficult to condense in any one impact. Changes which affect the distribution of a only for $a > RL$ are inconsequential. Changes that mainly shift probability mass from the range $a^k < a < RL$ to the range $a > RL$ increase the expected marginal return on loans and thus the loan stock. A shift of probability mass from the range $a < a^k$ and within this range have effects on the expected costs of capital regulation penalty. Thus an increase in the borrower quality in the sense that the distribution function shifts to the right, increases lending also in this range, unless perverse regulation makes low return realizations highly attractive.

In sum, assuming a positive penalty for capital insufficiency, the predicted behaviour corresponds quite well with standard views about bank behaviour. In contrast assuming no penalty implies that the bank's loan extention is essentially independent of bank characteristics; it is determined by the market interest rate and demand conditions, including the borrower quality. Finally, if banks which fail to meet the capital requirement are rewarded through ill-conceived bank support policies, perverse effects result.

4.3 Solution with weaker loan demand: M=0

When the demand for loans is not high enough to make the expected marginal revenue on loans MR^* equal the expected marginal cost of money market debt MC^M, the relevant marginal conditions are (15) and (16). Note that in (15) the second term disappears, as $a^M = a^D$ when $M = 0$, resulting thus in the marginal conditions:

$$R^B(1 - F(a^D) + cF(a^k)) - MR^* + \mu_B = 0 \quad (21)$$

$$Z^S = MR^* - R^B + \mu_S - \eta_S = 0 \quad (16)$$

The outcome depends thus on the relative sizes of MR^*, and the expected marginal revenue on bonds $MR^B \equiv R^B(1 - F(a^D) + cF(a^k))$ and the posted bond rate R^B, which is the expected marginal cost of subordinated debt for the bank.

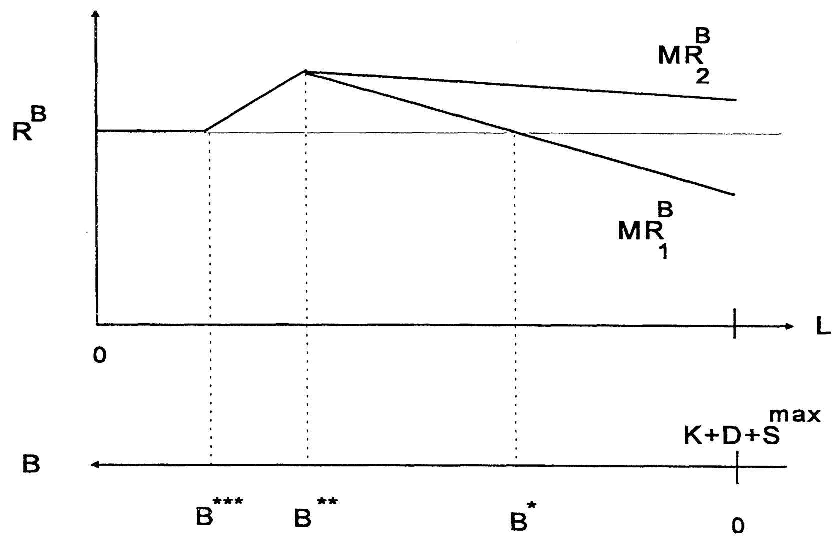
MR^B can in general be greater than, equal to or smaller than R^B. This is so, because one must deduct from the posted rate R^B the part that in expectation is paid out to the depositors in the case of bank default and add the benefit from a smaller expected penalty from not meeting the capital requirement when the amount R^B of sure value is created.

MR^B is increasing in B with small B as long as the density function is not too exotic and c not close to unity: increasing bonds increases the expected marginal return, as additional bond revenues decrease the probability of defaulting by $R^Bf(a^D)$ but increase the expected penalty only by the fraction c times $R^Bf(a^k)$.

At $B = 0$, $MR^B < R^B$ if $c < c^* \equiv F(a^D)/F(a^k)) < 1$. At high enough B, say B^*, MR^B reaches R^B. At a still higher $B^{**} \equiv (R^DD - a^{min})/R^B < D$, the deposits become fully safe ($F(a^D) = 0$), and only the declining capital requirement effect remains: MR^B is decreasing in B in this range. That ceases at $B = B^{***} \equiv ((1 + k)R^DD - a^{min})/R^B$, when the bank is sure to meet the capital requirement. For $B > B^{***}$, $MR^B = R^B$.

With $c > c^*$ MR^B starts right away above the bond rate, and in the special case of $c = 1$ and the distribution uniform MR^B is flat in the range $[0,B^*]$. This represents thus a very stiff enforcement of the capital adequacy regulation with such a penalty imposed in the case of inadequate capital that the bank owner/manager would in fact be fully liable. This is of course unlikely to be a feature of any real world capital regulation (Figure 2).

Figure 2. **Expected marginal return on bonds**



The kinky shape of the expected marginal return on bonds MR^B and the a priori rather unrestricted shape and position of the expected marginal return on loans schedule MR imply that many types optima can exist, even if the portfolio is always assumed to contain loans. Thus there may be either S or B in the portfolio, depending on the precise shapes and positions of MR^* and MR^B. As the banks with no money market funding do not appear to be representative, we do not pursue the analysis of such banks further here. Various cases are illustrated in Appendix 2. It is nevertheless important to notice that the comparative statics can differ radically depending on the precise nature of the optimum.

When the portfolio is a corner solution $L = K + D$ or $L = K + D + S^{max}$, loans are determined 1 to 1 by the exogenous funding K + D (and the maximum allowed amount of subordinate debt), and no other factors influence the optimum on the margin.

But the portfolio may also be defined by the marginal conditions $MR^* = MR^B$ or $MR^* = R^B$. When the portfolio is defined by the marginal condition is $MR^* = MR^B$, yet two alternatives are possible: MR^* can intersect MR^B either in the downward sloping (in L) section, when the bank is risky $F(a^D) > 0$, or in the upward sloping section when the bank is safe ($F(a^D) = 0$). If intersection of the two schedules happens to take place in the upward sloping range, the relevant bond return function collapses into $MR^B = R^B(1 + cF(a^k))$. If the intersection takes place in the downward sloping range of MR^B the also the $F(a^D)$ term is included. When the marginal condition is $MR^* = R^B$, yet different comparative statics are implied. The characteristics of the comparative statistics in the three types of interior solutions are shown in Table 2.

Table 2. **Comparative statics of L in interior solutions with c > 0**

	Exogenous variables							
L determined by:	R^B	c	k	K	R^D	D	x	z
(a) $MR^* = R^B(1-F(a^D)+cF(a^k))$	–	–	–	–	+	–	+(-)	+(-)
(b) $MR^* = R^B(1+cF(a^k))$	–	–	–	+	–	+	+(-)	+
(c) $MR^* = R^B$	–	0	0	0	0	0	+(-)	+

+(–): both possible but + more likely

The fundamental reason for the very varied outcomes is the capital requirement. Should k = 0, the MR^B schedule would never exceed R^B, and only corner solutions or the solution with $MR^* = R^B$ would be possible.

Although banks typically do borrow in the money market, so that the type of behaviour predicted by this subsection is not likely to be common, some banks may indeed find themselves in this demand postion According to the model, the behaviour of such banks is rather erratic. This has an important implication for empirical work. To the extent there are in the sample banks, the behaviour of which is determined as in this section, estimating loan supply may be highly difficult as one probably cannot a priori classify the banks within this group in different regimes. It may even be difficult to distinguish between banks that rely (essentially) on money market debt from the banks which face too weak demand for loans to borrow in the money market at all. The banks of weak demand for loans are likely to appear outliers in loan equations estimated for samples containing different types of banks.

5 Pricing of money market debt fixed

Here we relax the assumption that endogenous senior debt of the bank is fairly priced while keeping the assumption of fairly priced subordinated debt. Two types of differences in (the markets for) the respective claims could rationalize this discrepancy of pricing.

First, subordinated debt typically never is subject to any sort of formal creditor protection. In contrast, some senior bank liabilities, which are priced very close to proper money market debt, are covered by the deposit insurance schemes. In the Finnish context, taxable time deposits are such instruments. In addition in the case of bank bailouts, holders of senior debt are typically fully covered for losses while the holders of subordinated debt may incur some losses or at least be forced to inject further capital in the bank; implicit creditor protection applies with a higher probability to senior debt than to subordinated debt. Therefore, as a whole, the holders of senior debt potentially have less reason to worry about the default risk of their claims on banks than the holders of subordinated debt.

Second, buyers of such risky instruments as subordinated debt (presumably mainly professional investors) probably are better informed about the risks and behaviour of the issuers than the typical buyers of senior debt. Therefore the former may be in a better position to price the default risk than the latter. The latter – to the extent they see reason to consider credit risk – may resort to the use of quantitative restrictions (quotas). This may result in a highly convex marginal cost curve for senior debt.

