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Pricing Full Deposit Insurance in Germany amidst the Financial Crisis 2008-2010

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Abstract

This paper investigates the pricing of full deposit insurance in Germany in the context of its political promise by the German government. We implement the characteristics of the mutual guarantee framework of German banks and the specifics of the German deposit insurance system into a Monte Carlo model. The analysis suggests that banks have an incentive to increase their riskiness if they do not have to bear the fair value of the insurance costs of their deposits. On the other hand, the government should incentivise banks to reduce their size and become more specialized to achieve better diversification in the German banking landscape.

Keywords: Asset pricing, financial crisis, deposit insurance, mutual guarantee framework

1. Introduction

The financial crisis of 2008-2010 has shown an unprecedented surge in governmental interventions in the banking sector around the world. The size and interconnectedness of banks forced governments to devise rescue packages and measures to avoid a systemic meltdown of the financial system. The reason for governments to step in was that the banking system itself, due to a lack of trust, was no longer functioning smoothly as liquidity in the interbank market dried up. This liquidity crunch threatened to spill over to the real economy via credit markets. There are however several problems with governmental intervention. Firstly, insurance by the government induces moral hazard and can potentially increase the risk-taking behaviour that originally gave rise to the financial crisis. Furthermore, nationalized banks tend to work less efficiently in their operations and credit distribution as private banks. Lastly, the money tied up in the banking system increases government debt either explicitly or in an implicit way preventing the government to spend this money on its public obligations. The need for state intervention proofs that banks have not been operating with an appropriate attitude towards risk. Especially, banks that were coined "too big to fail" stand to benefit from an implicit state guarantee without bearing the cost of it. Thanks to this implicit guarantee, lenders grant favourable interest rate terms to them, shareholders are willing to pay higher prices for their equity and the probability of a bank run is reduced significantly. The reason for this special treatment by investors is that the liability insurance by the state induces a riskless bond to debt holders who would have asked for higher risk premiums in this market situation and reduces insolvency risk for shareholders. Without funding or repayment of these insurances by banks, further risk taking by financial institutions is encouraged and a repetition of the financial crisis becomes more likely. Moreover, the state's own financial position deteriorates by the amount taken to support financial institutions and it has to bear the costs with higher interest rates on its debt and a business climate of uncertainty that lowers investments. Thus, when the next financial crisis hits the economy, the state might not be able to cover the losses anymore.

In a free market environment, the state should not specify the amount of risk financial institutions take, but financial institutions should pay for the state insurance according to their risk exposure. Therefore, the implicit state guarantees for banks that have a systemic relevance should be made explicit by imposing a risk-adjusted deposit insurance premium. The assumption with deposit insurance is that only insured deposits are covered by the state guarantee and shareholders have to take the residual loss. Otherwise, market discipline suffers, because shareholders have the power to decide on the risk taking behaviour of financial institutions. This approach will reduce moral hazard problems and will keep the risk for depositors to a minimum. The setting of this study is in the context of the political promise of full deposit insurance in Germany from October 5th, 2008 and evaluates the value of this guarantee between January 2008 and May 2010 in quarterly steps. The foundation for the option-based estimation of deposit insurance was set with Merton (1977) and Merton (1978). The analysis of this study closely follows the article of De Giuli, Maggi, & Paris (2009) who consider a mutual guarantee framework like it exists in Germany. Prior studies received biased estimates of deposit insurance, because they neglect the effect of a mutual guarantee framework which is built to keep the government position sufficiently small. This paper extends the data series of De Giuli, Maggi, & Paris (2009) to the financial crisis data of 2008-2010 and adapts its features to the German system. Therefore, it covers not only a single point in time, like prior studies did, but shows the development of the guarantee value before and after the political promise and thereby allows to study the costs of this event. Since this study is set in a German context instead of the Italian one by De Giuli, Maggi, & Paris (2009), the applicability of the model to a larger set of countries is demonstrated.

Furthermore, it explicitly attaches an estimate to the political promises of the German government to insure all private deposits and outlines the effect public finances. Relevant policy parameters and asset correlation are scrutinized in a sensitivity analysis with respect to the level of asset volatility and correlations in downturn markets during the financial crisis. Thus, the question this analysis is going to answer is what the costs of full deposit insurance by the German government are to the public.

The remainder of the paper is organized as follows. Section 2 reviews the current literature and discusses the set up of the German deposit insurance system. Section 3 describes the data and estimates two parameters for the model. Section 4 explains the model for deposit insurance valuation and section 5 presents the model results. Section 6 applies a sensitivity analysis to the model. The final section concludes, mentions limitations and suggests further research.

