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The Banking Crisis, Banking Policy Regimes and the Value of a Bank

SUOMEN PANKIN KESKUSTELUALOITTEITA • FINLANDS BANKS DISKUSSIONSUNDERLAG

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Abstract

This paper studies the value of a bank under different banking policy regimes. As banks run into financial distress, authorities in different countries have used different approaches to deal with the crisis. The Nordic countries provide examples of different policy approaches. The results show that the uncertainty over the banking policy regime and changes in this uncertainty can have a major impact on the value dynamics of bank shares. The model produces moral hazard problems both before and after public sector intervention. On the other hand, bank support can increase the original shareholders' incentive to inject new capital into the bank. The model also implies that the government may have an incentive to cheat the bank's shareholders in order to ensure more capital injections from them.

Tiivistelmä

Työssä tutkitaan teoreettisesti pankin arvon määräytymistä erilaisissa pankkitukipolitiikan vaihtoehdoissa. Eri maat ovat toimineet eri tavoin, kun pankkisektori on ajautunut vaikeuksiin. Pohjoismaat tarjoavat esimerkin erilaisista lähestymistavoista. Työn tulosten mukaan epävarmuus pankkitukiregiimistä ja muutokset tässä epävarmuudessa voivat vaikuttaa olennaisesti pankin osakkeen arvoon. Malli tuottaa vääristyneitä kannustinongelmia sekä ennen julkisen sektorin interventiota että sen jälkeen. Toisaalta, pankkituki voi lisätä osakkeenomistajien kannustimia tehdä lisäsijoituksia pankkiin. Lisäksi julkisella sektorilla voi olla kannustin ohjata harhaan pankin osakkeenomistajia.

Contents

1 Introduction

The paper focuses on the valuation of banks under different banking policy regimes. The main purpose is to study the dynamics of a bank's value as it experiences into financial distress and the impact of different banking policy regimes on this dynamics.

The properties of the bank common stocks differ from those of corporations as the banks' earnings process differ from the corporations' earnings process. The public sector regulates banks and their earnings more than it regulates corporations. Banks are regulated by solvency ratios, audits and restrictions on banks investment behaviour.

From the investor's viewpoint, one of the most important questions regarding future earnings and public regulation is how the public sector will react if the bank falls into financial distress. Banks differ from corporations in that they are rarely allowed to go bankrupt. Instead they are either financially reorganized or bailed out. This is especially true for large banks.

Furthermore, there are clear differences in how the public sector reacts to a banking crisis. The Nordic countries in the late 1980s and early 1990s provide a good example of different approaches. In Norway the original shareholders' equity in large commercial banks was nullified in the early years of the banking crisis. In Sweden and Finland, this has not been the case, as public policy has been aimed more at helping the banks obtain funding from the markets. The Nordic cases are discussed in more detail in section 2.

In summary, from the shareholders point of view there are at least two distinct sources of uncertainty connected with a banking crisis. First, how will an individual bank cope? Secondly, how will the public sector react to the problems that arise? Will the government try to help the bank obtain funding or will it take control of the immediately? These questions provide the motivation for this paper.

I present a simplified model for bank valuation. Bank earnings are modelled as a regulated Brownian motion. The banking policy regime determines how the earnings are regulated. The emphasis is on capital instruments, not on the valuation of deposit insurance. The simplified model facilitates discussion of the valuation issues and moral hazard problems raised by bank support. Moral hazard problems can appear both before and after government intervention. Furthermore, it is shown that government behaviour can also entail moral hazard problems.

The approach used in this paper can be compared to the traditional deposit insurance literature (Merton (1977, 1978), Pennacchi (1987)). This literature focuses the value of deposit insurance and possible moral hazard problems raised by mispricing. This paper focuses on the management of a banking crisis and the valuation of banks' capital instruments. The paper takes deposit insurance and the valuation there of as given. The differences between different bank support regimes are in how the public sector treats banks' capital instruments if a bank falls into financial distress.

However, the approach taken here can also be used to study the fair price of deposit insurance. This is done in Fries, Mella-Barral and Perraudin (1994) (see also Fries, Mason and Perraudin (1993)). Fries, Mella-Barral and Perraudin (1994) study the fair price of a deposit guarantee and endogenous closure rules.

They model the deposit guarantee as a perpetual American put written by the government on the bank's assets and exercised optimally by the bank's shareholders. They study the actuarially fair deposit insurance rate, among other things. Below I will take deposit insurance and the deposit insurance fee as given and concentrate on the valuation of bank shares. More specifically, the earnings process specified below is assumed to present the earnings dynamics in the presence of deposit insurance and a deposit insurance fee.

The plan of the paper is as follows. Section 2 discusses the Nordic banking crisis. Section 3 presents the basic model. In section 4 I discuss the valuation of a bank with the shareholders having the option of abandoning it. This is the benchmark case. Section 5 discuss the value of a bank under different banking policy regimes. The final section contains concluding comments.

2 Nordic examples

In this section I discuss the banking policies in different Nordic countries.

In Finland, Norway and Sweden the banking industry run into severe difficulties which led to severe crises in the late 1980s and early 1990s. The bank support needed to deal with the crisis was of a considerable magnitude. The total amount as a percentage of GDP in 1989–1993 was 14.7 % in Finland, 4.5 % in Norway and 6.2 % in Sweden (Koskenkylä (1994)). The amount of government support provided to the banking sector was higher relative to GDP in each of the Nordic countries than, for example, in the United States (see BIS (1993)). In each of Sweden, Norway and Finland only two of the major commercial banks have managed to get by without direct government support (as of December 1994).

The main factors behind the crisis were the same in the three countries: very rapid lending growth and the acquirement of new customers prior to the crisis, bad credit screening and pricing policies, poor banking supervision and, finally, severe macroeconomic problems. See Koskenkylä (1994), Koskenkylä and Vesala (1994), Murto (1994), NOU (1992), Nyberg and Vihriälä (1994), Steigum (1992).[1]

The Nordic countries differ, however, in how they reacted to the banking crisis. This is true especially concerning the fate of the shareholders. Table 1 presents different bank support measures concerning commercial banks in Finland, Norway and Sweden.[2]

In Norway, the policy was straightforward. The banking crisis started 1987 and by 1991 all the major commercial banks were under state control. During

[1] Denmark differs from the other Nordic countries in the respect that the banking industry did not fall into an acute crisis and did not need large government support. The public support to banks has been clearly smaller than in the other Nordic countries and directed to a few small and medium-sized banks.