Allowing underpricing of money market debt M in the analysis means simply dropping the fair pricing constraint and postulating a fixed marginal cost function instead. Let us denote this posted function by MC. In general this may be a constant or a fixed increasing function of M. With this change the first order conditions corresponding to (15) through (17) are:

$$R^B(1 - F(a^M) + cF(a^k)) + \mu_B - MR^* = 0 \tag{22}$$

$$MR^* - R^B + \mu_S - \eta_S = 0 \tag{23}$$

$$MR^* - MC(1 - F(a^M) + c(1 + k)F(a^k)) + \mu_M = 0 \tag{24}$$

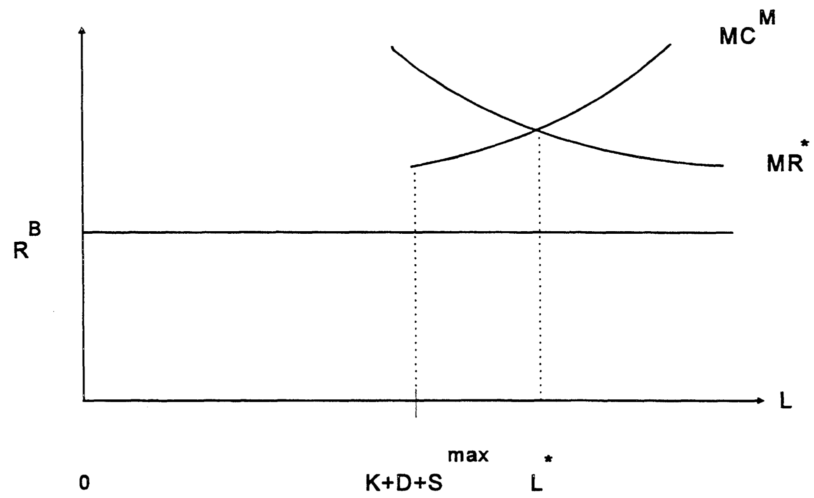
Again, on the basis of the reasonable assumption that $MC \geq R^B$, there cannot be bonds and money market debt on the balance sheet simultaneously, as can be seen by adding (22) and (24). Obviously, the case when no M is issued is the same that was already discussed in the former section. The case with positive M is, however, different. As the posted price of M is fixed (exogenous) rather than set so as to make the expected return equal R^B, the expected marginal cost of money market debt takes the form

$$MC^{Mf} \equiv MC(1 - F(a^M) + c(1 + k)F(a^k)) \qquad (25)$$

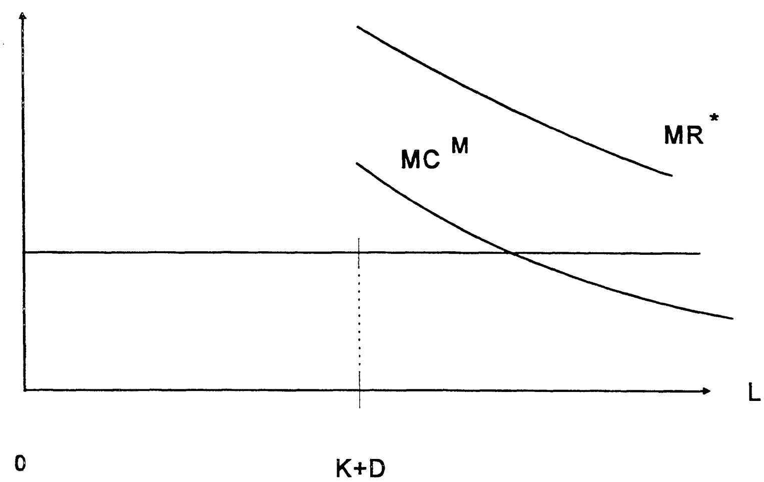
This quantity MC^{Mf} need not always be at least R^B, as MC^M in (20), but may be smaller. Only with a very strict capital regulation ($c(1 + k) \geq 1$ is sufficient) MC^{Mf} is always above R^B and increasing. In that case, S is necessarily always at the maximum S^{max} and the the second order condition is fulfilled so that there is a finite M at which the expected marginal cost MC^{Mf} is just equal the expected marginal revenue on loans MR^*. This result obtains even with a constant MC ie. the posted rate need not increase. The outcome is illustrated in panel (a) of Figure 3.

Figure 3. **MR* and the expected marginal cost of Money Market debt with fixed pricing, M > 0**

a) Stiff capital regulation



b) Normal capital regulation and MC relatively flat



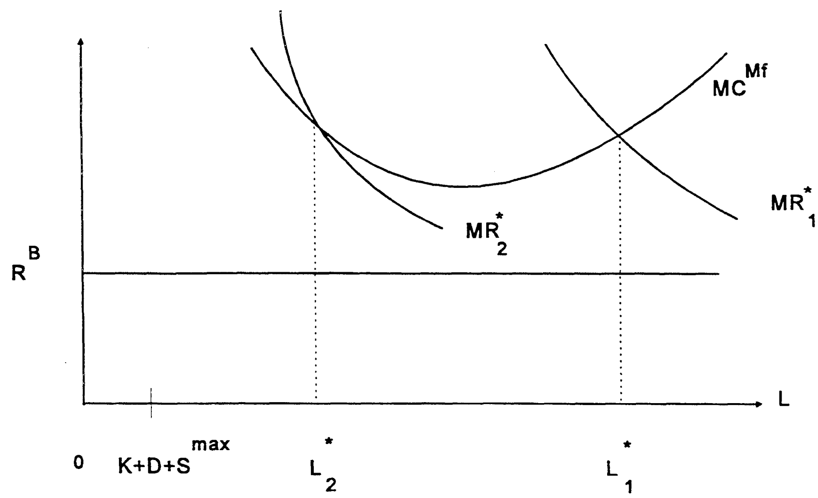
However, with a more lenient, "normal" capital regulation, MC^{Mf} is decreasing, unless MC is rising steeply enough. At an extreme, an infinite portfolio could result: The expected marginal cost declines with increasing probability of default while the expected return on lending does not decline as fast. As the expected cost of subordinated debt is R^B, no such debt would be issued but all funding would take the form of underpriced senior debt. This possibility, shown in panel (b) of Figure 3, illustrates at the purest the moral hazard problem associated with underpriced funding whether it stems from explicit deposit insurance or implicit creditor protection.

A more reasonable assumption is that MC is more or less constant with low values of M while it increases steeply with high enough M. For instance, simple rules of thumb could result in setting quotas on the amount of any investor's purchases of the money market debt of any individual bank. Once the quotas start to bind, the marginal costs of additional funds increase steeply.

Such a posted marginal cost schedule MC would imply a U-shaped expected marginal cost schedule MC^{Mf}, which may or may not be above R^B for all values of M. With sufficient convexity of MC the MC^{Mf} schedule intersects at some point MR^*.[8] That of course guarantees the existence of a finite solution. Depending on whether this point of intersection is above or below R^B, the bank issues the maximum allowed amount of subordinated debt or no such debt at all.[9]

An important consequence of this U-shaped expected marginal cost schedule is that the intersection of the expected marginal cost and expected marginal revenue curves can take place both in the downward sloping section and the upward sloping sections of MC^{Mf}. The latter occurs when demand for loans is high enough, as MR_1^* in Figure 4. The former can happen, if demand for loans is not too high, as MR_2^* in Figure 4.

Figure 4. **Solutions with a U-shaped expected marginal cost curve**



[8] Second order condition requires that only the MR^* schedules which intersect MC^{Mf} from above produce an optimum.

[9] One may argue on the basis of arbitrage that the expected marginal revenue on loans cannot decline much below the safe rate R^B, at least not for any individual bank of small size. Borrowers may namely invest the borrowed funds in bonds, which they pledge as collateral for borrowing and thus make lending safe for the bank.

The comparative statics hinges essentially on the point of intersection of the expected marginal return on loans schedule and the expected marginal cost schedule of money market debt. The qualitative results are shown in Table 3; the derivatives can be found in Appendix 1. The most interesting case is the positive penalty situation, as in this case the results differ in essential way from those obtained assuming fair pricing of money market debt.

Table 3. **Comparative statics with a fixed marginal cost schedule MC**

		Exogenous variables								
		R^B	m	c	k	K	R^D	D	x	z
$c > 0$	M	0	–	–	–	–	+(-)	+/-	+(-)	+(-)
	L	0	–	–	–	+/-	+(-)	+/-	+(-)	+(-)
$c = 0$	M	0	–	..	0	–	+	+/-	+(-)	+(-)
	L	0	–	..	0	+/-	+	+/-	+(-)	+(-)
$c < 0$	M	0	-(+)	–	+	–	+	+/-	+(-)	+(-)
	L	0	-(+)	–	+	+/-	+	+/-	+(-)	+(-)

m denotes here an increase in the posted marginal cost of M at any level of M
+/–: both possible depending on circumstances
+(–): both possible but + more likely

The role of the bond rate as the marginal cost of money market funding is replaced here by the shape of the cost schedule. An upward shift in the posted schedule implies less such funding and lending. The penalty parameters work just as with fair pricing. The roles of bank capital, deposit costs and deposit volume, however, change radically.