2. Literature Review

The literature stream dealing with the valuation of loans and deposit insurance in an option-based framework relies on the initial works of Merton (1977) and the follow-up study Merton (1978). Merton (1977) applies the option formula of Black & Scholes (1973) to deposit insurance for financial institutions. He establishes the relationship between ordinary put options to deposit insurance by determining the isomorphic relationship between the payoff-structure of deposit insurance and a European put option. The author argues that the payoff of the loan guarantee is essentially the same as the payoff of a European put option with strike price equal to the nominal value of insured deposits and where the time to maturity equals the remaining time to the next audit date. Thus, deposit insurance is modelled as a put option on the market value of bank assets. Merton (1978) takes the idea to the next level by taking into consideration surveillance costs and models deposit insurance as an infinite-maturity put with random audit dates. The option pricing frameworks of Merton (1977) and Merton (1978) is however limited to banks where valuations of a bank's market value of assets, and asset volatility are available. As this data cannot be observed in the market, it has to be estimated based on observable market variables. Ronn & Verma (1986) illustrate how bank's market value and asset volatility can be estimated from the variance and market value of bank's equity together with the balance sheet values of nominal debt in an option-based framework. In their analysis, they differentiate between insured and other deposits. De Giuli, Maggi, & Paris (2009) extend the contingent-claim framework of Merton (1977) by taking into account the effect of an existing mutual guarantee framework among banks that significantly lowers the value of deposit insurance by a third party guarantee. The authors differentiate the option positions from the point of view of an insured bank, the long position with respect to the consortium, the long position with respect to the government and the short position with respect to the consortium by applying Monte Carlo simulation to a multi-asset framework. They analyze the effect of changes in asset volatility, asset correlation, debt-to-assets ratio, capital requirements and policy variables. This paper extends the literature by examining the impact of full deposit insurance in Germany on public finance in a longitudinal study from 2008 until 2010. To the best of the author's knowledge, this is the only study examining German deposit insurance that takes the effect of the mutual guarantee framework into account.

2.1. Background Deposit Insurance System in Germany

According to Garcia (1999) deposit insurance systems are in place because they "(1) protect small depositors; (2) elucidate the rules under which sound depository institutions operate and under which failed institutions will be closed or otherwise resolved; and, in doing so, (3)

help to stabilize the financial system by establishing an incentive structure that will encourage good banking practice". The adequate premium financial institutions should pay for this deposit insurance differs from country to country and is dependent upon the regulatory and institutional framework as well as the business environment in which financial institutions operate. Several authors have reviewed the most important structure and design features such as membership, administration, funding, coverage and pricing. Garcia (1999) examines actual practices around the world and compares it with a set of best practices adopted by the International Monetary Fund (IMF). Demirgüç-Kunt & Sobaci (2001), whose data is updated and extended by Demirgüç-Kunt, Karacaovali, & Laeven (2005), lists the features of deposit insurance systems in different countries. These articles describe the German deposit insurance system amongst others in great detail. The German banking market is dominated by universal banks that combine investment banking and retail banking. Their legal form classifies them as either private commercial banks, cooperative banks or public-sector banks. Following the union of savings banks and Landesbanks, the German market is led by private commercial banks, which account for close to 28.2% of balance sheet sum in the banking market in Germany (Association of German Banks, 2009). This paper focuses on the mutual guarantee system of private commercial banks in Germany as it includes all banks operating in Germany that are listed on stock exchanges.

The first deposit insurance system of commercial banks was established in 1966 and revised in 1969 by the Association of German Banks ("Bundesverband deutscher Banken") (Association of German Banks, 2010). The initial EU Directive on deposit insurance was transposed into German law in 1998 and was devised to harmonize deposit insurance within the European Union. Next to the voluntary deposit insurance scheme of commercial banks, the act made the membership in a statutory compensation scheme obligatory for all banks that want to operate in Germany. It established the statutory deposit guarantee scheme, the "Entschädigungseinrichtung deutscher Banken" (EdB). The EdB performs the tasks of the compensation scheme for the area of the private commercial banks and private building and loan associations. In the past, the EdB provided compensation up to a maximum of € 20,000 per depositor. The voluntary Deposit Protection Fund ("Einlagensicherungsfonds des Bundesverbandes deutscher Banken") of private commercial banks then only covered deposits to the extent that the EdB does not already secure these, (Association of German Banks, 2009). The recent financial crisis has brought about further changes in June 2009 when the EU Directive on Deposit insurance was extended to increase the minimum guarantee on deposits by the EdB to € 50,000 and remove the co-insurance obligation of depositors. The co-insurance obligation required depositors to cover the losses of bank failure with 10% of their deposits in order to entice depositors to make choices that are more cautious on where to deposit their funds. The next step is to increase the minimum guarantee to € 100,000 on 31st December 2010, when also the period it takes to refund depositors in case of bank failure is shortened to a maximum of 30 days. The history of statutory deposit insurance in Germany is summarised in Table 1:

