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Leverage and Risk Taking under Moral Hazard

Christian Hott*

Abstract

This paper examines the impact of implicit guarantees and capital regulations on the behavior of a bank and on the expected losses for its depositors. I show that implicit guarantees increase the incentives of the bank to enhance leverage and/or risk taking and that this leads to higher expected losses for its depositors. To reduce the adverse effects of moral hazard, policy measures have to be taken. However, a simple leverage ratio is likely to increase expected losses further and risk adjusted capital requirements do not necessarily affect highly leveraged banks with very low risk assets. A combination of both requirements can be successful. Positive long-term effects can be achieved by a reduction of moral hazard and informational imperfections. However, it is difficult to achieve these reductions and potentially severe short-term effects have to be taken into account.

1 Introduction

About three decades ago Koehn and Santomero (1980, p. 1235) wrote:

“Recent large bank failures ..., coupled with an unstable economic environment, have rekindled the controversy over the adequacy of bank capital. There is, of course, an abundance of literature on both sides of the bank capital issue.”

These sentences apply also to the current crisis. Due to excessive leverage and risk taking, many financial institutions have suffered badly from the financial turmoil. There

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is still no agreement, however, on the effectiveness of tighter capital regulations in reducing risks for financial stability.

Reasons for excessive leverage and risk taking were bad risk management and poor information on some new products. In addition the current crisis, like many other crises in the past, has demonstrated that even though some smaller banks failed (e.g. IndyMac), systemically important banks are usually bailed out (an exception is maybe Lehman Brothers). This leads to concerns about the potential creation of moral hazard: A bank that is likely to be rescued under bad circumstances has an incentive to increase leverage and risk taking.

In addition, this crisis has demonstrated that capital requirements were not adequate to reduce the adverse effects of these market imperfections. This raises the question whether higher capital requirements have to be introduced. When asking for tighter regulation, however, one always has to keep in mind that a change in regulation will have an effect on the behavior of banks.¹ In fact it is possible that the change in behavior might totally abolish the intended positive effects of the regulation. Although capital regulations are introduced to reduce risks for financial stability, their actual effects can go both ways. Some increasing and some reducing them.²

One effect of higher capital requirements that reduces risks is that banks with more capital put more equity at risk and might therefore choose a less risky strategy. Following Rochet (1992) and Kim and Santomero (1988), for example, higher capital requirements can reduce the adverse effects of moral hazard. While Rochet finds that a simple leverage ratio can be sufficient, Kim and Santomero argue that a successful regulation has to be based on “optimal” risk weights.

Furlong and Keeley (1989) look at another effect that can lead to a positive relationship between risk and leverage. The authors develop a model where a bank maximizes the value of a deposit insurance. This value can be increased by increasing leverage or risk. Furlong and Keeley show that a restriction of leverage reduces the gain from higher risk taking. One reason for this result is, however, that the costs of the deposit insurance are assumed to be independent of the bank’s risk taking.

¹This is also pointed out in the famous Lucas (1976) critique and for example by Koehn and Santomero (1980).

²VanHoose (2007) provides a good overview on the existing theoretical literature on this issue. He also points out that the theoretical literature is sharply divided about the impact of tighter capital requirements on financial stability.

The disciplining effect of deposits is an important effect that leads to a negative relationship between leverage and risk taking. With higher capital levels a variation of risk has a lower impact on the refinancing costs of a bank and it might therefore choose a riskier strategy. This disciplining effect of deposits on the behavior of banks is demonstrated, for example, by Calomiris and Kahn (1991) and Ashcraft (2008). Koehn and Santomero (1980) also consider the disciplining effects of deposits and develop a model where banks decide on the riskiness of their portfolio. In this setting the authors demonstrate that it is possible that the default probability increases with tighter capital regulation. The main reason for this is that the bank reacts to tighter capital requirements by increasing risk. However, another reason for this result is that at that time, as in the model, bank regulation did not consider the risk taking of banks.³ In addition one has to be careful when judging regulation by looking at the default probability of banks (PD). Even though the PD increases with tighter capital requirements, the loss given default (LGD) can decrease. Therefore, it is possible that the regulation reduces expected losses ($EL=PD*LGD$).

In a dynamic framework Blum (1999) highlights two additional effects that can lead to higher risk taking of banks when capital requirements are tightened. Firstly, under tighter capital requirements a bank might want to increase its amount of capital by increasing its profits. To increase profits, however, the bank's investments have to be more risky. Secondly, tighter capital requirements lower expected profits of the bank and, therefore, the value of surviving.⁴ This might induce the bank to choose a more risky strategy. Like Koehn and Santomero (1980), however, Blum only looks at the PD of the bank and not at the EL.

The topic of this paper is the analysis of the success of different policy measures in reducing the adverse effects of moral hazard behavior on financial stability. Following the theoretical literature there are some important ingredients for a model to capture the relationship between capital requirements, risk taking and financial stability adequately. These ingredients are: Endogenous behavior of banks, disciplining effects of deposits and limited liability of banks. In addition, it is important to use expected

³This changed with the introduction of the Basel Capital Accord (Basel I) in 1988. Kahane (1977) also shows that, without an adequate consideration of the composition of the bank's balance sheet, a minimum capital requirement alone does not reduce the probability of default.

⁴In many studies the value of surviving is associated with the charter value of a bank. This is emphasized, for example, by Demsetz et. al (1996). This charter value can be influenced by the amount of capital as well as the risk taking of a bank. However, since this range of the literature is not directly linked to my analysis, I will not consider it in this paper.

losses rather than default probabilities as a measure for financial stability implications. To evaluate the impact of regulation not only simple leverage ratios have to be considered but also risk-based requirements. While other papers capture some of these ingredients, in this paper I develop a theoretical model of a bank and its depositors that incorporates all of them. This is also the main innovation of the paper.

The next section presents the benchmark model without any banking regulation. It is assumed that a monopolistic bank has limited liability but is disciplined by perfectly informed depositors. I show that expected losses for depositors can increase but also decrease with leverage. The rationale behind this is that there is a negative relationship between risk taking and the leverage of a bank. Expected losses can be zero if the leverage is high but the risk is zero and expected losses can be zero if the risk is very high and the leverage is one (no deposits). Between these two points there is a maximum of expected losses.