[2] In addition to commercial banks, the savings banks sector in different Nordic countries were hit by banking crisis. For example, in Finland the majority of the savings banks ceased to exist, as most of the independent savings bank were merged to a single bank, which was later sold in parts to it's competitors.

1991 the Government Bank Insurance Fund acquired full ownership of the second and third largest commercial bank of Norway: Christiania Bank and Fokus bank. Shareholders' equity was nullified. Majority ownership of the largest Norwegian bank, Den norske Bank, also fell to the state in 1991. Den norske Bank's original shareholders equity was written down to zero in March 1993. See more on NOU (1992).

By contrast, in Sweden and Finland public policy was aimed more at keeping the banks or at least most of the banks in private hands. In Sweden this was stated explicitly in a bill approved by the parliament on 18 December 1992. In summary it states that "the State shall not endeavour to become an owner of banks or other credit institutions."

Banks that remained independent were supported by capital injections and by help in funding themselves directly from the market. The latter aim was achieved by providing guarantees, resolutions and using so-called bad banks. The aim was to bridge the recession (see Nyberg and Vihriälä (1994), Lind and Nedersjö (1994), Murto and Eirola (1993)).

In Sweden Nordbanken, in which the state has had a majority holding, was split into two parts: Nordbanken and Securum. Nordbanken's bad loans were transferred to Securum. The state injected new capital into Nordbanken and issued a guarantee on a loan from Nordbanken to Securum. A small commercial bank, Gotabank, also fell into financial distress. As a result, it's initial share capital was nullified and it was merged to Nordbanken.

In Finland the attempt to assist banks through the recession can be seen from the general support given to the banks. As a general support measure, the government provided the banks with a capital injection totalling FIM 8 billion in March 1992. The capital injection took the form of investments in preferred capital certificates issued by the banks (see also section 5). Furthermore, the parliament approved a resolution in February 1993, stating that "Parliament requires the state to guarantee that Finnish banks are able to meet their commitments on time under all circumstances". The resolution is very close to the Swedish resolution mentioned above.

The Government Guarantee Fund in Finland has also decided, in principle, to support major banks with guarantees to be used when raising risk capital on international markets. So far, the banks have not used this facility.

Not all commercial banks remained independent or in private ownership in Finland. The Bank of Finland took control of Skopbank, which was the savings banks' commercial bank. Later the Government Guarantee Fund, which was formed in 1992, acquired the ownership of the bank. Individual investors who had a minority ownership of the Skopbank have kept their share capital. Furthermore, the good assets of the small commercial banks, STS Bank, were sold to one of the large commercial banks, Kansallis-Osake-Pankki. Since the transaction the STS Bank (renamed Siltapankki) has been an asset management company for bad assets, i.e. a bad bank. In January 1995, two leading Finnish commercial banks, Kansallis-Osake-Pankki and Union Bank of Finland, announced that they will merge by the end of 1995.

Table 1. **Nordic commercial banks and state support**

NORWAY

(i) Christiania Bank

The original share capital was nullified in December 1991. The former shareholders were offered a call option on up to 25 per cent of the Government Bank Insurance Fund. As a result 2.3 per cent of the shares passed into private hands. During December 1993, Christiana Bank issued shares to both domestic and foreign investors. At the same time the Government Bank Insurance Fund converted its suordinated loan into ordinary shares as well. After these transactions, the State's holding in Christiania Bank fell to 69 %.

(ii) Fokus bank

The original share capital was nullified in December 1991. As in the case of Cristiania Bank, the former shareholders were offered a call option. The sale was, however, postponed in the case of Fokus bank.

(iii) Den norske Bank

Den norske Bank is the Norway's largest commercial bank. The original share capital was written down by 90 % in 1992 through a reduction in the par value of a share from NKr 100 to Nkr 10. The remaining orginal share capital was nullified in March 1993. The new share offering for private investors was arranged in the first half of 1994. After the share offering the state owned 72 % of the bank.

(iv) General measures

As a general support measure, an arrangement was introduced in 1991 involving loans on special terms from the central bank, which carried appreciably lower interest rates than other loans from the central bank. These so-called G-loans were abolished in December 1993.

SWEDEN

(i) Nordbanken

Nordbanken was a commercial bank in which the state had majority ownership. It has been supported by several means, including capital injections and guarantees. Nordbanken was restructured in 1992; its bad assets were transferred to a separate asset management company, Securum. The private owners shares were bought back at a price corresponding to the price at which shareholders could buy shares that had been issued a year earlier.

(ii) Gotabank

Gota Bank was the smallest of Sweden's major commercial banks. Gota-Holding, parent to Gota Bank, filed for bankruptcy in September 1992. The bank was merged with Nordbanken. The initial share capital was nullified and bad assets were transferred to the separate asset management company, Retriva.

(iii) Other banks and general measures

In December 1992 the parliament passed an Act providing government support to all Swedish banks. According to the bill the State guarantees that banks and certain other credit institutions can meet their commitments on a timely basis. The State shall not endeavour to become an owner of banks. The support can be provided in the form loans, guarantees, capital contributions and other appropriate measures.

In 1991 over 300 cooperative bank merged into one bank, Föreningsbank.Föreningsbank acquired a guarantee from Bankstödsnämned in 1993. The state is committed to inject SEK 2.5 billion in share capital if the capital ratio (BIS) is in danger of falling below 8 per cent.

FINLAND

(i) Skopbank

Skopbank was a commercial bank owned by savings banks and individual investors. The savings banks had nearly 92 % of the voting rights before the Bank of Finland stepped in. Skopbank encountered severe problems and the Bank of Finland intervened in October 1990. The private owners have kept their share capital.