An increase in equity capital shifts the MC^{Mf} schedule to the right. Thus a positive shock to equity capital increases lending if MR^* intersects MC^{Mf} in the upward sloping section (MR_1^* in Figure 4). However, if the intersection happens to be in the downward sloping range of MC^{Mf}, the opposite is true. The economic explanation of the perverse effect is that the expected marginal benefit to the bank from defaulting on M declines more than the posted marginal cost plus the expected marginal cost of failing the capital regulation decline in response to increased capital. This makes the bank to reduce money market borrowing at a given level of lending by more than just to compensate for the additional funding in the form of equity capital (MR_2^* in Figure 4).

The effect of R^D is also ambiguous in principle. Higher deposit costs increase the likelihood of defaulting on the money market debt and thereby decrease the expected cost of such liabilities. Expansion of lending follows. The capital requirement on D nevertheless counteracts this moral hazard incentive, but unless the penalty parameter c is very high (close to 1), the effect on default probability dominates.

Similarily, the effects of the deposit volume are ambiguous. Higher deposits lower the posted marginal cost of M but lower the expected marginal benefit from defaulting on M (which is higher than that on D, as $R^M > R^D$). As long as $c > 0$, the capital requirement works to keep incentives correct. The outcome depends, as with equity capital, crucially on the shape of the MC^{Mf} schedule. It being rising is sufficient for a positive lending response to D. However, rising MC^{Mf} schedule is not necessary for a positive lending response, but such a response may obtain also with slightly decreasing MC^{Mf} schedule. Thus an increase in deposits can have a positive effect on lending while an increase in capital has simultaneously a negative effect.

The effects of loan demand are the same as with fair pricing. However, the effects of borrower quality become in principle ambiguous, as an improvement of borrower quality makes defaulting on M less likely and thereby increases the expected marginal cost of funding.

In sum, if the pricing of the marginal funding for the bank does not sufficiently reflect the riskiness of bank portfolio, moral hazard incentives may make the bank response perversely to changes in bank capital, costs, deposits and even borrower quality, even if failure to meet capital requirements is effectively penalized. Thus moral hazard leading to excessive risky lending may result both from underprincing of banks marginal funding and ill-conceived capital regulation (bank support policies which reward capital insufficiency).

6 Capital requirement levied on the asset side

Replacing the capital requirement levied on bank liabilities by a requirement that is levied on the risky assets does not alter much in the formal analysis. What is changed is basically the equation for the treshhold project return below which the bank owners start to incur non-pecuniary costs at the rate c:

$$a^k = kRL + R^D D + R^M M - R^B B \tag{26}$$

The threshhold continues to depend on the commitments vis-à-vis depositors and holders of money market debt and investments in the safe asset as all these influence bank net worth. The new element is that loans (the risky assets) instead of liabilities determine the level of required regulatory capital.

6.1 Fair pricing of money market debt

Assuming the pricing of both subordinated debt and money market debt fair leads to the following first order conditions which correspond to the earlier conditions (15) through (17):

$$\begin{aligned} &R^B(1 - F(a^M) + cF(a^k)) + \lambda_3 R^B(F(a^M) - F(a^D)) + \mu_B \\ &- MR(1 - F(RL) - ckF(a^k)) = 0 \end{aligned} \tag{27}$$

$$MR(1 - F(RL) - ckF(a^k)) - R^B + \mu_S - \eta_S = 0 \tag{28}$$

$$MR(1 - F(RL) - ckF(a^k)) - R^M(1 - F(a^M) + cF(a^k)) + \lambda_3(R^M(1 - F(a^M)) - R^B) + \mu_M = 0 \tag{29}$$

The difference between these and the earlier first order conditions is that the marginal expected revenue on loans is affected by the capital requirement and the marginal expected cost of money market debt does not anymore incorporate the effect of additional required capital.

Again, the portfolio cannot contain simultaneously money market debt and bonds. Here we consider only the more relevant case of positive money market debt. The portfolio is defined in this case by

$$MR(1 - F(RL) - ckF(a^k)) = R^B\left(1 + \frac{cF(a^k)}{1 - F(a^M)}\right) \tag{30}$$

or

$$MR(1 - F(RL)) = R^B\left(1 + \frac{c(1 + k)F(a^k)}{1 - F(a^M)} + ckF(a^k)\left(MR - \frac{R^B}{1 - F(a^M)}\right)\right) \tag{30'}$$

The outcome is thus very similar to what was obtained with the liability side capital regulation. (30) says that the expected marginal revenue on loans including the expected cost of failing to meet the capital requirement equals the expected marginal cost of funds. The marginal cost of money market debt is affected by the capital requirement penalty, as the amount money market debt affects the bank's contractual commitment and thereby the treshold project return that makes the bank just meet the capital requirement.

In (30') the last term is positive, as (28) implies that $MR > R^B/(1 - F(RL) - ckF(a^k)) > R^B/(1 - F(a^M))$. It shows that the asset side capital requirement leads to a higher marginal revenue requirement on loans and thus a lower loan volume than the liability side requirement with the same parameter values k and c. This is due to the fact that with the asset side regulation all loans are subject to the capital requirement while in the liability side regulation only the loans that are financed by D and M carry a capital requirement.

This difference implies that a shift from a capital regulation levied on the liability side to an asset side regulation without changing the required level of capital (parameter k) or the stiffness of enforcement (parameter c) leads to a smaller amount of risky lending.

The effects of changes in exogenous factors do not change much with the type of capital regulation. The comparative statics in the case with positive M remain qualitatively the same with the asset side regulation as with the liability side regulation. The derivatives are reported in the Appendix 1.

6.2 Pricing of money market debt fixed

Just as with the liability side regulation, the pricing principle of money market debt does not change the basic nature of the optimum. Again, banks which find it optimal to issue money market debt hold loans as the only asset. In this case the marginal condition defining the loan supply takes the form

$$MR(1-F(RL)-ckF(a^k)) = MC(1-F(a^M)+cF(a^k)) \tag{31}$$

where MC is the fixed marginal cost schedule of M. The comparative statics turn somewhat more messy but remain qualitatively the same as in the fixed pricing case of the liability side capital regulation, see Appendix 1.

7 Discussion

7.1 Summary and some general points

The analysis of bank portfolio choice in our simple static framework with symmetric information and risk neutral agents illustrates some basic issues of the importance of bank capital, capital requirement and the pricing principles of bank funding for risky bank lending. In addition, the model also incorporates influences from the "demand side": borrowers' willingness to pay and borrower quality.

The bank considered has the priviledge of being allowed to supply what could be called core deposits at a low fixed rate of interest. This priviledge creates "charter value" for the bank, which depends on the regulated rate, other exogenous costs of operation and on the scale at which these deposits are demanded. Exogenous equity capital and the exogenous deposits can be augmented by money market debt (a generic term for all other senior funding than core deposits). Money market debt is subject to either fair pricing or a fixed pricing schedule, which may imply underpricing or overpricing relative to the required expected return equal to the safe rate of interest. The bank can also issue subordinated debt, which is always fairly priced and counts as regulatory capital up to a maximum. The funds can be placed in risky loans subject to a declining demand curve or government bonds yielding the safe rate.

In the model bank behaviour depends crucially on whether or not demand for bank loans is high enough to make the use of money market debt profitable. In the case of no such debt, the behaviour varies a a great deal depending on not only the level of loan demand but also the nature of the capital requirement. However, thinking of many banking markets, certainly the Finnish one, this sort of bank is not typical. More relevant is the case, where the bank uses other (senior) funding than core deposits on the margin. In this case, the key issue is the pricing principle of this debt.

If money market debt is priced fairly, the default premium applied to funding exactly compensates for the default risk: no exploitation of the investors by the bank is possible. Now, if the bank incurs no penalty for not meeting the contractual commitment vis-à-vis depositors and holders of money market debt, plus possibly a fraction of this commitment as a safety margin constituting jointly "the capital requirement", the bank's loan supply is determined simply by the requirement that the expected marginal return on loans equals the safe rate of interest. In this case, banking is inconsequential in the sense that bank characteristics do not in any way affect lending. It is determined solely by the demand for credit, including borrower quality, in the bank's local market and the safe rate of interest. In particular, the amount of equity capital the owners have invested in the bank in the past and the amount of subsidy incorporated in the underpriced deposits do not affect lending in any way, although they naturally affect the rate of return on the exogenous equity.

However, if there is a positive penalty for failing the capital requirement, whether imposed by the authorities or "the market", lending depends greatly on bank characteristics. In particular, the higher capital and core deposits, the more lending, and the higher the charter value (the lower the rate on core deposits), the more lending. The reason is simple: the more there is equity capital or cheap deposits and the cheaper these cheap deposits are, the less likely it is, ceteris paribus, that the bank faces a penalty for capital insufficiency. This specification of the model thus predicts several types of "credit crunches" ie. leftward shifts in bank credit supply: First, a credit crunch due to disintermediation results when the amount of cheap deposits decline say due to additional competition from outside banking. Second, a reduction of the charter value of banking due to smaller subsidy in the form of underpriced core deposits (higher deposit rate) leads to a decline of lending. Analoguous effects relate to other exogenous costs of banking, caused for example by changes in wage costs or information technology. Third, a loss of equity, say, due to credit losses incurred, reduces lending. Fourth, a tightening of capital regulation whether in the form of a higher requirement or in the form of stricter enforcement leads to less lending.