Year	Coverage amount	Currency	Coinsurance
1966	10,000/20,000	DM	10%
1969	20,000	DM	10%
1998	20,000	EUR	10%
2009	50,000	EUR	0%
2010	100,000	EUR	0%

Table 1 - History of Deposit Insurance in Germany

For savings banks, state banks, state building societies and credit unions, an exemption exists that allows them not to participate in the statutory compensation scheme as long as their

respective deposit insurance association secures their liquidity and solvency. The difference to commercial banks is that their association secures the continuity of the whole institution whereas for private banks, only deposits are insured directly and the banks themselves can become insolvent. Garcia (1999) describes Germany as a country with an explicit deposit insurance system that relies on formal regulation, which specifies the main components of the deposit insurance system. The deposit insurance system for private banks covers deposits of private persons and small enterprises in national as well as in foreign currency, but no interbank deposits. Interbank deposits are not covered, because it can be expected that banks have the necessary experience and sophisticated business models to monitor other banks. An extension of coverage to interbank deposits would thus reduce market discipline as it keeps banks from mutual supervision. Demirgüç-Kunt, Karacaovali, & Laeven (2005) stated that the Deposit Protection Fund of private banks insures deposits of clients up to 30 percent of the relevant liable capital of the respective institution per depositor as stated in their last financial statement. This insurance covers term and saving deposits and registered savings certificates for all non-banking institutions but no bearer instruments. Insured deposits are for that matter virtually risk-free for almost all depositors as long as the mutual guarantee framework is fully funded by its members. To ensure proper financial support, the Deposit Protection Fund is funded by its members on a non-risk-adjusted basis with a yearly flat fee of 0.03% based on the value of insured deposits. The fee can be doubled in case of a crisis, but payment can also be discontinued if the administration of the Deposit insurance fund feels it is sufficiently covered. For such a system with pre-funding of deposit insurance, Demirgüç-Kunt & Kane (2002) point out the importance of a strong institutional environment, because these funds could literally be looted in countries with weak institutions. The true value of pre-funding is however not known to the public and cannot reliably be estimated by external parties, because the decision to discontinue payment requirements is not disclosed to the public. Thus, the main insurance is covered by the ex-post funding of the private banks that are required to contribute to the fund and refund depositors in case of bank failure if the ex-ante funding is not sufficient to cover all deposits affected by bank failure. Up to the writing of this paper, the Deposit Protect Fund has, to the extent of legal protection, wholly compensated depositors for all banks that failed since its inception (Association of German Banks, 2010).

On October 5th, 2008, the German government has given a political guarantee, which was extended in July 2009, by Chancellor Angela Merkel that no German saver would loose money if their bank failed. The guarantee however remains a political question because it was not specified how long this guarantee would remain in place and probably needs to be revised when the next government takes office.

Such an extensive guarantee on deposits protects depositors and stabilises the financial system, but brings about further problems as well. Garcia (1999) states that moral hazard can occur when the protection extended to depositors makes them less careful initially in the selection of their bank, and later deters them from moving their funds to a safer haven. In addition, shareholders and agents of the insured bank are no longer scrutinized by depositors and may therefore increase risk in their investments or decrease the amount of capital and liquid reserves, which might shelter them from adverse shocks. In addition, adverse selection becomes an issue when weaker banks opt in, knowing that they will not have to fund the system, while stronger institutions opt out, because they fear that they have to bear the burden if weaker institutions fail. The voluntary nature and the non-risk-adjusted premium of the Deposit Protection Fund encourage adverse selection. Once adverse selection has occurred, the financially strong banks will either leave the fund, or, if they are already outside of its protection, remain independent of the mutual guarantee system. This has a negative effect on

the remaining members, because they will have to pay higher premiums in case of bank failures. This vicious circle keeps on going until the system itself can no longer fund itself, collapses and may harm the banking system itself. Furthermore, agency problems may arise when the administration of the Deposit Protection Fund would either delay the resolution of an insolvent bank in order to safeguard the banking industry or bow down to political pressure when politicians force the administration to treat banks that support them personally with forbearance. Garcia (1999) coined the terms "regulatory capture" and "political capture" for these two types of agency problems in deposit insurance systems.