(ii) STS Bank

STS Bank was a small commercial bank whose status had been changed from that of a saving bank. It's good assets were transferred to a larger commercial bank, Kansallis-Osake-Pankki. Kansallis bought the majority of STS Bank shares at a price close to the market price, but substantially below their nominal value. The bad assets remained in STS Bank, which was renamed Siltapankki. The Government Guarantee Fund is responsible for 90 per cent and Kansallis 10 per cent of the loan losses.

(iv) Other banks and general measures

As a general support measure, the government provided the banks with a capital injection totalling FIM 8 billion in 1992. It was given in exchange for preferred capital certificates. The last time for capital injection was in December 1992. All the major banks have obtained this type of aid.

In 1992 most of the independent savings banks were merged into single bank, the Savings Bank of Finland (SBF). SBF was sold to its competitors in 1993. The bad loans were transferred to an asset management company, Arsenal Ltd.

In February 1993 the parliament approved a resolution confirming the state's commitment to support the banking system. The tone of the resolution is very similar to its Swedish counterpart.

In 1993 the Government Guarantee Fund decided that certain specified banks can, in principle, use state quarantees in acquiring risk capital from international markets. The banks were the major commercial banks, Kansallis-Osake-Pankki and Union Bank of Finland, and the cooperative banks.

3 The basic model

In this section I present a simple framework for valuing banks under different banking policy regimes.

I write the earnings dynamics as follows:

$$de = \mu dt + \sigma dW, \tag{1}$$

where W is a standard Wiener process. I assume that the drift μ is strictly positive. Note that e(t) is not speculative price and therefore, $e(t) < 0$ does not violate the limited liability condition. μ and σ are measured in markka (or \$) (see Merton (1993)).

It is assumed that equation (1) gives the earnings dynamics in the presence of deposit insurance and μ is the earnings drift net of any deposit insurance fee. In the following I focus on the valuation of bank shares which are not covered by deposit insurance.

I assume that the investor receives the cash flow e(t) at time t.[3] Thus the bank distributes all earnings to the owners. This implies that capital rations are not discussed here. Negative earnings imply that owners must make capital injections to the bank.

Let V(e) denote the value of a bank at time t for e = e(t). By Ito's lemma, the expected change in the value of the bank is

$$E(dV) = [V'(e)\mu + \tfrac{1}{2}V''(e)\sigma^2]dt, \tag{2}$$

where the primes denote the partial derivatives of V with respect to e. The standard deviation of its return is $V'(e)\,\sigma/V(e)$. The price appreciation (equation 2) plus cash flow give us the total instantaneous return that the owners of the bank expect to receive. In order to value the bank I have to combine the expected instantaneous return with the equilibrium valuation model.

Let Y be the price of an asset or dynamic portfolio of assets perfectly correlated with dW, so that

$$dY = \alpha_Y Y dt + \sigma_Y Y dW. \tag{3}$$

Then by the CAPM, the risk-adjusted expected retun on Y is $\alpha_Y = r + \gamma\rho\sigma_Y$, where α_Y is the required rate of return on asset Y, r is the risk-free rate, γ is the market price of risk and dW $dW_M = \rho dt$.[4]

From equilibrium pricing it follows that V satisfies the following ordinary second-order differential equation:

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[3] Where it does not create confusion, I drop the time-dependence notation.

[4] Alternatively we could assume that investors' preferences are logarithmic and obtain the risk premium from Cox, Ingersoll and Ross (1985).

$$0 = e + \lambda V'(e) + \tfrac{1}{2}\sigma^2 V''(e) - rV(e) \tag{4}$$

where $\lambda = \mu - \gamma\sigma$.

All solutions of (4) are linear combinations of the particular solution and of solutions for the its homogenous part, in the form

$$h(e) = A_1 \exp(\beta_1 e) + A_2 \exp(\beta_2 e), \tag{5}$$

where A_1 and A_2 are constant parameters, which are to be determined by the boundary conditions. β_1 and β_2 are the roots of the quadratic equation:

$$\tfrac{1}{2}\sigma^2\beta^2 + \lambda\beta - r = 0. \tag{6}$$

The particular solution is

$$V(e) = \frac{e(t)}{r} + \frac{\lambda}{r^2}. \tag{7}$$

Further insight to the particular solution can be obtained by taking the expectation of the future cash flow under the risk-adjusted probability measure and discounting at the risk free rate. This can be carried out by changing the drift of e(t) to $\lambda = \mu - \gamma\sigma$.

Equation (7) gives us the value of the bank's earnings stream when the earnings stream follow a (unregulated) Brownian motion. V(e) is the value of the bank assuming unlimited liability. Note that there is nothing to prevent V(e) from being negative given that e(t) can be negative. In order to value common stock I have to restrict the behaviour of the earnings process. This is done in the next section by modelling earnings as a regulated Brownian motion.

Combining (5) and (7), the solution for (4) must take the form

$$V(e) = \frac{\lambda}{r^2} + \frac{e}{r} + A_1 \exp(\beta_1 e) + A_2 \exp(\beta_2 e). \tag{8}$$

Equation (8) forms the basis of the forthcoming analysis. I proceed to model different banking policy regimes by assuming different boundary conditions for V(e). The different assumptions about the behaviour of the earnings process and/or value process at the different boundaries lead to different market value dynamics.

4 Value of a bank and the option to abandon

As a first specific example of banking policy, I consider the case where the bank is closed in a prespecified lower boundary. This means that there is a lower limit for e(t). In the case of common stock, the reorganization implies that e_D is an absorbing barrier and $V(e_D)$ is zero. In other words, shareholders lose their investments whenever e(t) hits the lower barrier.

The above implies that I can write the boundary condition

$$V(e_D) = 0. \tag{9}$$

Furthermore, we assume that bubbles are not possible. As the earnings approach ∞ the likehood of hitting the lower boundary becomes smaller and smaller. Thus the value of the bank should approach it's intrinsic value without the lower boundary. This is represented by equation (7). Thus

$$\lim_{e \to \infty} h(e) = 0. \tag{10}$$

If the β_2 is the negative root, then A_1 is equal to zero. This leaves A_2 to be determined.