The behaviour of the bank may be very different if the pricing of marginal funding is not fair but follows a fixed (non-decreasing) posted schedule. If the marginal cost of funding rises fast enough (and the penalty for capital insufficiency is positive), the behaviour is qualitatively the same as above in the fair pricing case. In fact, bank lending may decline more say in response to a decline in equity in this case than with fair pricing. A steeply increasing marginal cost curve can be interpreted as standing in for the unmodelled situation of asymmetric information leading to a lemons premium, which lies behind much of the recent theoretical thinking of financial intermediation.

But if the posted rate on money market debt rises too slowly, the bank can shift a part of the credit risk of its lending to the holders of money market debt (or if these are guaranteed by the authorities to the authorities). Bank behaviour is characterized by moral hazard: it is profitable for the bank to increase risky lending beyond the point where it would be with fair pricing, as the investors in bank liabilities can be made to share in the credit risk. Furthermore, in this case decline in equity capital, an increase in the exogenous (deposit) costs and even a decline in the volume of core deposits (the requirement for this is somewhat more stringend) can lead to increased risky lending.

The penalty for insufficient capital reduces bank incentives of moral hazard. However, the penalty would need to be close to an equivalent of unlimited liability to eliminate such incentives altogether. It is unlikely that any real world capital regulation carries such penalties nor that "the markets" impose such penalties on the banks. In the model both the required level of capital and the expected penalty applied in the case of failure work in the same direction. However, the size of the safety margin ie. required capital on top of the contractual commitments vis-á-vis the depositors and holders of money market debt is not important nor is the exact form of the requirement. Even under no such margin a positive penalty levied in the case of capital insufficiency discourages risky lending. Similarily, a requirement calculated on the basis of risky assets works essentially in the same way as a requirement calculated on the basis of (senior) liabilities, although a shift from the latter to the former tightens the regulation if the parameters are kept the same. In contrast, a zero penalty is equivalent to no capital regulation at all.

One may even contemplate a negative penalty. Such a perverse situation could emerge if the authorities gave transfers to the bank that does not meet the capital requirement. In practice many types of transfers can be though of, including subsidized loans, asset purchases at inflated prices and even capital injections. If the bank expects such behaviour on the part of the authorities, perverse incentives exist even with a fair pricing of bank liabilities. The model thus suggests of two kinds of moral hazard, one stemming from underpriced marginal funding, the other from misguided bank support policies. Both lead to excessive risky lending (relative to fair pricing, non-rewarding bank support policies).

The basic results of the model are in no way new. Neither is the theoretical set-up particularly original. The model is a modification of a standard model of banking firm, used eg. by Dermine (1984, 1986).

The potential for a credit crunch due to disintermediation has been recognized long, see eg. Wojnilower (1980). Lack of bank capital or net worth as cause of credit crunch has been extensively discussed in the United States in the early 1990, following the early contribution by Bernanke and Lown (1991). Theorically the possibility of a credit crunch has received a lot of attention in the models that develop under the assumption of asymmetric information a rationale for financial intermediation from the first principles, see eg. Bernanke and Gertler (1987), or Holmström and Tirole (1995). In this paper, just as for example in Kashyap and Stein (1994), a fixed steeply rising marginal cost schedule stands in for the more elaborate adverse selection or moral hazard arguments of the models explicitely taking into account asymmetric information. A paper relatively close to the credit crunch aspects of this analysis is Passmoore and Sharpe (1994), which also develops testable implications of the credit crunch hypothesis.

Similarily, the possibility that mispriced funding can lead to excessive risk taking has been a central element of much of the literature on the pricing of deposit insurance. Among the important contributions are apart from Merton (1977), also Kareken and Wallace (1978) and Pennachi (1987). Also in the analysis of Dermine the implications of mispriced deposit insurance are taken up. Also the effects of bank support policies on the incentives of risk taking in banking have received substantial attention in the discussion and analyses of bank support policies, see for example Calomiris (1995).

What this paper does is to show how both excessive risky lending due to underpriced funding or misguided bank support policies and excessive contraction of credit due to shortage of inherited equity capital or cheap deposits and due to high costs can emerge in a single framework.

The model is set up so as to resemble the situation of the Finnish cooperative and savings banks since the mid-1980s. An important feature of the model in this respect is to split bank capital into an exogenous equity capital and subordinated debt, which the bank can use up to a maximum to meet the capital requirement. Here the model deviates clearly from that of Dermine, which assumes that equity capital is available in unlimited amounts at the expected rate equal to the bond rate. The model predicts that a bank which issues money market debt uses the maximum allowed amount of subordinated debt if there is a positive penalty for capital insufficiency and the pricing of marginal funding is fair. Therefore, the amount of subordinated debt can be used separately from the differing comparative static results of lending to infer about the stringency of capital regulation and the pricing of bank funding.

Another deviation from the formulation of Dermine is to make a clear distinction between priviledged deposit funding that creates "charter value" for the bank from other funding that is available at "market" rates of interest. The used formulation makes very explicit the relationship between bank charter value and lending. In particular, with underpriced marginal funding, lowering of the charter value, for whaterver reason, leads to an increase in risky lending.

Finally, unlike Dermine's model, the model of this paper analyzes the behaviour of banks under two different forms of capital regulation. It shows in particular that the basic results are not sensitive to whether capital regulation is of the type applied in Finland in the 1980s or of the type in place in the 1990s.

7.2 The Finnish credit cycle in the light of the theory

A central feature of the period of rapid credit expansion 1986 through 1990 was that savings banks expanded lending substantially more than other banks and among the savings banks (as also among the cooperative banks) the rates of growth varied a great deal. Furthermore, a clear positive relationship appears between the rate of growth of lending in the boom years and the subsequent asset quality, see Solttila and Vihriälä (1994). Similarily in the contraction phase, some banks contracted lending much more than others, and this time the savings banks typically reduced lending more than other banks. The question thus arises, what made certain banks to expand risky lending so rapidly in the late 1990s and certain banks contract lending so strongly in the early 1990s.

The model provides several types of explanations for the bank-wise variation in lending growth.

First, the differences may be essentially due to demand side factors (including borrower quality). A given bank expanded lending more than banks one average because there was in the local credit market (1) higher demand for loans (relative to the cheap core deposits) at any given loan rate or (2) a more favourable (less risky) return distribution of the projects to be financed or higher collateral values (better borrower quality). The analysis also rationalizes why in both cases strong expansion of credit was risky in the sense that more credit implied higher percentage of credit losses. As long as the distribution of the return for the project for which finance is seeked remains given in the model, more lending implies higher credit losses relative to the outstanding loan commitment by the borrower.

As real estate businesses and many other non-manufacturing activities have traditionally been very important in the lending of the savings banks, one may argue that strong demand in these sectors boosted lending especially by the savings banks.

And as the real estate sector was worst hit in the economic downturn, also the relative losses were the highest. And by the same token it can be argued that during the crisis years demand was weakest in this sector leading to a weaker than average growth of lending by the savings banks in the early 1990s. The findings by Solttila and Vihriälä nevertheless suggest that this type "bad luck" in terms of business specialization, although it played a role, is not the only explanation for the period of rapid growth; even if the sectoral differences are accounted for, banks that expanded faster in the 1980s also ended up with a higher shares of problem assets in the early 1990s.

The model also accomodates explanations based on subjective expectations about the project returns (borrower quality) deviating from the true ones, if one interpretes the distribution function F(.) as a perceived rather than true distribution of the return of the risky activity to be financed. As noted in the introduction, Minsky and Kindleberger among others have argued that such concepts as optimism, euphoria and pessimism govern changes in the expectations of bankers as well as those of the ultimate investors. Thus if one assumes that some bankers became highly and unrealistically optimistic about the lending opportunities, and that this happened particularly in the savings banks sector in the late 1980s, the model would naturally predict high growth of lending for such banks. However, this sort of hypotheses are very difficult if not impossible to test, as one cannot measure, at least not ex post, the perceptions of the bankers in question.

Another and somewhat more structured version of the explanation based on the difference between perceived and true probability distributions of the project returns is provided by Guttentag and Herring (1984). They argue that in periods of no major shocks in the economy, the perceived risks tend to diminish relative to the true ones. The closer an experience of a major negative shock is, in the time dimension or otherwise, the more risky the investment opportunies are perceived. In the case of Finnish banking in the mid-1980s, it might be argued that a virtual absence of credit losses for decades in the tightly regulated financial system had led bankers and their borrowers alike to believe that credit risks would be largely absent also in the future. Financial liberalization, which eliminated the possibility of shifting the burden of financial distress from borrowers to depositors through negative real rates of interest, however, changed the situation fundamentally but in a way which probably was not fully understood by the bankers.[10] One might even argue, that as the cooperative banks had rather recently experienced significant solvency difficulties, they were less likely to assume away credit risks.[11] Nevertheless, it seems very difficult to subject even this version of the "wrong expectations" explanation for rigorous testing. The same applies to the credit crunch explanations that are based on the argument that the bankers became very conservative in their risk assessments during the economic crisis starting in 1991.