In section 3 I introduce moral hazard effects by assuming that there is a positive probability that the government will bailout the bank if it gets insolvent. I demonstrate that this assumption is equivalent to assuming that depositors underestimate the riskiness of a bank. As a result, for a given risk profile of the bank's assets, depositors are willing to provide a higher amount of deposits and finance a higher leverage of the bank. In other words, the disciplining effect of deposits is reduced and the bank increases leverage and/or risk taking. This leads to higher aggregated expected losses for depositors and the government.

In section 4 I evaluate the effects of different policy measures on the behavior of a bank and on financial stability. I show that neither a leverage ratio nor risk adjusted capital requirements do necessarily reduce expected losses. The optimal combination of both requirements, however, can be successful. In addition I point out that a reduction of moral hazard and imperfect information is difficult to achieve but would have positive long term effects. Section 5 examines the empirical relevance of the basic results and section 6 offers some concluding remarks.

2 The Benchmark Model

The basic setting of the following model is very similar to Calomiris and Kahn (1991). There are three assets and two sectors. The three assets are a safe asset (money), a risky asset (bonds) and deposits. There is an unregulated monopolistic bank that

exclusively invests in the bond market and finances its investment via its own capital and deposits. The second sector is formed by the depositors. Depositors decide on how much of their wealth they want to lend to the banking sector and how much they want to hold as money.

2.1 Basic Assumptions

2.1.1 Safe Asset

The supply of the safe asset is completely elastic and it pays zero interest rate. Therefore, the safe asset can be interpreted as money in a world without inflation.

2.1.2 Risky Asset

The supply of the risky asset is completely inelastic and equal to one. Time is discrete and in period t the price of the risky asset is P_t . As long as the asset does not default it pays a coupon of one in each period. However, in each period it defaults with probability π , where $0 < \pi < 1$, and the loss given default is 100%. Hence, the risky asset can be interpreted as a bond with infinite maturity and a recovery rate of zero. The expected return of the bond in the next period $[E(R_{t+1})]$ is:

$$E(R_{t+1}) = -\pi + (1 - \pi) \left[\frac{1 + E(P_{t+1})}{P_t} - 1 \right], \quad (1)$$

where $E(P_{t+1})$ is the expected bond price in $t + 1$.

2.1.3 Deposits

The bank can borrow from depositors. The maturity of deposits is one period and in t the interest rate is r_t . If the bank defaults, all its remaining assets are transferred to its depositors.

2.1.4 The Bank

The monopolistic bank is assumed to be risk neutral and to maximize its expected profits in the next period $[E(Y_{t+1})]$. I assume that the bank only invests in the bond market (risky asset). I further assume that the bank can reduce the default probability π of its portfolio by financial engineering. This financial engineering, however, creates

costs for the bank. The corresponding cost function is $k(\pi) > 0$, where $k(\pi \rightarrow 0) \rightarrow \infty$, $k' < 0$ and $k'' > 0$. This assures that the bank chooses a positive default probability.

To finance its investment the bank uses its own capital and deposits. In period t the amount of capital of the bank is C_t and the amount of its deposits is $(f_t - 1)C_t$. Hence, f_t is the leverage of the bank and $f_t C_t$ its total assets. In $t + 1$ the bank has to pay the interest rate r_t on its deposits. The expected return on its investment is given by equation (1). However, for $f_t > 1$ the bank gets insolvent if the asset defaults. In this case the return on equity would then be -1 and the bank would not bear all the losses. Therefore, expected profits of the bank in $t + 1$ are:

$$E(Y_{t+1}) = -\pi C_t + (1 - \pi) \left[f_t \left(\frac{1 + E(P_{t+1})}{P_t} - 1 \right) - (f_t - 1)r_t \right] C_t - k(\pi). \quad (2)$$

Since the bank acts as a monopolist, it considers the influence of its decisions on the interest rate (r_t). On the other hand, I assume that the bank does not consider its influence on the bond price (P_t). The strength of this influence depends on how high the market share of the bank is. For simplicity I assume the extreme case that the bank is the only investor in the bond market (although it does not consider the price effect of its decisions). Since I have assumed that the bank only invests in the bond, the value of the bond is equal to the value of the bank's total investment. Therefore, P_t is equal to the total assets of the bank:

$$P_t = f_t C_t. \quad (3)$$

I further assume that the entire profits of the bank are distributed to its equity holders. Since the bank makes either positive profits or defaults, its capital is either C or zero.

2.1.5 Depositors

Depositors are assumed to have constant relative risk aversion and, at least in this benchmark model, perfect information with regard to the default probability of the bank (π).⁵ In period t depositors have the amount I_t for investment purposes available. They invest the fraction ϕ_t ($0 \leq \phi_t \leq 1$) of this amount in deposits and the rest $(1 - \phi_t)$

⁵The second assumption is relaxed in section 3.

in the safe asset (money). If the bank is still solvent in $t + 1$ (probability: $1 - \pi$) the return for the depositor (R_{t+1}^D) is:

$$R_{t+1}^D = \phi_t(1 + r_t) + (1 - \phi_t) - 1 = \phi_t r_t \quad (4)$$

and if the bank defaults (probability: π) it is:

$$R_{t+1}^D = (1 - \phi_t) - 1 = -\phi_t. \quad (5)$$

By investing in deposits and money, depositors transform their investment (I_t) into $(1 + R_{t+1}^D)I_t$ in the next period. I assume that they maximize the expected utility from the resulting amount by adjusting the fraction ϕ_t :

$$\begin{aligned} \max_{\phi_t} E \left(U[(1 + R_{t+1}^D)I_t] \right) \quad & \text{where} \\ E \left(U[(1 + R_{t+1}^D)I_t] \right) &= E \left(\ln[(1 + R_{t+1}^D)I_t] \right) \\ &= \pi \ln [(1 - \phi_t)I_t] + (1 - \pi) \ln [(1 + \phi_t r_t)I_t]. \end{aligned}$$

Maximization leads to the following optimal investment fraction ϕ_t :

$$\phi_t = 1 - \pi \frac{1 + r_t}{r_t}. \quad (6)$$

Therefore, the supply of deposits is given by:

$$\phi_t I_t = \left[1 - \pi \frac{1 + r_t}{r_t} \right] I_t. \quad (7)$$

As we can see, the supply of deposits depends positively on the total investment amount of the depositors (I_t) and the interest rate (r_t) and negatively on the default probability (π).

I further assume that depositors use their entire profits from their investment for consumption. As a result, as long as the bank stays solvent, the amount I_t is constant (I).

2.2 The Relationship Between Leverage, Risk Taking, and Risk Premiums

Proposition 1:

For the monopolistic bank with perfectly informed depositors, there is a negative relationship between leverage (f) and asset risk (π).