Using the above boundary conditions we can rewrite the bank's market value as follows:

$$V(e) = \frac{\lambda}{r^2} + \frac{e}{r} - \left(\frac{\lambda}{r^2} + \frac{e_D}{r} \right) \exp[\beta_2 (e - e_D)], \tag{11}$$

where β_2 is $[-(\lambda^2 + 2\sigma^2 r)^{1/2} - \lambda]/\sigma^2$, which is the negative root of equation (6).

Equation (11) has a simple interpretation. The first part of the right-hand side, $\lambda/r^2 + e/r$, represents the discounted value of the earnings stream in the absence of an option to abandon the bank as discussed in the previous section.

The second part is more interesting. It is the negative of the expected discounted value of a claim to the bank's earnings stream when it first reaches e_D given that earnings currently equal e(t). It is the amount of asset value lost in the case of financial reorganization. The earnings stream is discounted by the average discount factor weighted by the probability that the earnings process hits the absorbing barrier at a given time (see Karlin and Taylor (1975), p. 362). The weight depends on the earnings (risk-adjusted) drift, the volatility of the earnings, the riskless discount rate and distance between the earnings and the absorbing barrier.

The owners have an option to liquidate the bank. Thus they can close the bank at the level e_D which they can choose (assuming that the public sector

does not intervene).[5] This implies that the owners choose the value e_D^*, which maximizes the value of stock, i.e. e_D^* is the solution to the following maximizing problem:

$$\max V(e,e_D) = \frac{\lambda}{r^2} + \frac{e}{r} - \left(\frac{\lambda}{r^2} + \frac{e_D}{r} \right) \exp[\beta_2 (e - e_D)]. \tag{12}$$

The corresponding value of e_D^* is $1/\beta_2 - \lambda/r$. The results imply, among other things, that the term $(\lambda/r^2 + e_D^*/r)$ in equation (12) is negative. The owner of the common stock is better off as stock carries limited rather than unlimited liability. The option to abandon the bank has a positive value.[6] The market value of the future earnings stream is greater with the absorbing barrier in e_D^* than without the absorbing barrier. It can be also shown that the value of the bank is greater than zero when $e \geq e_D^*$.[7]

Note also that e_D^* is lower than the level at which the discounted expected earnings for an unregulated Brownian motion hits zero. This is because by regulating the earnings process an investor can cut out the possible large negative values of e(t).

5 Role of the banking policy regime

5.1 Intervention with certainty

Above we assumed that shareholders make the decision to abandon independently of public authorities. In this section I discuss the role of banking policy. More specifically, I model the banking policy where the public sector intervenes in order to prevent the bankruptcy.

The main assumptions are as follows. I assume that there is a lower limit for e(t) set by the public sector, denoted as e_D. When earnings hit the lower limit, the public sector intervenes by moving earnings from e_D to e_E. The public sector subsidizes a bank. The level of e_E is a policy variable. This implies that there is a jump in the earnings process when e(t) hits the lower boundary.

From the shareholders' point of view, however, there is a cost of intervention. The public sector will in the future collect a fixed fee, c, from the banks' earnings process if the intervention occurs. The public sector collects c

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[5] For a model in which the deposit insurer chooses the point at which to close the bank, see Allen and Saunders (1993). They model deposit insurance as a callable put. The call has a value if the stockholders choose to close the bank later than the regulator. The corresponding analysis could also be done here.

[6] This is analogous to the results presented in the real option literature (see Dixit and Pindyck (1994)).

[7] By evaluating V'(e) at the e_D^* it can be seen that $V'(e_D^*) = 0$. Thus, the value matching condition implies the smooth pasting condition (see Dumas (1991)).

only after the bank has restored it's profitability. This implies that c is collected only when the earnings are above some trigger level e_L (on condition that the intervention has occurred).

The example mimics some of the features of Finnish policy. The Finnish Government decided in March 1992 to provide the banks with a capital injection totalling FIM 8 billion. The injection was provided in exchange for preferred capital certificates. The certificates are regarded as Tier I capital. The instrument carries a non-cumulative return. The certificates can be converted into voting stock if interest remains unpaid for three years in succession (or the bank's solvency ratio falls below the legally required minimum). Thus one of the aims seems to be to provide banks a bridge over the bad years. Note that it is possible that banks will not pay interest in the first three years after which banks can refund the certificates if they are willing and able to do so. Banks acquired FIM 7.9 billion of new capital for the certificates.[8]

The above considerations lead us to the following ordinary differential equations using the arguments presented in section 3.

$$V(e) = \frac{e}{r} + \frac{\lambda}{r}V'(e) + \tfrac{1}{2}\frac{\sigma^2}{r}V''(e) \tag{4a}$$

if intervention has not occurred or
if intervention has occurred and $e < e_L$.

$$V(e) = \frac{e}{r} - \frac{c}{r} + \frac{\lambda}{r}V'(e) + \tfrac{1}{2}\frac{\sigma^2}{r}V''(e) \tag{4b}$$

if intervention has occurred and $e \geq e_L$.

The corresponding solutions are the following:

$$V_A(e,0) = \frac{\lambda}{r^2} + \frac{e}{r} + A_1\exp(\beta_1 e) + A_2\exp(\beta_2 e) \tag{8a}$$

if intervention has not occurred,

$$V_B(e,I) = \frac{\lambda}{r^2} + \frac{e}{r} + B_1\exp(\beta_1 e) + B_2\exp(\beta_2 e) \tag{8b}$$

if intervention has occurred and $e < e_L$.

[8] At the end of August 1992, after the banks had raised FIM 4.9 billion of capital for certificates, their Tier I capital was FIM 26.2 billion.

$$V_C(e,I) = \frac{\lambda}{r^2} + \frac{e}{r} + C_1 \exp(\beta_1 e) + C_2 \exp(\beta_2 e) - \frac{c}{r} \tag{8c}$$

if intervention has occurred and $e \geq e_L$.

$V_A(e, 0)$ denotes the value of the bank if intervention has not occurred and $V_B(e, I)$ and $V_C(e, I)$ if intervention has occurred. The constants in the solutions are determined using the following boundary conditions.