But the model's main thrust concerns explanations which relate to the objective conditions of individual banks: (1) differences in the opportunities faces by the bank in terms of the pricing of marginal funding and the strictness of capital regulation and

[10] Pettersson (1993) argues strongly that in Sweden, whose banking crisis resembles very much the Finnish one, bankers typically paid very little if any attention at all to credit risk in the late 1980s.

[11] The central bank of cooperative banks, Okobank had been on the brink of collapse in the early 1970s threathening the solvency of many of its owners (cooperative banks). In the 1980s, a relatively large cooperative bank, Iisalmen Osuuspankki, had also experienced serious solvency problems which caused costs to the mutual deposit insurance fund.

(2) differences in the bank characteristics ie. in the amounts of equity capital and core deposits and the charter value implied by the underpricing of these deposits relative to the going market rate.

The theory suggests in particular that the banks which expanded faster in the 1980s, faced an underpriced marginal cost schedule of funding, and/or more lenient if not preverse capital regulation and perhaps also were initially weaker in terms of capital and costs.

The marginal sources of funds for individual banks were the market for bank certificates of deposits, borrowing from other banks, which in the case of the savings banks and cooperative banks means their "central banks", Skopbank and Okobank, respectively, and mainly in the case of commercial banks, foreign banks. The argument suggest thus examining the characteristics of these markets, especially to what extent pricing there reflected bank risk and whether there were differences in this regard, say between the savings banks and the cooperative banks.

A true money market started to develop in Finland from the beginning of 1987. Banks' certificates of deposit (CD's) became the main instrument in this market. There was basically no price differentiation between the CD's issued by different major banks. Thus, to the extent banks indeed were associated with different credit risks these differences did not show up in the pricing of the main money market instrument. This is, if nothing else, at least consistent with the idea that banks' marginal funding was not fairly priced.

The model suggests also examining capital regulation. As noted earlier the regulations in force in the 1980s were more lenient for the cooperative banks and the savings banks than for the commercial banks. But for the savings bank group and the cooperative bank group the requirements were the same. Thus to the extent regulation can explain differences in risky lending among the cooperative and savings banks, the reason can only be enforcement. Not very much can be said about potential differences in this regard. Some scope for differences may in any case have existed, as for the most part supervision was carried out by two different bodies under the main supervisory agency.

But to really explain the differences in behaviour across individual cooperative banks and savings banks on the basis of the moral hazard or credit crunch hypotheses, one needs to examine the relationships on the one hand bank lending and on the other hand bank equity capital, bank costs and core deposits.

A negative effect of bank capital (and potentially even that of core deposits) and a positive effect of bank costs would be compatible with the moral hazard explanation but in conflict with the argument that credit growth was determined purely by demand conditions (including borrower quality).

Analogous issues need to be examined for the contraction phase. Thus: are there reason to believe that pricing of the banks' marginal liabilities and/or capital regulation turned highly stiff at least for some subset of banks, and can one observe a positive relationship between bank capital (core deposits) and lending and a negative relationship between bank costs and bank lending? Affirmative answers to these questions would suggest that some type of credit crunch is at least partitially responsible for the observed credit contraction.

References

Bernanke, B. and Gertler, M. (1987) **Banking and Macroeconomic Equilibrium.** In Barnett, W. and Singleton, K. (eds): New Approaches to Monetary Economics. Cambridge University Press.

Bernanke, B. and Lown, C. (1991) **The Credit Crunch.** Brooking Papers on Economic Activity 2:1991, 205-247.

Broecker, T. (1990) **Credit-Worthiness Tests and Interbank Competition.** Econometrica 58, 429-452.

Calomiris, C. (1995) **Financial Fragility: Issues and Policy Implications.** Journal of Financial Services Research 9, 241-257.

Dermine, J. (1984) **Pricing Policies of Financial Intermediaries.** Springer-Verlag. Berlin.

Dermine, J. (1986) **Deposit Rates, Credit Rates and Bank Capital.** Journal of Banking and Finance 10, 99-114.

Gorton, G. and Rosen, R. (1995) **Corporate Control, Portfolio Choice, and the Decline of Banking.** Journal of Finance 50, 1377-1419.

Guttentag, J. and Herring, R. (1984) **Credit Rationing and Financial Disorder.** Journal of Finance 34, 1359-1382.

Holmström, B. and Tirole, J. (1994) **Financial Intermediation, Loanable Funds and the Real Sector.** Unpublished manuscript.

Kashyap, A. and Stein, J. (1994) **The Impact of Monetary Policy on Bank Balance Sheets.** NBER Working Paper No. 4821.

Kareken, J. and Wallace, N. (1978) **Deposit Insurance and Bank Regulation: A Partial-equilibrium Exposition.** Journal of Business 51, 413-439.

Keeley, M. (1990) **Deposit Insurance, Risk, and Market Power in Banking.** American Economic Review 80, 1183-1200.

Keeley, M. and Furlong, F. (1990) **A Re-examination of Mean-variance Analysis of Bank Capital Regulation.** Journal of Banking and Finance 14, 69-84.

Kindleberger, C. (1982) **Manias, Panics and Crashes. A History of Financial Crises.** Basic Books, N.Y.

Klein, M. (1971) **A Theory of the Banking Firm.** Journal of Money, Credit and Banking 3, 205-218.

Kuusterä, A. (1995) **Aate ja raha. Säästöpankit suomalaisessa yhteiskunnassa 1822-1994.** Otava, Helsinki.

Merton, R. (1977) **An Analytic Derivation of the Cost of Deposit Insurance and Loan Quarantees.** Journal of Banking and Finance 1, 3-11.

Minsky, H. (1977) **A Theory of Systemic Fragility.** In Altman, E. and Sametz, A. (eds): Financial Crises, Wiley, N.Y.

Passmoore, W. and Sharpe, S. (1994) **Optimal Bank Portfolios and the Credit Crunch.** Federal Reserve Board, Finance and Economics Discussion Series 94-19.

Peek, J. and Rosengren, E. (1994) **The Capital Crunch: Neither a Borrower Nor a Lender Be.** Journal of Money Credit Banking 26.

Pennachi, G. (1987) **Alternative Forms of Deposit Insurance. Pricing and Bank Incentive Issues.** Journal of banking and Finance 11, 291-312.

Pettersson, K.-H. (1993) **Bankkrisen Inifrån.** SNS Förlag, Stockholm.

Rajan, R. (1992) **Insiders and Outsiders: The Choice between Relationship and Arm's Length Debt.** Journal of Finance 47, 1367-1400.

Rajan, R. (1994) **Why Bank Credit Policies Fluctuate: A Theory and Some Evidence.** Quarterly Journal of Economics 109, 399-441.

Rotemberg J. and Saloner, G. (1986) **A Supergame-Theoretic Model of Price Wars During Booms.** American Economic Review 76, 391-407.

Solttila, H. and Vihriälä, V. (1994) **Finnish Banks' Problem Assets: Result of Unfortunate Asset Structure or too Rapid Growth?** Bank of Finland Discussion papers 23/94.

Vihriälä, V. (1996) **Theoretical aspects to the Finnish Credit Cycle.** Bank of Finland Discussion Papers 8/96.

Vives, X. (1991) **Banking Competition and European Integration.** In Giovanni A. and Mayer, C. (eds.) European Financial Integration. Cambridge University Press.

Wojnilower, A. (1980) **The Central Role of Credit Crunches in Recent Financial History.** Brookings Papers on Economic Activity, 1980:2.

Appendix 1

The second order conditions and the comparative statics

A. Liability side capital requirement, fair pricing, M > 0

First order condition (FOC):

$$H \equiv MR^* - R^B \cdot \lambda_3 = 0, \quad \lambda_3 = 1 + \frac{c(1+k)F(a^k)}{1-F(a^M)}$$

Second order condition (SOC):

$$\frac{\partial H}{\partial M} = MR^{*\prime} - MC^{M\prime},$$

where

$$MC^{*\prime} \equiv \frac{\partial MR^*}{\partial M} = MR^{\prime} \cdot (1-F(RL)) - MR^2 \cdot f(RL) < 0,$$

when MR is decreasing ie $MR' < 0$.

$$MC^{M\prime} \equiv R^B \cdot R^M \left(\frac{c \cdot (1+k)^2 \cdot f(a^M)}{1-F(a^M)} + \frac{c(1+k) \cdot F(a^k) \cdot f(a^M)}{(1-F(a^M))^2} \right) = \begin{cases} >0, \text{ when } c>0 \\ =0, \text{ when } c=0 \\ <0, \text{ when } c<0 \end{cases}$$

$$\Rightarrow \frac{\partial H}{\partial M} < 0$$

always with $MR' < 0$ and $c \geq 0$.