Proof: See below.

Since I have assumed that the bank acts as a monopolist on the market for deposits, I also assume that it considers the effects of its decisions on the price on this market: the interest rate r_t . Following section 2.1.4, in period t the bank's demand for deposits is $(f_t - 1)C$ and following section 2.1.5 the supply is $\phi_t I$. In equilibrium the demand has to be equal to the supply and we get:

$$(f_t - 1)C = \phi_t I = \left[1 - \pi \frac{1 + r_t}{r_t} \right] I. \quad (8)$$

From this we can calculate the interest rate in dependence on the leverage of the bank:

$$r_t = \frac{\pi I}{(1 - \pi)I - (f_t - 1)C}. \quad (9)$$

Since the risk free interest rate is zero, r_t can also be interpreted as the risk premium the bank has to pay. Following equation (9) this risk premium depends positively on the risk taking (π) and the leverage (f_t) of the bank; which is a reasonable result.

Following section 2.1.4 the unregulated bank maximizes its expected income. Beside other factors, this expected income depends on the expected bond price in $t + 1$ ($E(P_{t+1})$). Since I have assumed that C_t and I_t are constant as long as the bond does not default and all exogenous factors (coupon of the bond = 1, default probability = π and risk free interest rate = 0) are constant, the bond price stays constant as well. Therefore, the expected non-default bond price in $t + 1$ is equal to the present bond price: $E(P_{t+1}) = P_t = P$. Hence, I can rewrite the expected profit equation (2) to:

$$E(Y_{t+1}) = -\pi C + (1 - \pi) \left[f_t \frac{1}{P} - (f_t - 1)r_t \right] C - k(\pi). \quad (10)$$

By replacing the interest rate r_t by equation (9) I get:

$$E(Y_{t+1}) = -\pi C + (1 - \pi) \left[f_t \frac{1}{P} - \frac{(f_t - 1)\pi I}{(1 - \pi)I - (f_t - 1)C} \right] C - k(\pi). \quad (11)$$

The profit maximizing leverage is given by:

$$f_t = 1 + \frac{I}{C} \left[1 - \pi - \sqrt{\pi(1 - \pi)P} \right]. \quad (12)$$

As we can see, this optimal leverage depends positively on the fraction I/C and negatively on the bond price (P) and the default probability (π).

Hence, proposition 1 is proven.

An implication of equation (12) is that the bank prefers to build up leverage if the depositors sector is relatively big, the risk is low and the bond price is low. In other words, the bank prefers a high leverage if deposits are cheap and investment opportunities have a high return. In addition, we can see that f_t is constant as long as the bond and, therefore, the bank does not default and we can write: $f_t = f$.

Proposition 2:

For the monopolistic bank with perfectly informed depositors, there is a negative relationship between leverage (f) and the risk premium it has to pay (r).

Proof: See below.

From equation (9) we know that the direct effect of leverage on the interest rate is positive. However, there is also an indirect effect via the risk taking (π). Following equation (12) leverage depends negatively on π . Therefore, higher leverage comes with lower risk taking and this has a negative effect on r_t . When we plug equation (12) into equation (9) we can see that the indirect effect is stronger and that the interest rate or risk premium, respectively, depends negatively on the leverage of the bank:

$$r = \frac{\pi}{\sqrt{\pi(1 - \pi)P}}. \quad (13)$$

Hence, proposition 2 is proven.

Equation (12) can also be used to calculate the equilibrium bond price. When we replace the leverage in equation (3) by equation (12) and solve for P we get:

$$P = C + (1 - \pi)I + \frac{\pi(1 - \pi)}{2}I^2 - (1 - \pi)I\sqrt{\frac{\pi}{1 - \pi}C + \pi I + \frac{\pi^2}{4}I^2}. \quad (14)$$

This equilibrium price depends negatively on the default probability (π). Therefore, the non-default return of the bond ($1/P$) increases with π . One can also show that the expected return on the bond $[(1 - \pi)/P]$ increases with π .

2.3 Financial Stability

There are many different possible objectives for the society with regard to the behavior of the bank. We can look, for example, at expected profits of the entire society, the utility of depositors or expected losses for depositors. With regard to financial stability expected losses for depositors seem to be the most relevant variable.⁶ Therefore, I focus on this objective. This is in line with the current capital regulation, which also focuses on expected losses.

Proposition 3:

For the monopolistic bank with perfectly informed depositors, there is a concave relationship between leverage (f) and expected losses for its depositors with a maximum expected loss between a leverage of one and the maximum leverage of $f = I/C + 1$.

Proof: See below.

Expected losses (EL) for depositors are equal to the default probability ($PD = \pi$) multiplied by the loss given default ($LGD = P - C$).⁷ Hence, we get:

⁶According to Hellmann et al. (2000) regulation aims to protect the economy from the costs of banking crisis. This is consistent with lowering expected losses for depositors (and the government, see section 3). Kahane (1977), on the other hand, assumes that regulation aims to minimize the probability of default, i.e. without regarding the corresponding loss-given-default (LGD). In my model a lower default probability is accompanied by a higher LGD. Therefore, this purpose of regulation would be an unrealistic assumption and would lead to an insufficient regulation.

⁷This LGD is equal to the value of the total assets (P) minus the capital (C) of the bank and, therefore, equal to the total debt of the bank.

$$EL = \pi(P - C) = \pi(f - 1)C. \quad (15)$$

As we can see, expected losses are zero if $f = 1$ and $\pi = 1/(C + 1)$ and if $f = I/C + 1$ and $\pi = 0$. In the relevant range (15) is a continuous function and following proposition 1 there is a negative relationship between f and π . Therefore, there has to be a maximum expected loss (EL) between $f = 1$ and $f = I/C + 1$.

Hence, proposition 3 is proven.

The relationship between the leverage of the bank and expected losses for its depositors is displayed in Figure 1. The parameter values are $a = 0.00001$, $C = 24$ and $I = 2000$. As we can see, expected losses are zero for $f = 1$ and almost zero for $f = f^{max} = I/C + 1 \approx 84$. With $f = 1$ expected losses are zero because the bank bears all the losses ($LGD = P - C = 0$). With $f \rightarrow f^{max}$ or $\phi \rightarrow 1$ expected losses are almost zero because the default probability is almost zero ($PD = \pi \rightarrow 0$). For a leverage between one and 84 expected losses are positive. The maximum EL is at a leverage of about seven.