Consider first the solution after the intervention has occurred. The same arguments as above can be used to determine C_1 in case $e \geq e_L$. By allowing the value of the bank to approach it's instrict value as earnings approach infinity we can set C_1 to zero.

Furthermore, I equate the values and derivatives of the two component solutions at e_L. Thus we have $V_B(e_L, I) = V_C(e_L, I)$ and $V_B'(e_L, I) = V_C'(e_L, I)$. The extra boundary condition comes from the requirement that $V_B(e_D, I) = V_B(e_E, I)$. This is again the value matching condition arising from the arbitrage arguments. I assume that $e_E < e_L$.

These lead to three equations in the unknowns B_1, B_2 and C_2, as presented in th appendix. The solutions for the coefficients are

$$B_1 = \frac{-c\beta_2}{(r(\beta_1 - \beta_2)\exp(\beta_1 e_L))} \tag{13}$$

$$B_2 = [\text{Exp}(\beta_2 e_E) - \text{Exp}(\beta_2 e_D)]^{-1}\left[\frac{(e_D - e_E)}{r} + \left(\frac{c\beta_2}{(r(\beta_1 - \beta_2))}\right)\right. \tag{14}$$
$$\left.*(\text{Exp}(\beta_1 e_D - \beta_1 e_L) - \text{Exp}(\beta_1 e_E - \beta_1 e_L))\right]$$

$$C_2 = [\text{Exp}(\beta_2 e_E) - \text{Exp}(\beta_2 e_D)]^{-1}\left[\frac{(e_D - e_E)}{r} + \left(\frac{c\beta_2}{(r(\beta_1 - \beta_2))}\right)\right. \tag{15}$$
$$\left.*(\text{Exp}(\beta_1 e_D - \beta_1 e_L) - \text{Exp}(\beta_1 e_E - \beta_1 e_L))\right] + \frac{c\beta_2}{(r(\beta_1 - \beta_2)\text{Exp}(\beta_1 e_L))}$$

We can now obtain the solution for $V(e(t), 0)$. Again we assume that $e_E < e_L$. Using the same arguments as above, we can set A_1 to zero. Next, we use the value matching condition, which states that the value of the banks just prior to intervention corresponds to their value at e_E after the intervention, i.e. $V_A(e_D, 0) = V_B(e_E, I)$. (See appendix equation A4).

The above boundary conditions yield the following solution for $V_A(e,0)$:

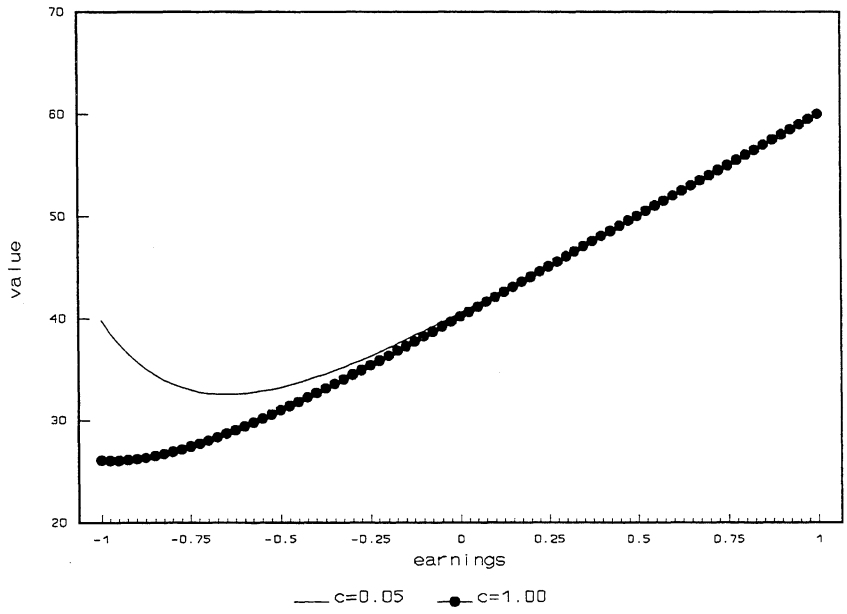
$$V_A(e,0) = \frac{\lambda}{r^2} + \frac{e}{r} + \left\{ \frac{\left[\frac{(e_E - e_D)}{r} + B_1 \exp(\beta_1 e_E) + B_2 \exp(\beta_2 e_E) \right]}{\exp(\beta_2 e_D)} \right\} \exp(\beta_2 e). \quad (16)$$

As above, the solution consists of two parts. The first part is the same as in the case of unlimited liability. The second part is considerably more complicated.[9]

The numerical examples help to illustrate the properties of the solution. The following parameter values are used unless otherwise stated: $\lambda = 0.1$, $r = 0.05$, $\sigma = 0.25$, $e_D = -1.0$, $e_E = 0.0$ and $e_L = 0.5$.

Figure 1 shows V(e, 0) for c = 0.05 and c = 1.0. The most striking feature in the case where c = 0.05 is that value of the bank does not react monotonically to changes in earnings. At certain earnings levels the decrease in earnings increases the value of the bank. As the earnings decrease the probability of the hitting the lower boundary increases. In the same time a low value of c implies that the public sector does not price its subsidy flow at the market value.[10] Thus at certain earnings levels decreases in earnings are more than offset by increase in the expected value of bank support. This is one example of the moral hazard problem introduced by mispriced bank support.

Figure 1. **The value of a bank before intervention**



[9] We assume that the e_D, e_U and c are chosen so that the shareholders do not have an incentive to close the bank. Thus we assume that the the option to abandon the bank has zero value. Correspondingly, we assume that V(e,0) and V(e,I) > 0 for all feasible values of e (limited liability).

[10] In principle one can estimate the amount of subsidy by calculating the difference between V(e,I) or V(e,0) and V(e) i.e. the values with and without bank support.