Comparative statics:

R^B: $$\frac{\partial H}{\partial R^B} = -\lambda_3 + R^B \frac{\partial \lambda_3}{\partial R^B} = -\lambda_3 < 0 \text{ when } B=0 \Rightarrow \frac{dM}{dR^B} = \frac{dL}{dR^B} < 0$$

c: $$\frac{\partial H}{\partial c} = -R^B \cdot \frac{(1+k)F(a^k)}{1-F(a^M)} < 0 \quad \Rightarrow \frac{dM}{dc} = \frac{dL}{dc} < 0$$

k: $$\frac{\partial H}{\partial k} = -R^B \cdot \frac{cF(a^k) + c(1+k)\cdot(R^M M + R^D D)\cdot f(a^k)}{1-F(a^M)} = \begin{cases} <0, & c>0 \\ =0, & c=0 \\ >0, & c=0 \end{cases}$$

$$\Rightarrow \frac{dM}{dk} = \frac{dL}{dk} = \begin{cases} <0, & c>0 \\ =0, & c=0 \\ >0, & c<0 \end{cases}$$

K: $$\frac{\partial H}{\partial K} = MR^{*\prime} \Rightarrow \frac{dM}{dK} = -\frac{MR^{*\prime}}{MR^{*\prime} - MC^{M\prime}} < 0$$

$$\frac{dL}{dK} = 1 + \frac{dM}{dK} = \frac{-MC^{M\prime}}{MR^{*\prime} - MC^{M\prime}} = \begin{cases} >0, & c>0 \\ =0, & c=0 \\ <0, & c<0 \end{cases}$$

R^D: $$\frac{\partial H}{\partial R^D} = -R^B \cdot \left(\frac{c(1+k)^2 \cdot D \cdot f(a^k)}{1-F(a^M)} + \frac{c(1+k)F(a^k)\cdot D \cdot f(a^M)}{(1-F(a^M))^2} \right) < 0$$

$$\Rightarrow \frac{dM}{dR^D} = \frac{dL}{dR^D} = \begin{cases} <0, & c>0 \\ =0, & c=0 \\ >0, & c<0 \end{cases}$$

D: $$\frac{\partial C}{\partial D} = MR^{*\prime} - R^B \cdot R^D \cdot \underbrace{\left(\frac{c(1+k)^2 f(a^k)}{1-F(a^M)} + \frac{c(1+k)F(a^k)f(a^M)}{(1-F(a^M))^2} \right)}_{=A}$$

$$\Rightarrow \frac{dM}{dD} < 0, \text{ when SOC}'\text{s hold}$$

$$\frac{dL}{dD} = \frac{(R^D - R^M)\cdot A}{MR^{*\prime} - R^B R^R \cdot A} = \begin{cases} >0, & \text{when } c>0 \\ =0, & \text{when } c=0 \\ <0, & \text{when } c<0 \end{cases}$$

x: $$\frac{\partial H}{\partial x} = MR_x^* \equiv MR_x(1-F(RL)) - MR \cdot R_x \cdot L \cdot f(RL) > 0$$

unless f(RL) very large

z: $$\frac{\partial H}{\partial z} = -MR \cdot F_z(RL) - R^B\left(\frac{c(1+k)F_z(a^k)}{1-F(a^M)} + \frac{c(1+k)F(a^k)F_z(a^M)}{(1-F(a^M))^2}\right) > 0,$$

when $F_z(.) < 0$ and $c \geq 0$

B. Liability side capital regulation, fixed pricing, M > 0

FOC: $$H \equiv MR^* - MC^{Mf} = 0,$$

where

$$MC^{Mf} = MC \cdot (1 - F(a^M) + c \cdot (1+k) \cdot F(a^k))$$

SOC: $$\frac{\partial H}{\partial M} = MR^{*\prime} - MC^{Mf\prime},$$

where

$$MR^{*\prime} = MR^{\prime}(1 - F(RL)) - MR^2 \cdot f(RL)$$

and

$$MC^{Mf\prime} = MC^{\prime}(1 - F(a^M) + c(1+k)F(a^k)) - MC^2(f(a^M) - c(1+k)^2 f(a^k))$$

$$\Rightarrow \frac{\partial H}{\partial M} < 0$$

when $MC^{\prime}$ large enough or $f(RL)$ not too much smaller than $f(a^M)$.

Comparative statics

R^B: $$\frac{\partial H}{\partial R^B} = 0 \Rightarrow \frac{dM}{dR^B} = \frac{dL}{dR^B} = 0$$

m: $$\frac{\partial H}{\partial m} = -MC_m(1 - F(a^M) + c(1+k)F'(a^k)) + MC(R_m^M \cdot M \cdot f(a^M) - c(1+k)^2 R_m^\mu M f(a^k)) < 0$$

on the assumption $MC_m > 0$, $R_m^\mu > 0$ and $f(a^M)$ not too large

$$\Rightarrow \frac{dM}{dm} = \frac{dL}{dm} < 0$$

unless $f(a^M)$ very large

c: $$\frac{\partial H}{\partial c} = -MC(1+k)F(a^k) < 0 \Rightarrow \frac{dM}{dc} = \frac{dL}{dc} < 0$$

k: $$\frac{\partial H}{\partial k} = -MC(cF(a^k) + c(1+k)(R^D D + R^M M) \cdot f(a^k)) < 0$$

$$\Rightarrow \frac{dM}{dk} = \frac{dL}{dk} = \begin{cases} <0, & c>0 \\ =0, & c=0 \\ >0, & c<0 \end{cases}$$

K: $$\frac{\partial H}{\partial K} = MR^{*\prime} < 0 \Rightarrow \frac{dM}{dK} < 0$$

$$\frac{dL}{dK} = 1 + \frac{dM}{dK} = \frac{-MC^{Mf'}}{MR^{*\prime} - MC^{Mf'}} = \begin{cases} >0, & MC^{Mf'} > 0 \\ =0, & MC^{Mf'} = 0 \\ <0, & MC^{Mf'} < 0 \end{cases}$$

R^D: $$\frac{\partial H}{\partial R^D} = MC \cdot D \cdot (F(a^M) - c(1+k)^2 f(a^k)) > 0$$

$$\Rightarrow \frac{dM}{dR^D} = \frac{dL}{dR^D} > 0$$

unless c large (close to unity)

D: $$\frac{\partial H}{\partial D} = MR^{*\prime} + MC \cdot R^D \cdot (f(a^M) - c(1+k)^2 f(a^k)) \lesseqgtr 0 \Rightarrow \frac{dM}{dD} \lesseqgtr 0$$

$$\frac{dL}{dD} = 1 + \frac{dM}{dD} = \frac{-MC^{Mf\prime} - MC \cdot R^P(f(a^M) - c(1+k)^2 f(a^k)}{MR^{*\prime} - MC^{Mf\prime}}$$

$$= \begin{cases} >0, \text{ when } MC^{Mf\prime} > -MC \cdot (R^D \cdot f(a^M) - c(1+k)^2 f(a^k)) < 0 \\ <0, \text{ when } MC^{Mf} < -MC \cdot (R^D \cdot f(a^M) - c(1+k)^2 f(a^k)) < 0 \end{cases}$$

x: $$\frac{dM}{dx} = \frac{dc}{dx} = -\frac{MR_x^*}{MR^{*\prime} - MC^{Mf\prime}} > 0$$

unless f(RL) very large

z: $$\frac{\partial H}{\partial Z} = -MRF_z(RL) + MC[F_z(a^M) - c(1+k)F_z(a^k)] > 0$$

unless $|F_z(a^M)|$ much greater than $|F_z(RL)|$

$$\Rightarrow \frac{dM}{dz} = \frac{dL}{dz} > 0$$

unless $|F_z(a^M)|$ much greater than $|F_z(RL)|$

C. Asset side capital regulation, fair pricing, M > 0

FOC: $H \equiv MR^{**} - R^B \lambda_3 = 0,$

where

$$MR^{**} \equiv MR(1 - F(RL) - c \cdot k \cdot F(a^k))$$

$$\lambda_3 = 1 + \frac{c \cdot F(a^k)}{1 - F(a^M)}$$

SOC: $$\frac{\partial H}{\partial M} = MR'(1 - F(RL) - C \cdot k \cdot F(a^k)) - MR^2(f(RL) - c \cdot k^2 f(a^k))$$

$$\equiv MR^{**'} < 0$$

$$-MR \cdot c \cdot k \cdot MC \cdot f(a^k) - R^B \cdot \frac{\partial \lambda_3}{\partial M} < 0$$

where

$$\frac{\partial \lambda_3}{\partial M} = c \cdot MC\left[\frac{f(a^k)}{1 - F(a^M)} + \frac{F(a^k) \cdot f(a^M)}{1 - F(a^M)}\right] > 0$$

<u>Comparative statics</u>

R^B: $$\frac{\partial H}{\partial R^D} = -\lambda_3 \Rightarrow \frac{dM}{dR^B} = \frac{dL}{dR^B} < 0$$

c: $$\frac{\partial H}{\partial c} = kF(a^k) - R^B \frac{F(a^k)}{1 - F(a^M)} < 0 \Rightarrow \frac{dM}{dc} = \frac{dL}{dc} < 0$$

k: $$\frac{\partial H}{\partial k} = -c \cdot F(a^k) - c \cdot k \cdot RL \cdot f(a^k) - R^B \frac{c \cdot RL \cdot f(a^k)}{1 - F(a^M)} < 0 \Rightarrow \frac{dM}{dk} = \frac{dL}{dk} < 0$$