[Insert Figure 1 about here.]

3 Moral Hazard

Moral hazard effects emerge if depositors expect that the government will bailout the bank in the case of an imminent insolvency. In this case depositors have a smaller incentive to monitor the bank and the bank has a smaller incentive to keep its default probability low. In this section I examine the effects of (implicit) government guarantees on the leverage and the risk taking of the unregulated bank.

3.1 Effects on the Behavior

3.1.1 Behavior of Depositors

In the following I assume that depositors know that with probability $0 < \beta < 1$ the government will bailout the bank if it gets insolvent. Hence, the probability that depositors will get the positive return ϕr is now:

$$\beta\pi + 1 - \pi = 1 - (1 - \beta)\pi > 1 - \pi. \quad (16)$$

Accordingly, the probability for the negative return $-\phi$ is now:

$$(1 - \beta)\pi = < \pi. \quad (17)$$

This setting is equivalent to assume that there is asymmetric or imperfect information on the default probability π . Suppose that depositors believe that with probability κ the default probability is not π but $(1 - \epsilon)\pi$. With $\beta = \epsilon\kappa$ this assumption leads to exactly the same result as the above moral hazard case. Hence, β can be interpreted as a measure of moral hazard and of informational imperfections.⁸

By replacing the actual default probability π in equation (7) by the “moral hazard” default probability $(1 - \beta)\pi$ we get the supply of deposits under moral hazard ($\phi'I$):

$$\phi'I = \left[1 - (1 - \beta)\pi \frac{1+r}{r} \right] I > \phi I. \quad (18)$$

Therefore, for a given default risk π and interest rate r , under moral hazard depositors are willing to supply more deposits than without moral hazard. This in turn implies that depositors demand a lower interest rate for a given supply of deposits and a given default risk. Equation (9) can be rewritten to:

$$r' = \frac{(1 - \beta)\pi I}{(1 - (1 - \beta)\pi)I - (f - 1)C} < r. \quad (19)$$

3.1.2 Behavior of the Bank

Proposition 4:

Under implicit government guarantees for a given leverage f of the unregulated monopolistic bank, the default probability is $1/(1 - \beta)$ times higher than without guarantees. However, the risk premium (r) the bank has to pay stays unchanged.

Proof: See below.

Given the new interest rate reaction function (19), expected profits $[E(Y'_{t+1})]$ of the bank are now:

⁸Note that with informational imperfections β can also get negative. If ϵ is negative β would also be negative and depositors would overestimate the default probability. However, in this paper I only consider the case of $\beta > 0$.

$$E(Y'_{t+1}) = -\pi C + (1 - \pi) \left[f \frac{1}{P} - \frac{(f - 1)(1 - \beta)\pi I}{(1 - (1 - \beta)\pi)I - (f - 1)C} \right] C - k(\pi). \quad (20)$$

The profit maximizing leverage under moral hazard (f') is given by:

$$f' = 1 + \frac{I}{C} \left[1 - (1 - \beta)\pi - \sqrt{(1 - \beta)\pi(1 - (1 - \beta)\pi)P} \right] > f. \quad (21)$$

Hence, moral hazard leads to a higher leverage and a higher investment in the risky asset.⁹ This leads of course to a higher bond price (P'):

$$P' = f'C > fC = P. \quad (22)$$

Following (21), the optimal leverage f' depends only on the moral hazard default rate $(1 - \beta)\pi$ and not on π directly. Therefore, for a given leverage f the true moral hazard default probability (π') is $1/(1 - \beta)$ times higher than the default probability without moral hazard. If we plug this default risk under moral hazard ($\pi' = \pi/(1 - \beta)$) into the interest rate equation (19) we can see that for a given leverage f the interest rate under moral hazard is identically with the interest rate without moral hazard: $r'(f) = r(f)$. However, with moral hazard the underlying risk is higher.

Hence, proposition 4 is proven.

3.2 Effects on Financial Stability

Proposition 5:

For a given leverage f of the unregulated monopolistic bank, under implicit government guarantees expected losses on its deposits are higher than without guarantees. However, the maximum expected loss under either implicit government guarantees or without them is obtained at the same level of leverage.

Proof: See below.

⁹The effect that moral hazard increases asset prices is also demonstrated by Krugman (1998). He shows that because of implicit government guarantees banks tend to invest more into risky assets and, therefore, they are driving up prices.

Under (implicit) state guarantees expected direct losses for depositors are reduced because with some probability the government will pay in the case of a default. However, depositors are still affected indirectly because the government has to finance the bailout via taxes. Therefore, we have to look at the aggregated expected losses (EL') for depositors and the government. Under moral hazard we get:

$$EL' = \pi'(P - C) = \frac{\pi}{1 - \beta}(f - 1)C \geq EL. \quad (23)$$

Like in the case without moral hazard expected losses are zero if the leverage is one and they are going towards zero if the leverage reaches its maximum and the risk is going towards zero. For an intermediate leverage, expected losses under moral hazard (EL') are always higher than the non-moral hazard expected losses (EL). The reason for this is that following proposition 4 for a given leverage f the moral hazard default rate is $1/(1 - \beta)$ times higher than the default rate without moral hazard. Accordingly, for a given leverage f we get: $EL' = EL/(1 - \beta)$. Therefore, expected losses under moral hazard reach their maximum at the same leverage as the expected losses without moral hazard.

Hence, proposition 5 is proven.

The impact of moral hazard on expected losses and expected profits is displayed in Figure 2.¹⁰ As we can see, for a leverage between one and f^{max} moral hazard leads to an increase in expected losses.

[Insert Figure 2 about here.]

4 Policy Evaluation

As we have seen in section 3, moral hazard and imperfect information lead to market imperfections and higher expected losses for depositors (and the government). Following equation (23) expected losses under moral hazard are given by:

$$EL' = \frac{\pi}{1 - \beta}(f - 1)C.$$

¹⁰The parameter values are $a = 0.00001$, $C = 24$, $I = 2000$ and $\beta = 0.5$

Given this expected-loss equation one can think of several ways to reduce or limit expected losses: We can reduce leverage (f), risk (π) and the moral hazard parameter β . In the following I examine the effects of different policies.