The Norwegian commission on the banking crisis, which was appointed to asses the extent and causes of the banking crisis, discusses on these issues in its report, NOU (1992, p. 36). There was a clear increase in commercial banks' provisions for losses on loans and guarantees in the second half of 1991. The commission suspects that the increases in provisions can be partly explained by the change in the banks' policy. As it became more apparent that banks would become entirely dependent on government capital injections, there was no longer an incentive to maintain a low level of provisions om order to achieve higher earnings.[11] In the Commission's view, however, the main reason for the change in policy was intensified efforts to assess problem assets as the banking crisis become evident.

Figure 2 shows the reaction of bank value to changes in σ, with c = 0.05 and the other parameters as defined above. The lines two graphs give the share values for σ = 0.4 and 0.2. If the stated policy is implemented, the shareholders may have an incentive to lower the expected earnings and increase the volatility. This is just another characterization of the moral hazard problem: shareholders may be inclined to take more risk than otherwise.

Figure 2. **The value of a bank and the volatility of earnings**

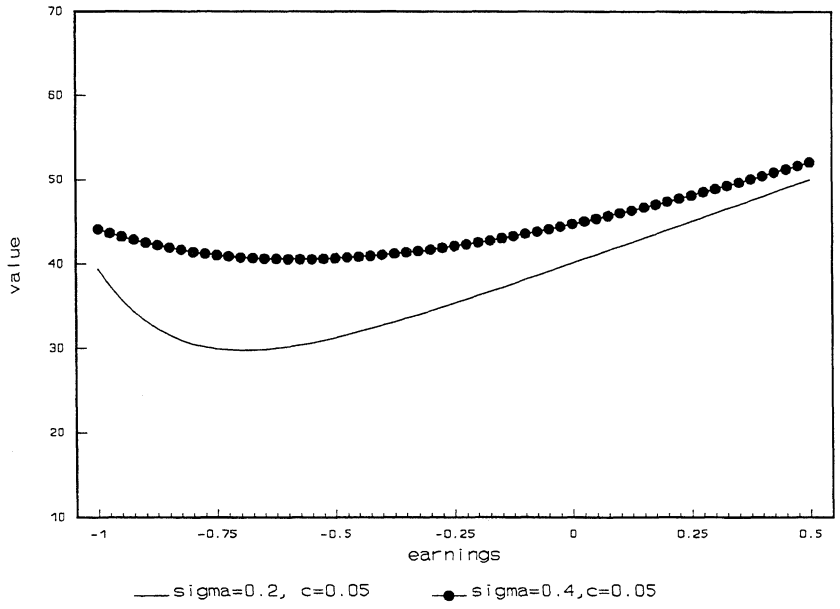


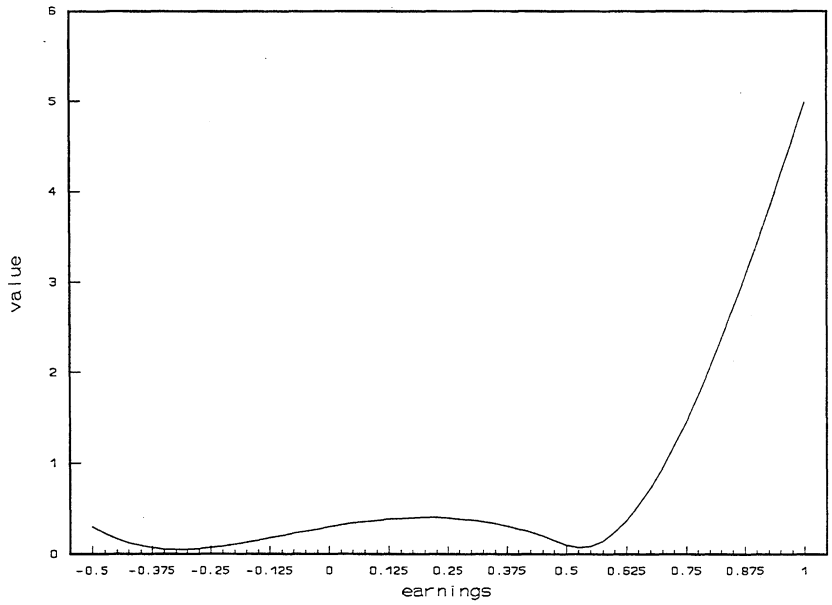
Figure 3 shows V(e, I) i.e. the value of the bank after intervention has occurred. The parameter values are as above with the exception that c = 2.8 and e_D = −0.5. The later parameter values are chosen to illustrate the possibility of rather twisted reactions to changes in earnings.

The value of a bank can react very differently to a change in the earnings depending on the earnings level. Note that value reacts differently to changes in earnings depending on whether the earnings are to the left or right of e_L. This is because to the right of e_L shareholders are charged a fixed cost, c. The value of

[11] A similar change in policy can be found regarding the Savings Bank of Finland. The credit losses increased dramatically after the individual banks were merged to the single bank and the government became the majority owner in the bank.

the bank increases monotonically as earnings increase on the right side of the e_L.

Figure 3. **The value of a bank after intervention**



This example illustrates that intervention by the public sector can disturb shareholders' incentives in two ways. First, before the intervention the shareholder may have an incentive to move the earnings to the lower boundary, which triggers intervention. Secondly, after the intervention shareholders may have an incentive not to increase earnings to the level where they have to pay the fee to the public sector (i.e. repay the government support).

In summary, the moral hazard problems can arise both before and after intervention. However, it seems likely that one should expect moral hazard problems to be more severe before intervention than after intervention. Here the moral hazard problem after intervention relies on the assumption of a specific financial contract due to the intervention. The example is merely a demonstration of the possible twisted reactions triggered by public policy.

5.2 Modelling the uncertainty of the future banking policy regime

Above we assumed that the public sector would intervene with certainty if the earnings level hits the lower boundary. In many countries there is no explicit policy of government support of banks in financial distress. Investors are uncertain about future banking policy. This was evident, for example, in Finland during the first years of the banking crisis. There was considerable discussion in the press of whether or not Finland would follow the Norwegian approach, i.e. nullify the original share capital. The authorities also participated in that discussion. In this section I analyze this uncertainty.