In order to resolve these problems the next section is going to discuss a model for the estimation of risk-adjusted premiums for the full deposit insurance of the German government as well as for the funding of the mutual guarantee system. To simplify the model, the protection by the EdB and the Deposit protection fund are considered as one mutual guarantee system and the amount already accumulated in the fund by pre-funding is ignored as its value is non-public and cannot reliably be estimated.

3. Data and settings

The statistics department of the German Central Bank (Bundesbank) provides the balance sheet data of private commercial German banks. The data has been downloaded from Bloomberg and converted to Euro. The reason for this is that virtually all depositors as well as the German government have a Euro investment perspective and will evaluate banks accordingly. The data is based on quarterly balance sheet publications by each bank. For missing data, linear interpolation was used. Statistical breaks have been eliminated. The figures are adjusted for removals or additions, mergers or liquidations of individual banks as well as reporting mistakes for which correction have been published later on. Banks that have been taken over by the German State are taken into consideration up to the point of their nationalization. Within the mutual guarantee framework of private commercial banks, there are 26 banks that are listed on a stock exchange and for which suitable market data is available. Data listed on Table 2 are retrieved from January 2007 to May 2010:

Names	Symbol
German Treasury Rate	r
Market value of equity	$E_i(t)$
Book value of equity	$BVE_i(t)$
Book value of covered deposits	$D_i(t)$
Book value of other liabilities	$P_i(t)$
Daily stock price	$S_i(t)$