4.1 Leverage Ratio

An obvious way to deal with moral hazard is to limit leverage by introducing a leverage ratio:

$$f \leq \bar{f}, \quad (24)$$

where \bar{f} is the regulatory maximum leverage. If \bar{f} is small enough it would reduce the leverage of the bank. However, since risk taking is not regulated, following proposition 1 the reduction in leverage would lead to higher risk taking (higher π). As a result, if \bar{f} is higher than the leverage that leads to the maximum expected losses (f^*) a binding leverage ratio would increase expected losses instead of decreasing them. Even if \bar{f} is lower than f^* expected losses are not necessarily reduced. When we look at the example in Figure 2, a reduction of the leverage from 20 to $\bar{f} = 4$ ($f^* = 6.8$) would increase expected losses. Only if the unregulated leverage would be lower than f^* as well, a reduction of expected losses by a binding leverage ratio would be certain. However, if f^* is unknown, to be sure that a leverage ratio does not increase expected losses, one would have to set the maximum leverage at one. But then the bank would not have any deposits and would therefore not be a bank anymore.

4.2 Risk Adjusted Capital Requirements

Because of the adverse effects of a pure leverage ratio on risk taking, Basel I and especially Basel II introduced risk adjusted capital requirements. To transform this into my model world, I assume that the capital of the bank (C) has to be higher than its total assets (P) multiplied by the default probability (π) and divided by a constant (ρ).¹¹ Therefore, we get:

$$C \geq \frac{1}{\rho} \pi P$$

¹¹Therefore, the capital has to cover a kind of Value at Risk of the Assets.

$$\Rightarrow f \leq \rho \frac{1}{\pi}. \quad (25)$$

Hence, the maximum leverage depends negatively on the default probability. From this we can calculate expected losses under risk adjusted capital requirements (EL^{ra}):

$$EL^{ra} \leq \pi(f - 1)C = \left(\rho - \frac{\rho}{f}\right)C. \quad (26)$$

As we can see, with binding risk adjusted capital requirements expected losses depend positively on the leverage and the upper limit (for $f \rightarrow \infty$) of the expected losses is given by ρC . However, following proposition 3 for an unregulated bank there is a concave relationship between leverage and expected losses. This means that from a certain leverage on depositors demand a lower default probability than the risk adjusted capital requirements. Hence, for a bank with a high leverage the requirements are not binding. For such a bank the disciplining effect of the high deposits is stronger than the capital requirements. Hence, for banks with very high leverage and low risk the introduction of risk adjusted capital requirements does not reduce the adverse effects of moral hazard.

Figure 3 displays expected losses in the benchmark case (EL), under moral hazard (EL') and with risk adjusted capital requirements (EL^{ra}). The parameter values are: $C = 25$, $I = 2000$, $\beta = 0.5$ and $\rho = 0.04$. As we can see, for a low leverage the risk adjusted capital requirements bring the expected losses down, closer to the benchmark expected losses. With increasing leverage expected losses go toward their maximum of one. However, for banks with a leverage of more than 23, the risk adjusted capital requirements are not binding.

[Insert Figure 3 about here.]

Another problem with risk adjusted capital requirements is that it is difficult for authorities to assess the risk (π) correctly. If they underestimate the risk expected losses would be much higher than intended.

4.3 Risk Adjusted Capital Requirements plus Leverage Ratio

As mentioned in the previous subsection, there are two problems with risk adjusted capital requirements: Firstly, it is difficult to assess the riskiness of banks' balance

sheets correctly and, secondly, the risk adjusted capital requirements are not binding for banks with a very high leverage.

As demonstrated by the current crisis, risks on the balance sheets of banks were substantially underestimated and capital requirements were therefore too low. One way of dealing with this is to increase capital requirements by increasing ρ . However, as demonstrated in section 4.2, this does not necessarily affect banks with very high leverage. A way to address this problem is to introduce a leverage ratio in addition to the risk adjusted capital requirements. Then the minimum of both requirements would be binding:

$$f \leq \min \left[\rho \frac{1}{\pi}; \bar{f} \right]. \quad (27)$$

The introduction of a leverage ratio as a compliment to the risk adjusted capital requirements could force the bank to adjust its leverage and its risk taking in a way that the risk adjusted capital requirements become binding. When we look at Figure 3, however, we can see that this might nevertheless increase expected losses. For example, the expected losses under moral hazard (EL') at a leverage of 40 are lower than the expected losses under risk adjusted capital requirements (EL^{ra}) at a leverage of 20.¹²

To avoid this effect the parameter ρ of the risk weighted capital requirements has to be increased until they become binding. In addition to this, a leverage ratio has to be introduced which reduces the leverage of the bank. Since EL^{ra} depends positively on the leverage f , this would reduce the expected losses. Figure 4 demonstrates the effects of this policy.

[Insert Figure 4 about here.]

A problem with this kind of regulation is that the capital requirements might have to be increased very strongly. It is not clear, however, if a very strong increase of the requirements would be politically enforceable and if it would be economically desirable.

¹²Blum (2008) also looks at a combination of a risk-sensitive requirements and a leverage ratio and examines the resulting impact on financial stability. However, the author abstracts from any disciplining effects of deposits. Therefore, Blum concludes that this combination is successful, independent of the initial leverage of the bank.

4.4 Influencing β

The main reason for the need of regulations is that moral hazard and imperfect information lead to market imperfections. In the previous subsections I have evaluated different policies that aim to reduce market imperfections by affecting their symptoms: excess leverage and risk taking. Another way, however, would be to restrain the causes of the market imperfections: the perceived likelihood of a bailout and the uncertainty with regard to the riskiness of the bank. The reduction of either of these causes would lead to reduction of β and, according to equation (23), to lower expected losses (EL') for the depositors and the government.

One problem is that the reduction of β is very difficult. This is especially true for the reduction of the perceived likelihood of a bailout if the bank is systemically important. Another problem with a reduction of β are its implied short term effects. As the failure of Lehman Brothers has demonstrated, a sudden drop in the perceived likelihood of a bailout could have severe effects on the entire financial sector.¹³ Although crises times might be times when the reduction of β is comparatively easy, these are also times when it has to be avoided the most.

The reduction of the uncertainty with regard to the riskiness of the bank is also a very difficult task. But a higher transparency through better and more standardized reporting or the forbiddance to hold assets that are difficult to value, would clearly reduce uncertainty.

5 Empirical Relevance

In this section I examine the empirical relevance of the basic results of my model.