K: $$\frac{\partial H}{\partial K} = MR^{**'} < 0 \Rightarrow \frac{dM}{dK} < 0$$

$$\frac{dL}{dK} = 1 + \frac{dM}{dK} = \frac{-MR \cdot c \cdot k \cdot MC \cdot f(a^k) - R^B \cdot \frac{\partial \lambda_3}{\partial M}}{MR^{**'} - MR \cdot c \cdot k \cdot MC \cdot f(a^k) - R^B \cdot \frac{\partial \lambda_3}{\partial M}} > 0$$

R^D: $$\frac{\partial H}{\partial R^D} = -c \cdot k \cdot D \cdot f(a^k) - R^B \frac{\partial \lambda_3}{\partial R^D} < 0$$

as

$$\frac{\partial\lambda_3}{\partial R^D} = c \cdot D \cdot \left[\frac{f(a^k)}{1 - F(a^M)} + \frac{F(a^k) f(a^M)}{(1 - F(a^M))^2}\right] \geq 0,$$

when $c \geq 0$

$$\Rightarrow \frac{dM}{dR^D} = \frac{dL}{dR^D} < 0$$

D:

$$\frac{\partial H}{\partial R^D} = MR^{**\prime} - MR \cdot c \cdot h \cdot R^D \cdot f(a^k) - R^B \cdot \frac{\partial\lambda_3}{\partial D} < 0$$

as

$$\frac{\partial\lambda_3}{\partial D} = c \cdot R^D \cdot \left[\frac{f(a^k)}{1 - F(a^M)} + \frac{F(a^k) f(a^M)}{(1 - F(a^M))^2}\right] \geq 0$$

when $c > 0$

$$\Rightarrow \frac{dM}{dD} < 0$$

$$\frac{dL}{dD} = 1 + \frac{dM}{dK} = \frac{-(MC - R^D) MR \cdot c \cdot k \cdot f(a^k) - R^B \cdot \left(\frac{\partial\lambda_3}{\partial M} - \frac{\partial\lambda_3}{\partial D}\right)}{MR^{**\prime} - MR \cdot c \cdot k \cdot MC \cdot f(a^k) - R^B \cdot \frac{\partial\lambda_3}{\partial M}} > 0$$

as $MC > R^D$

x:

$$\frac{\partial H}{\partial x} = MR_x \cdot (1 - F(RL) - c \cdot k \cdot F(a^k)) - MR \cdot R_x \cdot L \cdot (f(RL) + c \cdot k^2 \cdot f(a^k)) \gtrless 0$$

z:

$$\frac{\partial H}{\partial z} = -MR(F_z(RL) + c \cdot k \cdot F_z(a^k)) - R^B \cdot c \cdot \left(\frac{F_z(a^k)}{1 - F(a^M)} + \frac{F(a^k) F_z(a^M)}{(1 - F(a^M))^2}\right) > 0$$

given the assumption $F_z(.) < 0$

$$\Rightarrow \frac{dM}{dz} = \frac{dL}{dz} > 0$$

D. Asset side capital regulation, fixed pricing, M > 0

FOC: $H \equiv MR^{**} - MC^{Mf} = 0$

when

$$MR^{**} = MR(1 - F(RL) - c \cdot k \cdot F(a^k))$$

and

$$MC^{Mf} = MC(1 - F(a^M) + c \cdot F(a^k))$$

SOC: $$\frac{\partial H}{\partial M} = MR^{**\prime} - MR \cdot c \cdot k \cdot MC \cdot f(a^k) - MC^{Mf\prime},$$

where

$$MC^{**\prime} = MR^{\prime}(1 - F(RL) - c \cdot k \cdot F(a^k) - MK^2(f(RL) - c \cdot k^2 \cdot f(a^k))$$

and

$$MC^{Mf\prime} = MC^{\prime}(1 - F(a^M) + cF(a^k)) + MC(MC \cdot f(a^M) + c \cdot (k \cdot MR + MC)f(a^k))$$

$$\frac{\partial H}{\partial M} < 0$$

when MC' large enough or when $f(RL)$ not too much smaller than $f(a^M)$ (note: FOC $\Rightarrow$ MR > MC)

Comparative statics

R^B: $$\frac{dM}{dR^B} = \frac{dL}{dR^B} = 0$$

m: $$\frac{\partial H}{\partial m} = -MR \cdot c \cdot k \cdot f(a^k) \cdot R^M_M \cdot M - MC_m(1 - F(a^M) + cF(a^k))$$

$$+ MC \cdot R^M_m \cdot M \cdot (f(a^M) - cf(a^k)) < 0$$

unless $f(a^M)$ very large

$$\Rightarrow \frac{dM}{dm} = \frac{dL}{dm} < 0$$

unless $f(a^M)$ very large

c: $$\frac{\partial H}{\partial c} = -MR \cdot k \cdot F(a^k) - MC \cdot c \cdot F(a^k) < 0 \Rightarrow \frac{dM}{dc} = \frac{dL}{dc} < 0$$

k: $$\frac{\partial H}{\partial k} = -MR \cdot c \cdot (F(a^k) + k \cdot RL \cdot f(a^k)) - MC \cdot c \cdot RL \cdot f(a^k) < 0 \Rightarrow \frac{dM}{dk} = \frac{dL}{dk} < 0$$

K: $$\frac{\partial H}{\partial K} = MR^{**\prime} - MC \cdot c \cdot k \cdot MR \cdot f(a^k) < 0 \Rightarrow \frac{dM}{dK} < 0$$

$$\frac{dL}{dK} = \frac{-MR^{Mf\prime}}{MR^{**\prime} - MC \cdot c \cdot k \cdot MR\, f(a^k) - MC^{ML\prime}} = \begin{cases} >0, \text{ when } MC^{Mf\prime} > 0 \\ =0, \text{ when } MC^{Mf\prime} = 0 \\ <0, \text{ when } MC^{Mf\prime} < 0 \end{cases}$$

R^D: $$\frac{\partial H}{\partial R^D} = -MR \cdot c \cdot k \cdot D \cdot f(a^k) + MC \cdot D \cdot (f(a^M) - c \cdot f(a^k))$$

> unless c very large

$$\Rightarrow \frac{\partial M}{\partial R^D} = \frac{\partial L}{\partial R^D} > 0$$

unless c very large

D: $$\frac{\partial H}{\partial D} = MR^{\prime}(1 - F(RL)) - c \cdot k \cdot F(a^k)) - MR^2(f(RL) - c \cdot k^2 f(a^k))$$

$$-MR \cdot c \cdot k \cdot R^D \cdot f(a^k) + MC(R^D f(a^M) - c \cdot (kMR + R^D) f(a^k))$$

< 0 unless f(.) very exotic

$$\Rightarrow \frac{dM}{dD} < 0$$

$$\frac{dL}{dD} = \frac{-MR \cdot c \cdot k \cdot F(a^k)(MC - R^D) - MC^{Mf'} - MC(R^D f(a^M) - c(kMR + R^D) f(a^k))}{MR^{**'} - MR \cdot c \cdot k \cdot MC \cdot f(a^k) - MC^{Mf'}}$$

$$= \begin{cases} >0, \text{ when } MC^{Mf'} > -MC(R^D f(a^M) - c(kMR + K^D) f(a^k)) - MR \cdot c \cdot k \cdot F(a^k)(MC - R^D) < 0 \\ <0, \text{ when } MC^{Mf} < -MC(R^D f(a^M) - c(kMR + K^D) f(a^k)) - MR \cdot c \cdot k \cdot F(a^k)(MC - R^D) < 0 \end{cases}$$

x:

$$\frac{\partial H}{\partial x} = MR_x(1 - F(RL) - c \cdot k \cdot F(a^k)) - MR \cdot R_x \cdot L(f(RL) + c \cdot k^2 \cdot f(a^k))$$

$$-MC \cdot c \cdot k \cdot R_x \cdot L \cdot f(a^k) \gtrless 0 \Rightarrow \frac{dM}{dx} = \frac{dL}{dx} \gtrless 0$$

z:

$$\frac{\partial H}{\partial z} = -MR(F_z(RL) + c \cdot k \cdot F_z(a^k)) + MC(F_z(a^M) - c \cdot F_z(a^k)) \gtrless 0 \Rightarrow \frac{dM}{dz} = \frac{dL}{dz} \gtrless 0$$

Appendix 2

Solutions with weak loan demand

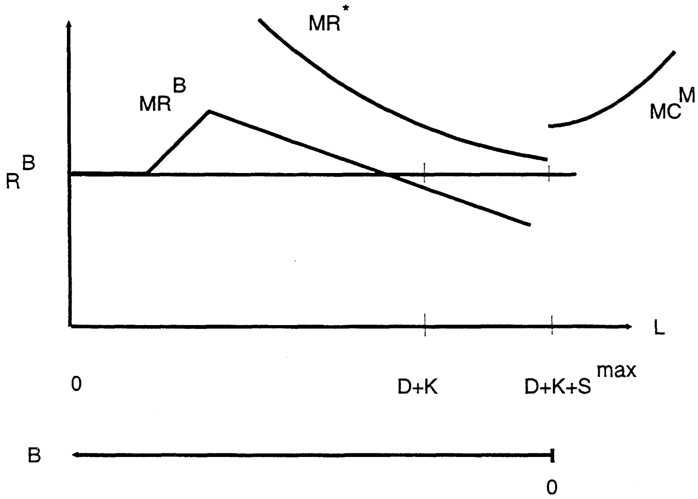
FOC'S: $\begin{cases} MR^{B} - MR^{*} + M_{B} = 0 \\ MR^{*} - R^{B} - \mu_{s} - \eta_{s} = 0 \end{cases}$