As above, I assume that there is a lower limit for e(t). Whenever e(t) reaches the limit, the authorities intervene. I assume that the authorities have

two alternatives. First, they can force the bank into financial reorganization and nullify the initial share capital, implying that e_D is a absorbing barrier as in section 2.1.[12] The difference here compared to section 4 is that now the authorities choose the level of e_D, not the shareholders. The other alternative is that the authorities intervene by moving e(t) to e_E. This corresponds to the case analyzed above. The shareholders do not know ex ante what the banking policy is. Let p denote the probability that banking policy is such that the authorities move e(t) to e_E. The probability that e_D turns out to be an absorbing barrier is thus 1−p.

The above considerations lead to the following boundary condition:

$$V_A(e_D,0,p) = pV_B(e_E,I,p) + (1-p)V(e_D,I,0) \tag{17}$$

where in V(..,..,..) the first argument refers to the earnings level, the second to whether or not intervention has occurred and the last to the probability of the lower boundary not being an absorbing barrier. Thus $V_A(e_D, 0, p)$ denotes the value of the bank at earnings level e_D, when intervention has not occurred and the probability that the lower boundary is not an absorbing barrier is p. Correspondingly, $V_B(e_E, I, p)$ denotes the value when intervention has occurred and the public authority moves e(t) to e_E. I require $V(e_D, I, 0)$ to be zero.

The second value-matching condition is:

$$V_B(e_D,I,p) = pV_B(e_E,I,p) + (1-p)V(e_D,I,0). \tag{18}$$

Furthermore, I use the familiar value-matching and smooth-pasting conditions at e_L: $V_B(e_L, I, p) = V_C(e_L, I, p)$ and $V_B'(e_L, I, p) = V_C'(e_L, I, p)$.

The value of the bank can be written as

$$V_A(e,0,p) = \frac{\lambda}{r^2} + \frac{e}{r} + \left[\frac{(p-1)\lambda}{r^2} + \frac{(pe_E - e_D)}{r} + pB_1\exp(\beta_1 e_E) + pB_2\exp(\beta_2 e_E)\right] \exp(\beta_2 e_D)^{-1}\exp(\beta_2 e), \tag{19}$$

where

$$B_1 = \frac{-c\beta_2}{(r(\beta_1 - \beta_2)\mathrm{Exp}(\beta_1 e_L))} \quad \text{and}$$

[12] In Norway the parliament adopted legislative amendments in November 1991 which gave the government the right to write down the old share capital against losses disclosed in the audited interim accounts in certain circumstances. In other words, authorities were given the right to intervene against the will of the orginal share holders. This right was used in the case of Cristiania and Fokus banks.

$$B_2 = [p\,Exp(\beta_2 e_E) - Exp(\beta_2 e_D)]^{-1}\left[\frac{(e_D - pe_E)}{r} + \frac{\lambda(1-p)}{r^2} + \left(\frac{c\beta_2}{r(\beta_1 - \beta_2)}\right)\right.$$

$$\left.*(Exp(\beta_1 e_D - \beta_1 e_L) - pExp(\beta_1 e_E - \beta_1 e_L))\right].$$

If p = 1, equation (19) collapses to equation (16). If p = 0, equation (19) collapses to equation (11).

Figure 4 shows the value of a bank when p = 0.25 and 0.75. c is 0.5. Otherwise the parameter values are the same as in figure 1. It is evident that the lower the p, the lower the value of the bank. Note also that by increasing uncertainty authorities can correct some of the disturbed incentives shareholders may have. That is because the higher the probability of a non-intervention regime, the lower the expected value of bank support (due to intervention) to the shareholders.

The policy implication of the above analysis is that the authorities should keep some uncertainty on the future policy (assuming that bank support is undervalued).[13] If there is no undervaluation of the bank support (and the shareholders know it), there is also no need for uncertainty.

Figure 4. **The value of the bank under uncertainty over future banking policy**

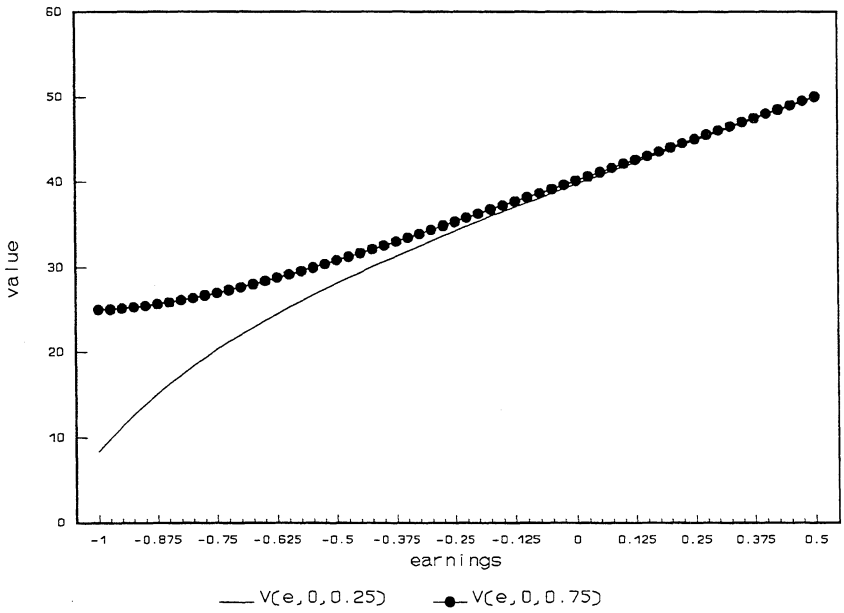


Figure 4 facilates an analysis of the impact of the policy announcements, which change the expectations as to future banking policy regimes.

An announcement may concern, for example, how the public sector will support banks in funding themselves in the market. It is assumed that this decreases the perceived probability that the lower boundary is an absorbing one. This implies a lower value for p, which in turn causes the value of the bank to

[13] Note, however, that there are typically other considerations that argue that uncertainty should be lowered.

move from the lower curve to the upper curve in figure 4. The change in p generates the jump in the bank's value if the earnings are low enough. The example illustrates that the changes in perceived banking policy regime can have dramatic effects on the value of the bank.