5.1 Leverage and Risk Taking

A very important result of my model is that expected losses for depositors decreases with the leverage of the bank. Therefore, we should observe a negative relationship between the market view of expected losses and the leverage of a bank. Figure 5 displays the relationship between the leverage and the senior 5 year CDS prices (as a measure of the risk premium a bank has to pay for its debt) of 26 international big banks between 2004 and 2007. A linear regression indicates a negative relationship

¹³See section 5.3.

between the risk premium and the leverage of a bank. This is in line with my model but also with results of other studies like Calomiris and Kahn (1991).¹⁴

[Insert Figure 5 about here.]

5.2 Non-Binding Capital Requirements

Following section 4.2 risk adjusted capital requirements a la Basel I or II are not binding for banks with a very high leverage. If this result is of any empirical relevance, we should observe something in the relationship between the leverage of a bank and its risk weighted leverage according to the BIS rules. Figure 6 displays this relationship for the fifty largest European and US banks in 2006.¹⁵ As we can see, for a low leverage the risk adjusted leverage seems to increase with the actual leverage. For a higher leverage, however, the relationship seems to be reversed: The risk adjusted leverage decreases with the actual leverage. This implies that in this region of leverage the risk (π) decreases more with increasing leverage (f) than required by the BIS rules. This finding is in line with the results of my model. From a certain leverage on the market disciplines more than the capital requirements.

[Insert Figure 6 about here.]

5.3 Shocks to β

The sub-prime crisis is a good opportunity to examine the effects of shocks to the parameter β , the moral-hazard and informational-imperfection parameter. Before the onset of the crisis the general opinion was that risks at banks are rather low and that the likelihood of a bailout in the case of an imminent insolvency is high. In other words, before the crisis β was very high. From theory we would expect therefore low risk premiums for banks (r), high leverage (f) and high asset prices (P).

In July 2007, however, the market became aware of the problems in the sub-prime/housing market and their potential impact on banks. The first phase of the crisis, when the extent of the exposures of the banks was slowly revealed, lasted until the end of the

¹⁴Using annual data for large, publicly traded US bank holding companies between 1992 and 2006, Berger et al. (2008) find empirical evidence that the target capital level of a bank depends positive on its risk taking.

¹⁵According to The Banker (2007).

first quarter of 2008. In this phase, therefore, the parameter β gradually declined, risk premiums (r) increased and banks' profits fell. Deleveraging was a much slower process, but some banks managed to get capital injections (mainly from sovereign wealth funds) and to reduce their total assets.

On 14 March 2008 the rather small investment bank Bear Stearns was rescued. As a result of this, in the eyes of the market the likelihood of a bailout for banks increased. This had a positive effect on the moral hazard parameter β and risk premiums (r) decreased again.

On 14 September 2008 Lehman Brothers was not rescued and filed for chapter 11 bankruptcy protection. This came rather unexpectedly and led to a sudden drop of the perceived likelihood of a bailout and β decreased. As a result, risk premiums (r) suddenly jumped up.

In the following, governments around the globe took actions aimed at decreasing risk premiums again. Among other things they tried to increase β by improving deposit guarantees or by providing guarantees for interbank lending.

Figure 7 shows the development of the average CDS prices of 13 international big banks. These CDS prices reflect the theoretical effects of the different shocks on β and therefore on the risk premium r . At the end of the sample CDS prices are still substantially above the starting point before the crisis. This is one reason why banks are still in the phase of deleveraging.

[Insert Figure 7 about here.]

6 Conclusions

In this paper I have examined the effects of implicit government guarantees and capital regulation on the behavior of a bank and on expected losses for its depositors. In a benchmark model without moral hazard, informational imperfections and regulatory requirements, the risk taking of a bank depends negatively on its leverage. The reason for this is that the bank has to reduce risk in order to attract more affordable deposits from risk averse depositors. To get to a extremely high leverage the bank's assets have to be almost risk free and expected losses for the depositors would be almost zero. If, on the other hand, the bank takes very high risks, deposits become very expensive and the bank chooses to finance its investment solely by its own capital. As a result, expected losses are, again, zero. Hence, starting from a leverage of one, expected losses for its

depositors increase with leverage. However, from a certain leverage on the relationship is reversed.

The introduction of implicit guarantees does not change the basic relationship between leverage, risk taking and expected losses. However, with implicit guarantees a bank has to reduce its risk taking less to attract more deposits. As a result, for a given leverage, the bank takes a higher risk. This leads to higher expected losses for depositors.

Furthermore, I have discussed the impact of different policy measures that aim to reduce the adverse effects of moral hazard. As we have seen, a simple leverage ratio does not necessarily reduce expected losses for depositors. On the contrary it is very likely that the leverage ratio will increase them. With risk adjusted capital requirements expected losses of the depositors of a bank with a low leverage can be reduced. However, the requirements do not affect a highly leveraged bank with very low risk assets. In such a case risk adjusted requirements would not reduce the adverse effects of moral hazard. But in contrast to the simple leverage ratio, expected losses would not increase.

The combination of risk adjusted capital requirements and a leverage ratio reduces expected losses if the risk adjusted requirements would also be binding without a leverage ratio. For depositors of a highly leveraged bank that is not affected by risk adjusted requirements, this combination of regulatory measures can lead to higher expected losses. A way to avoid this is to increase the risk adjusted requirements until they become binding. In addition, a leverage ratio has to be introduced that is binding as well. This combination would lead to a reduction of expected losses. However, to get to this solution requires that the regulation applies only for a small number of banks or a very homogenous group of banks. Otherwise it would be very difficult to enforce a regulation that is binding for all banks. Positive long-term effects would have a reduction of moral hazard and informational imperfections. But it is difficult to achieve these reductions and they could involve adverse short-term effects.

There are mainly two shortcomings of the present paper. Firstly, the model treats the amount of capital of the bank as given and fixed. Therefore, the model does not capture the effects of an adjustment of the amount of capital on the profits of the bank and the expected losses for depositors. Secondly, because of the payout structure of its assets, the bank either survives or fails completely. Therefore, the leverage of the bank has no direct effect on its probability of default, which would be more realistic.

Nevertheless, I believe that my model is able to explain some very relevant aspects of bank behavior under implicit guarantees, imperfect information and various kinds of capital regulations.