Table 2 - Bloomberg retrieved data

The effect of the economic and financial crisis on German 1-year treasury rates is shown in Figure 1. The yield on the 1-year German treasury rate decreased from close to 4% to below 1%, demonstrating the bleak economic outlook for the medium term.
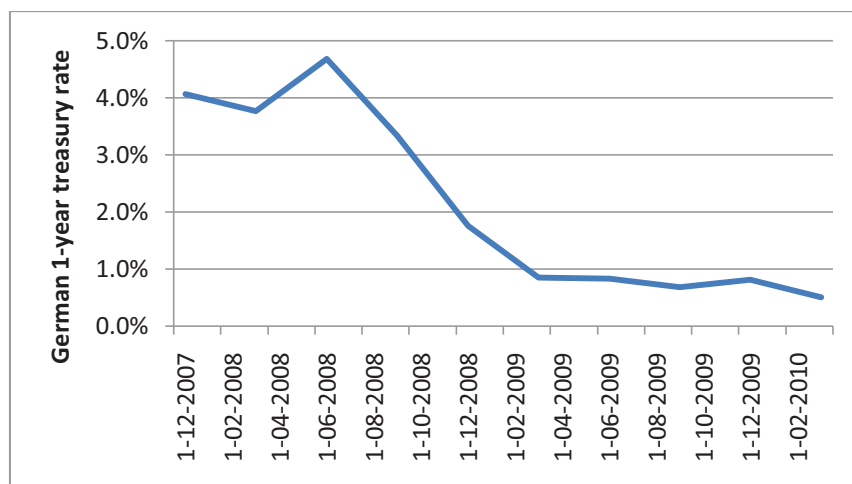
The development of bank's book values for customer deposits, other liabilities and equity are shown in Figure 2. The values are averaged among the sample banks and normalized to focus on the development. The figure demonstrates that book values of liabilities and equity did not change much during the financial crisis. The only visible trend is that banks tended to increase their equity capital, either by capital infusions or retained earnings, while at the same time decreasing other liabilities in recent times. The trend towards deleveraging points to a more conservative investment policy of banks at the end of the financial crisis.
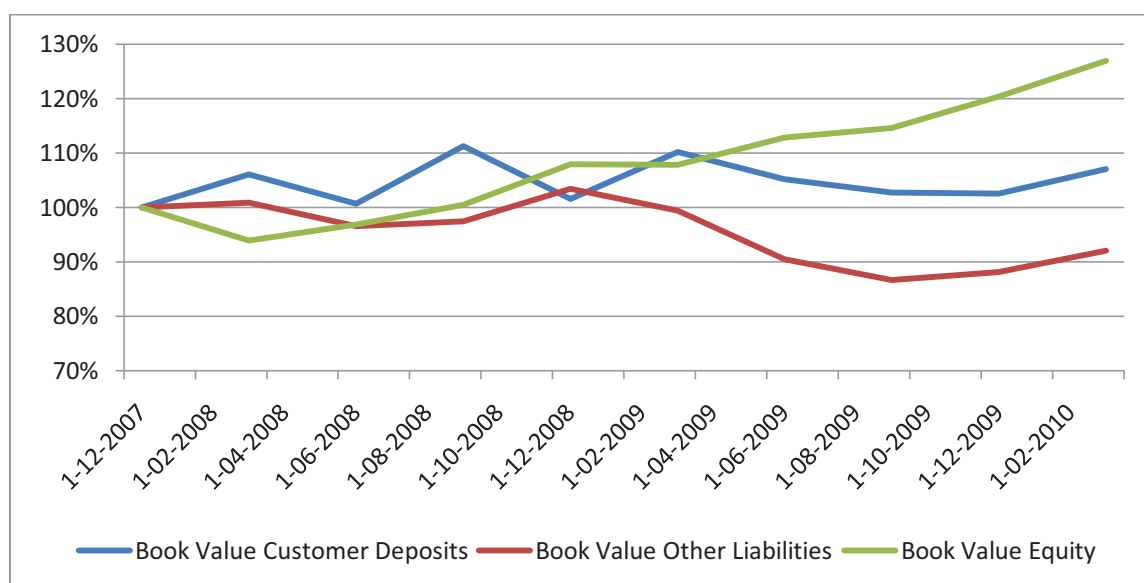
Market values however tell a less stable story. As Figure 3 illustrates, the market value of equity was fluctuating significantly. It decreased until spring 2009 and then started to recover. Equity volatility showed the opposite picture. The observation that equity volatility increases in downturn markets can be seen frequently in financial markets. Relatively low equity valuations and high equity volatility at the same time are a signal by the market that an investment is risky ceteris paribus. This signal thus serves as a first indication that the cost of deposit insurance to the government at that point in time was especially high.
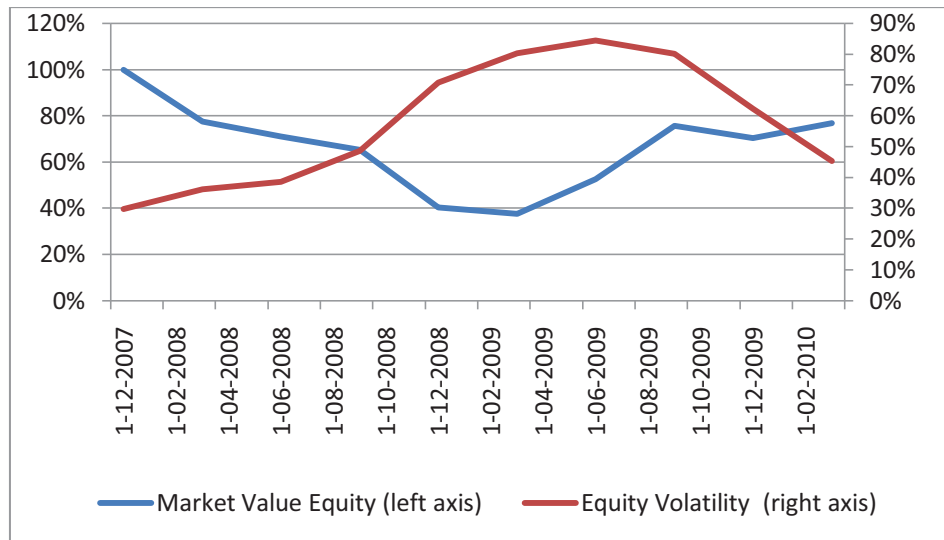
Following prior studies (Merton, 1977; Ronn & Verma, 1986; Kendall & Levonian, 1991; Allen & Saunders, 1993; Laeven, 2002) the time horizon T is set to 1 year. The German government did not provide an estimate on when the political promise would fade out, therefore a yearly audit period for banks appears reasonable and it provides the methodological advantage that annual deposit insurance premiums can directly be estimated. Deposits are assumed to grow at the respective German Treasury rate, because the government ultimately insures them. For simplicity, it is assumed that other bank liabilities evolve at the German treasury rate as well. The rescue packages designed for German banks significantly lowered the risk of banks with lower ratings and enabled them to borrow cheaper money than their rating would otherwise have demanded. The German Treasury rate until maturity is known at $t = 0$. With respect to asset correlation, ρ_{ij}, the analysis of the German mutual guarantee system faces the same lack of reliable bank asset correlation data as did De Giuli, Maggi, & Paris (2009). Therefore, an initial correlation coefficient of 0.7 is assumed, but the effect of changes in asset correlation will be illustrated in a sensitivity analysis. The data for the two types of liabilities and the asset value are averaged among the 26 banks, for which the complete data was available, and normalised to EUR 1 of assets to represent the average capital structure of the complete set of 174-182 German banks in the deposit insurance system within the financial crisis. The instantaneous standard deviation of equity, σ_E, is estimated annually from daily equity returns on the assumption that historical price volatility will prevail in the near future as well.