Above I have discussed the possible moral hazard problems raised by mispriced bank support. However, very little has been said so far about incentives faced by the government. This is done next.

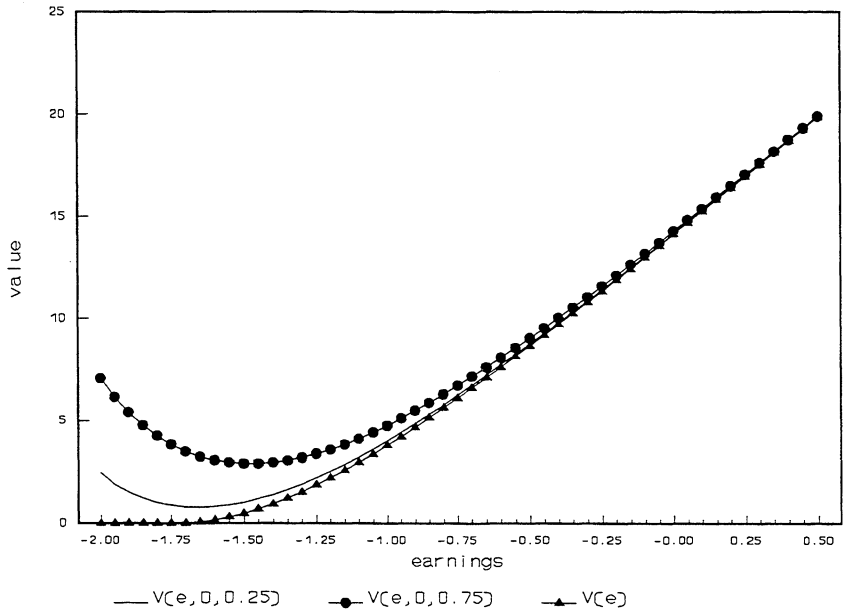
Figure 5 shows the value of the bank for three different cases. The parameter values used are the following: $\lambda = 0.1$, $r = 0.085$, $\sigma = 0.40$, $e_D = -2.0$, $e_E = 0.0$ and $e_L = 1.0$ and $c = 1.0$. V(e) gives the value of the bank without government intervention. The share-holders close the bank at e_d^*, which is -1.72. V(e,0,0.25) denotes the value of the bank with uncertain intervention and $p = 0.25$. V(e,0,0.75) corresponds to the case where $p = 0.75$.

The 25 % probability of (underpriced) government support ensures that shareholders have an incentives to invest new capital in the bank at earnings levels where they otherwise would have already closed the bank. Recall that negative earnings imply capital injections. This means that by keeping up hope of bank support the goverment can get more capital from the orginal shareholders.

The above examples imply that the result of underpriced bank support can have ambigious effects. First, the shareholders may have an incentive to decrease earnings. On the other hand, by promising (possible) underpriced bank support the government can increase shareholders' capital injections into the bank.

Finally, note that in above example the incentive problems are associated with the public sector. The government has an incentive to cheat shareholders by giving the impression that the bank's share capital will not be nullified in the case of government intervention.

Figure 5. **The value of a bank with and without possible bank support**



6 Conclusions

During a banking crisis investors face at least two kinds of uncertainty concerning the value of a bank. First, how the bank will manage its affairs during the recession. Second, how the public sector will react to a banking crisis.

Nordic countries faced banking crises during the late 1980s and early 1990s. They provide differing examples of how public authorities react to a crisis. In Norway, all the major commercial banks' initial share capital was nullified. In Sweden and Finland, the approach has been different. In the later countries the aim has been to provide banks with support so that they can get through the recession.

This paper studies the value of a bank under different banking policy regimes. The value of a bank depends crucially on the banking policy regime, as the earnings and solvency ratio approach their lower boundaries. The results also show that uncertainty as to banking policy can have a major impact on the bank's share value dynamics. The model produces moral hazard problems: in some cases the shareholders are better off as earnings decrease. The results also indicate that in some cases the public sector should keep up a degree of uncertainty about it's future policy. A higher level of uncertainty can decrease the incentive problems.

However, a bank subsidy can also have positive effects on shareholders' incentives. The results show that the bank shareholders are more willing to inject new capital into bank if they know that the public sector will (possibly) subsize the bank in the case of financial distress. The model also implies that the government may have an incentive to cheat the bank shareholders in order to induce further capital injections from the shareholders.

Appendix

In the following I present the boundary conditions and corresponding equations used in sections 5.1 and 5.2.

$V_B(e_L, I) = V_C(e_L, I)$:

$$\frac{\lambda}{r^2} + \frac{e_L}{r} + B_1 \exp(\beta_1 e_L) + B_2 \exp(\beta_2 e_L) = \frac{\lambda}{r^2} + \frac{e_L}{r} + C_2 \exp(\beta_2 e_L) - \frac{c}{r}. \tag{A1}$$

$V_B'(e_L, I) = V_C'(e_L, I)$:

$$\frac{\lambda}{r^2} + \frac{e_D}{r} + B_1 \exp(\beta_1 e_D) + B_2 \exp(\beta_2 e_D) = \frac{\lambda}{r^2} + \frac{e_E}{r} + B_1 \exp(\beta_1 e_E) + B_2 \exp(\beta_2 e_E) \tag{A2}$$

$V(e_D, I) = V(e_E, I)$:

$$\frac{1}{r} + \beta_1 B_1 \exp(\beta_1 e_L) + \beta_2 B_2 \exp(\beta_2 e_L) = \frac{1}{r} + \beta_2 C_2 \exp(\beta_2 e_L). \tag{A3}$$

I assume that $e_E < e_L$.

$V(e_D, 0) = V(e_E, I)$:

$$\frac{\lambda}{r^2} + \frac{e_D}{r} + A_2 \exp(\beta_2 e_D) = \frac{\lambda}{r^2} + \frac{e_E}{r} + B_1 \exp(\beta_1 e_E) + B_2 \exp(\beta_2 e_E). \tag{A4}$$

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