References

- [1] **Ashcraft, Adam B. (2008)** Does the Market Discipline Banks? New Evidence from Regulatory Capital Mix. *Journal of Financial Intermediation*, Vol. 7, 543-561.
- [2] **Banker, The (2007)** *Top 1000 World Banks*. July 2007.
- [3] **Berger, Allen, Robert DeYoung, Mark Flannery, David Lee and Ozde Oztekin (2008)** How do Large Banking Organizations Manage Their Capital Ratios? *The Federal Reserve Bank of Kansas City Research Working Papers*, RWP 08-1.
- [4] **Blum, Juerg (1999)** Do Capital Adequacy Requirements Reduce Risks in Banking? *The Journal of Banking and Finance*, Vol. 23, 755-771.
- [5] **Blum, Juerg (2008)** Why Basel II May Need a Leverage Ratio Restriction. *The Journal of Banking and Finance*, Vol. 32, 1699-1707.
- [6] **Calomiris, Charles W. and Charles M. Kahn (1991)** The Role of Demandable Debt in Structuring Optimal Banking Arrangements. *The American Economic Review*, Vol. 81, No. 3, 497-513.
- [7] **Demsetz, Rebecca S., Marc R. S Maidenberg, and Philip E. Strahan (1996)** Banks with Something to Lose: The Disciplinary Role of Franchise Value. *FRBNY Economic Policy Review*, Vol. 2, No. 2, 1-14.
- [8] **Furlong, Fredeick T. and Michael C. Keeley (1989)** Capital Regulation and Bank Risk-Taking: A Note. *The Journal of Banking and Finance*, Vol. 13, 883-891.
- [9] **Gennotte, Gerard and David Pyle (1991)** Capital Controls and Bank Risk. *The Journal of Banking and Finance*, Vol. 15, 805-824.

- [10] **Hellmann, Thomas F., Kevin C. Murdock and Joseph E. Stiglitz (2000)** Liberalization, Moral Hazard in Banking, and Prudential Regulation: Are Capital Requirements Enough? *The American Economic Review*, Vol. 90, No. 1, 147-165.
- [11] **Kahane, Yehuda (1977)** Capital Adequacy and the Regulation of Financial Intermediaries. *The Journal of Banking and Finance*, Vol. 1, 207-218.
- [12] **Kim, Daesik and Anthony M. Santomero (1988)** Risk in Banking and Capital Regulation. *The Journal of Finance*, Vol. 43, No. 5, 1219-1233.
- [13] **Koehn, Michael and Anthony M. Santomero (1980)** Regulation of Bank Capital and Portfolio Risk. *The Journal of Finance*, Vol. 35, No. 3, 1235-1244.
- [14] **Krugman, Paul (1998)** *What Happened to Asia?* MIT Mimeo.
- [15] **Lucas, Robert (1976)** Econometric Policy Evaluation: A Critique. *Carnegie-Rochester Conference Series on Public Policy*, Vol 1, 1946.
- [16] **Rochet, Jean-Chales (1992)** Capital Requirements and the Behavior of Commercial Banks. *European Economic Review*, Vol. 36, 1137-1178.
- [17] **VanHoose, David (2007)** Theories of Bank Behavior under Capital Regulation. *The Journal of Banking and Finance*, Vol. 31, 3680-3697.

Figure 1: Expected losses for depositors (EL) in dependence on the leverage.

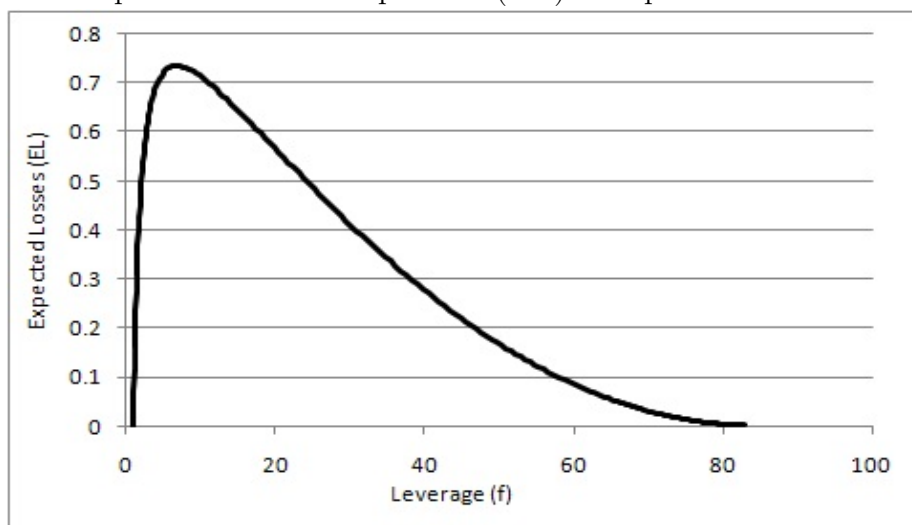


Figure 2: Expected losses under moral hazard (EL') and without moral hazard (EL) in dependence on the leverage.

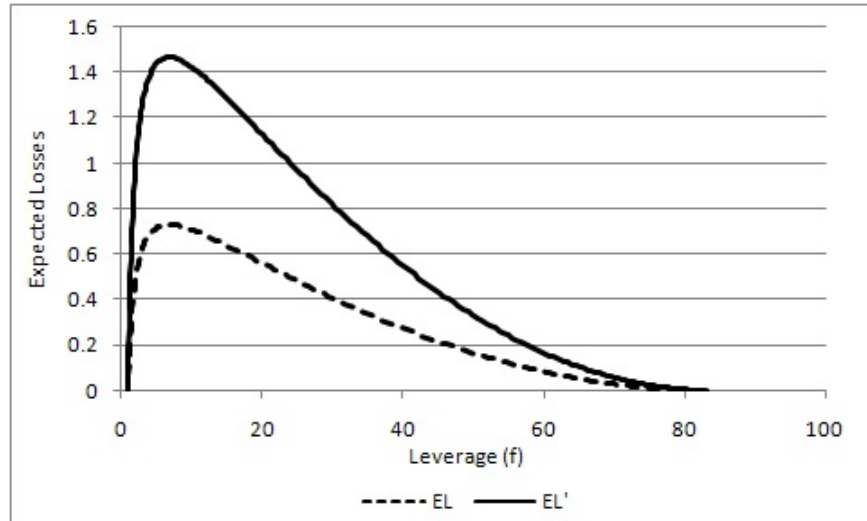


Figure 3: Expected losses in the benchmark case (EL), under moral hazard (EL') and with risk adjusted capital requirements (EL^{ra}) in dependence on the leverage.