<u>Alternative constellations</u>

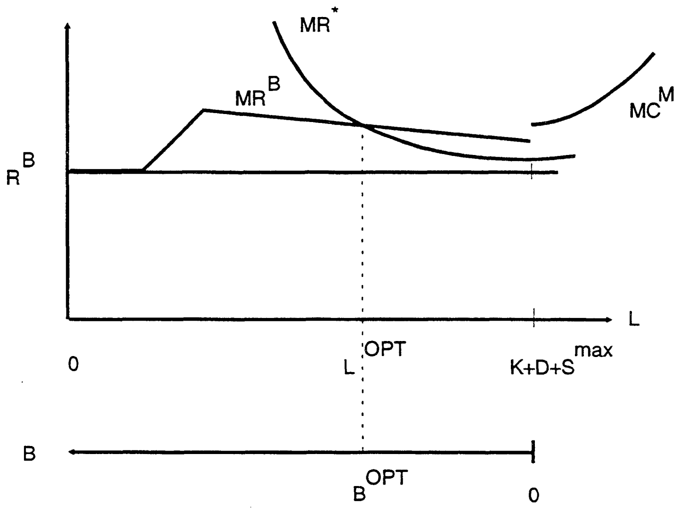
1 $\quad MR^{*} > R^{B} \ \forall L \Rightarrow \eta_{s} > 0 \Rightarrow S = S^{max}$

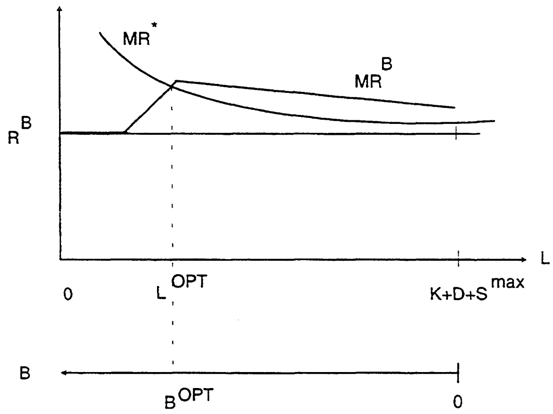
1.1 $\quad MR^{*} > MR^{D} \ \forall L \Rightarrow \mu_{B} > 0 \Rightarrow b = 0$

$\Rightarrow$ balance sheet: $L^{OPT} = K + D + S^{max}$



1.2 $MR^* = MR^B$ for some L^{OPT} $\Rightarrow \mu_B = 0$ and normally $B > 0$
$\Rightarrow$ balance sheet $L^{OPT} + B^{OPT} = K + D + S^{max}$



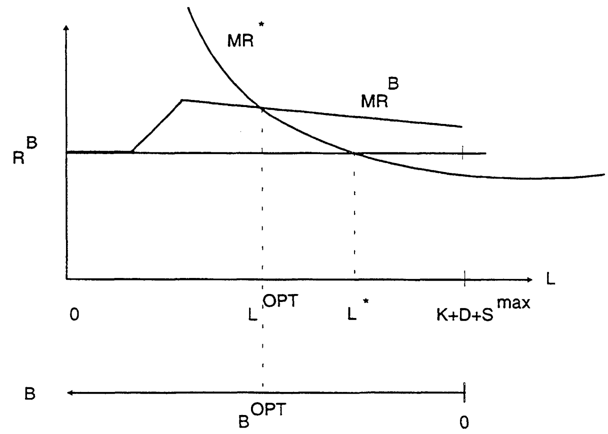


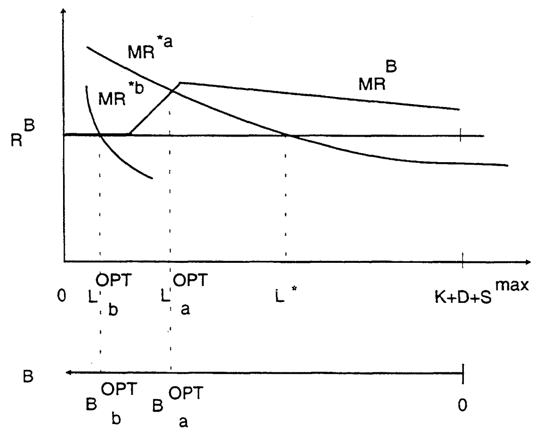
$$2 \quad MR^* = \begin{Bmatrix} > \\ = \\ < \end{Bmatrix} R^B, \text{when } L = \begin{cases} < L^* \\ = L^* \\ > L^* \end{cases}$$

2.1 $MR^B > R^B \ \forall B \Rightarrow \eta_s > 0 \Rightarrow s = s^{max}$

$MR^* = MR^B \Rightarrow \mu_B = 0$ and normally $B > 0$

balance sheet: $L^{OPT} + B^{OPT} = K + D + S^{max}$

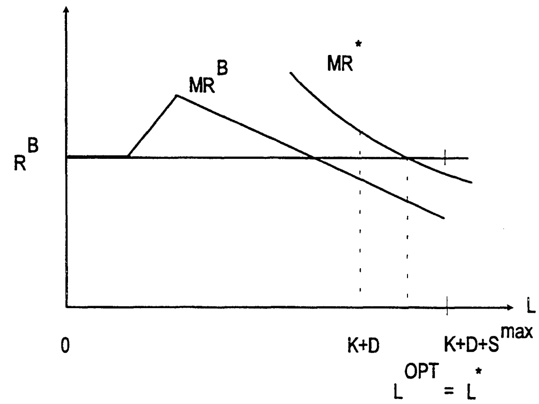




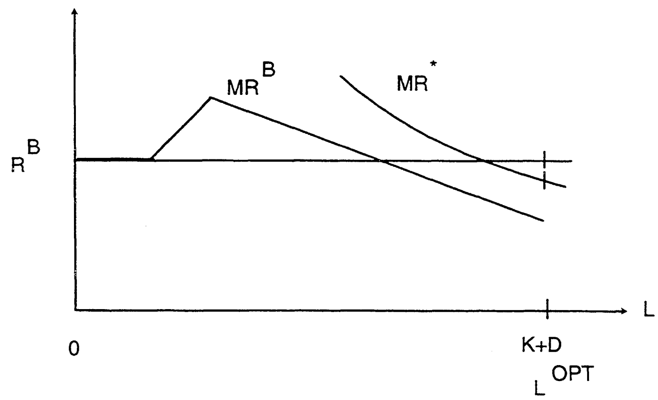
2.2 $MR^* > MR^B \;\; \forall \;\; B \Rightarrow M_B > 0 \Rightarrow B = 0;$

$MR^B < R^B$, when $B > B^* > 0$

2.2.1 $MR^*_{L=K+D} > R^B \;\; \Rightarrow$ balance sheet $L^{OPT} = K+D+S^{OPT}$



2.2.2 $MR^*_{L=K+D} > R^B \;\; \Rightarrow$ balance sheet: $L^{OPT} = K+D$



BANK OF FINLAND DISCUSSION PAPERS

ISSN 0785-3572

1/96 Kari T. Sipilä **A Data Communication Network for Administrative Purposes within the EU.** 1996. 53 p. ISBN 951-686-492-9. (TK)

2/96 Veikko Saarinen – Kirsti Tanila – Kimmo Virolainen **Payment and Settlement Systems in Finland 1995.** 1996. 60 p. ISBN 951-686-493-7. (RM)

3/96 Harri Kuussaari **Systemic Risk in the Finnish Payment System: an Empirical Investigation**. 1996. 32 p. ISBN 951-686-494-5. (RM)

4/96 Janne Lauha **OTC-johdannaiset ja Suomen oikeus** (OTC Derivatives and Finnish Law 1996. 98 p. ISBN 951-686-495-3. (RATA)

5/96 Jukka Ahonen – Ilmo Pyyhtiä **Suomen teollisuuden rakenne ja häiriöalttius suhteessa muihin EU-maihin** (The structure of Finnish industry and its sensitivity to shocks in comparison to other EU countries). 1996. 37 p. ISBN 951-686-496-1. (RP)

6/96 Pekka Ilmakunnas – Jukka Topi **Microeconomic and Macroeconomic Influences on Entry and Exit of Firms**. 1996. 33 p. ISBN 951-686-497-X. (TU)

7/96 Jaakko Autio **Korot Suomessa 1862–1952** (Interest Rates in Finland). 1996. 55 p. ISBN 951-686-498-8. (TU)

8/96 Vesa Vihriälä **Theoretical Aspects to the Finnish Credit Cycle.** 1996. 63 p. ISBN 951-686-500-3. (TU)

9/96 Vesa Vihriälä **Bank Capital, Capital Regulation and Lending**. 1996. 52 p. ISBN 951-686-501-1. (TU)