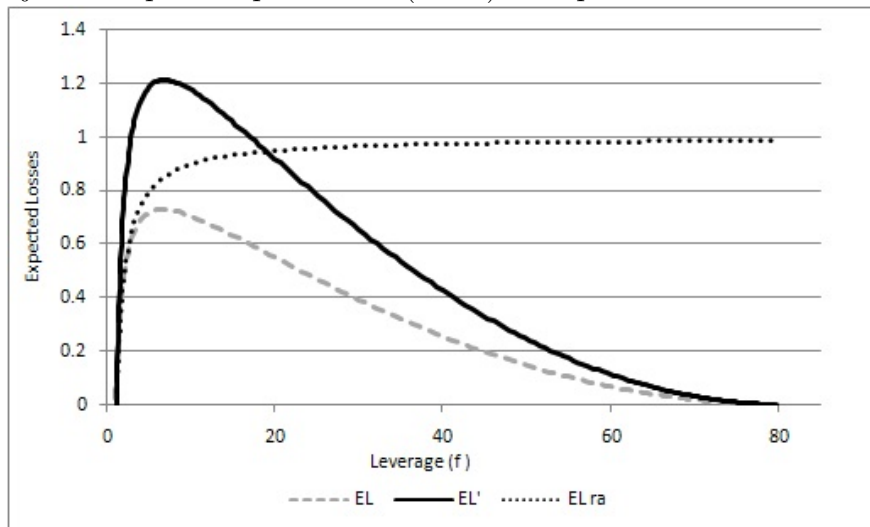


Figure 4: Expected losses in the benchmark case (EL), under moral hazard (EL') and with the old and new risk adjusted capital requirements (EL^{ra}) in dependence on the leverage.

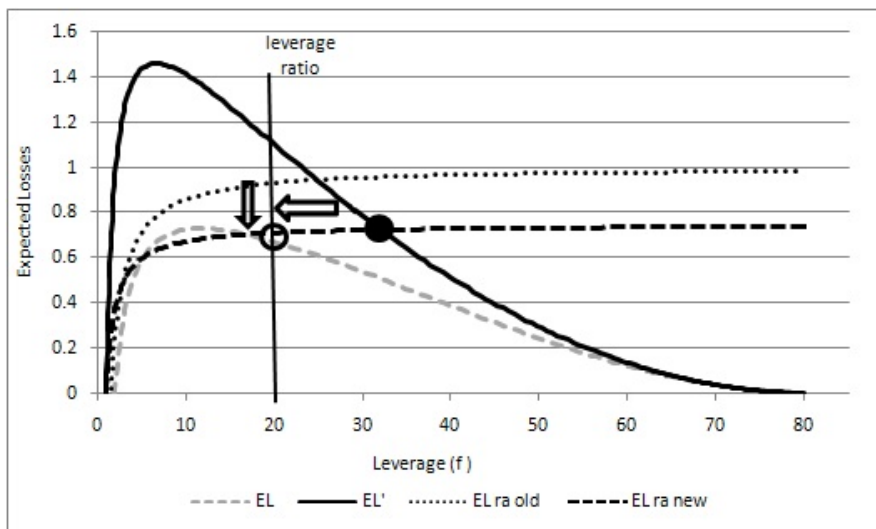


Figure 5: CDS prices of international banks (CDS) in dependence on the leverage and their linear trend (Linear). Source: The Banker and Datastream.

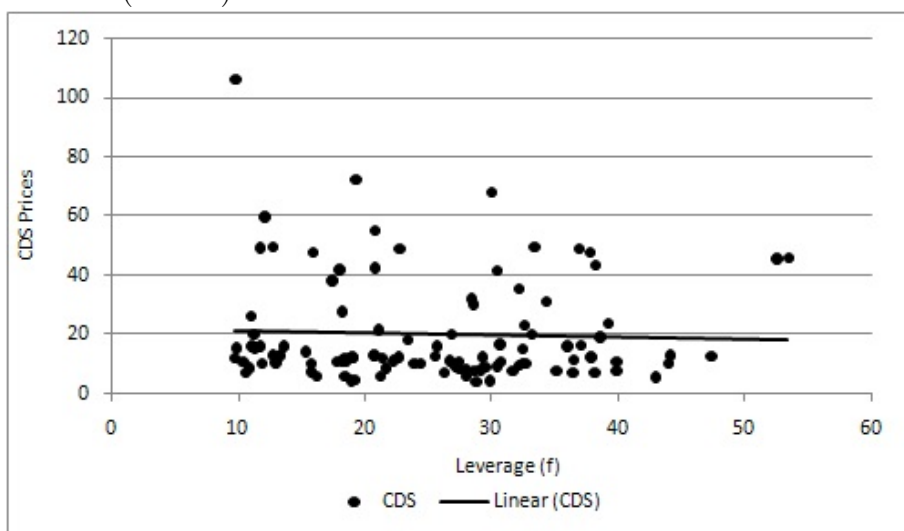


Figure 6: The risk adjusted leverage according to the BIS rules in dependence of the actual leverage and a quadratic trend (Poly). Source: The Banker.

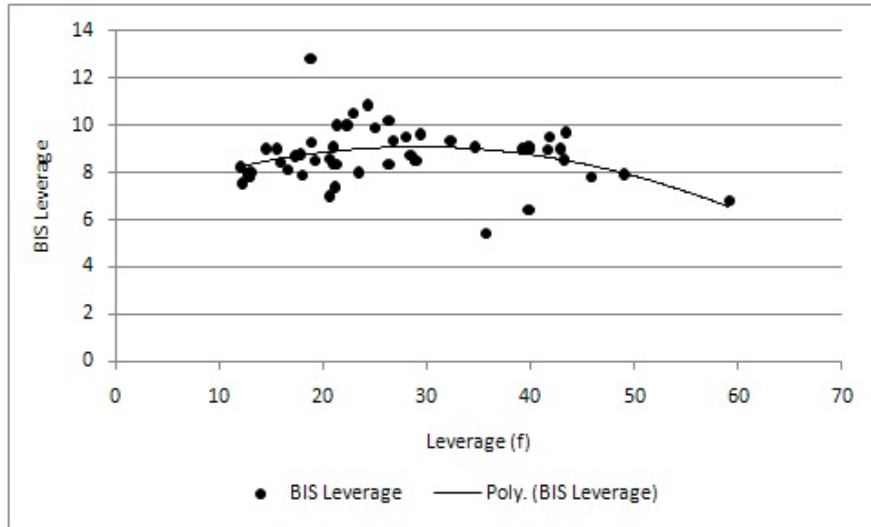


Figure 7: Development of the average CDS premiums of 13 international big banks during the sub-prime crisis. Source: Datastream.