3.1. Estimating asset market value and volatility

In order to estimate the asset-weighted average volatility and the market value of assets for the sample, the Ronn & Verma (1986) model is applied to each bank separately in each quarter. Schellhorn & Spellman (1996) summarise the relevant assumptions for this model. The authors state that the capital structure consists of equity, insured and other liabilities. All liabilities have the same term to maturity which coincides with the banks next audit date. There are no auditing costs. Banks roll over their liabilities every quarter to keep the maturity constant. The model specifies that at the next audit date the value of equity be given by

$$E = max\{0, V - (D + P)\}$$

Where V represents the market value of assets. Based on the assumptions in the Black & Scholes (1973) option-pricing model, Ronn & Verma (1986) evaluated this by

$$E = VN(x) - (D + P)N\left(x - \sigma_V\sqrt{T}\right)$$

where

$$x \equiv \frac{ln(V/(D + P)) + \sigma_V^2 T/2}{\sigma_V\sqrt{T}}$$

[1]

and

$$\sigma_V = \frac{\sigma_E E}{VN(x)}$$

[2]

The instantaneous standard deviation of the market value of assets is denoted by σ_V. Equations [1] and [2] assume that all debt is valued at the risk-free interest rate. As stated above and noted by Ronn & Verma (1986) this assumption is going to understate the value of the deposit insurance premium. However, the effect is going to be negligible, because option values are not very sensitive to small changes in the interest rate. Furthermore, the assumption only affects other liabilities because deposits can be regarded as risk-free due to deposit insurance.

The financial crisis has shown that governments intervened in several bank closures where they either injected capital, guaranteed loans or did not immediately declare a bank as insolvent even if the value of bank assets did not sufficiently cover its obligations. The latter method is nonetheless only tolerated as long as a certain threshold in value is not undercut. Below this threshold, liquidation would become prohibitively expensive and the government has to resort to bank closure. Ronn & Verma (1986) defines this threshold as a percentage of banks total debt, ρB, where $\rho \leq 1$. No forbearance ($\rho = 1$) occurs when at maturity, the value of assets is less than total liabilities and the bank is immediately declared insolvent. Alternatively, the deposit insurer may temporarily allow the bank to operate with insufficient assets to cover liabilities. A ρ value less than one effectively lowers the closure threshold and represents a policy of forbearance. Ultimately ρ is a forward looking policy parameter that is difficult to estimate in the environment of a financial crisis. With this modified closure rule equations [1] and [2] become

$$E = VN(x) - \rho(D + P)N\left(x - \sigma_V\sqrt{T}\right)$$

where

$$x \equiv \frac{ln(V/\rho(D + P)) + \sigma_V^2 T/2}{\sigma_V\sqrt{T}}$$

[3]

and

$$\sigma_V = \frac{\sigma_E E}{VN(x)}$$

[4]

This paper adopts a value of $\rho = 0.97$ (Ronn & Verma, 1986; De Giuli, Maggi, & Paris, 2009) for the analysis. The sensitivity analysis in section 6 outlines the effect of other values for ρ. To estimate the market value of assets, V, and its asset volatility, σ_V, equations [3] and [4] are solved simultaneously for the two unknowns. The starting values, V and σ_V, in the MATLAB® solver function are set to the sum of market value of equity and face value of debt and the volatility of equity scaled down by the leverage ratio respectively. The application of the Ronn & Verma (1986) model to this dataset shows that in the period of the highest asset volatility, the market value of assets were most depressed. This increases the likelihood of insolvency and thus a possible claim on the deposit insurance. The next section

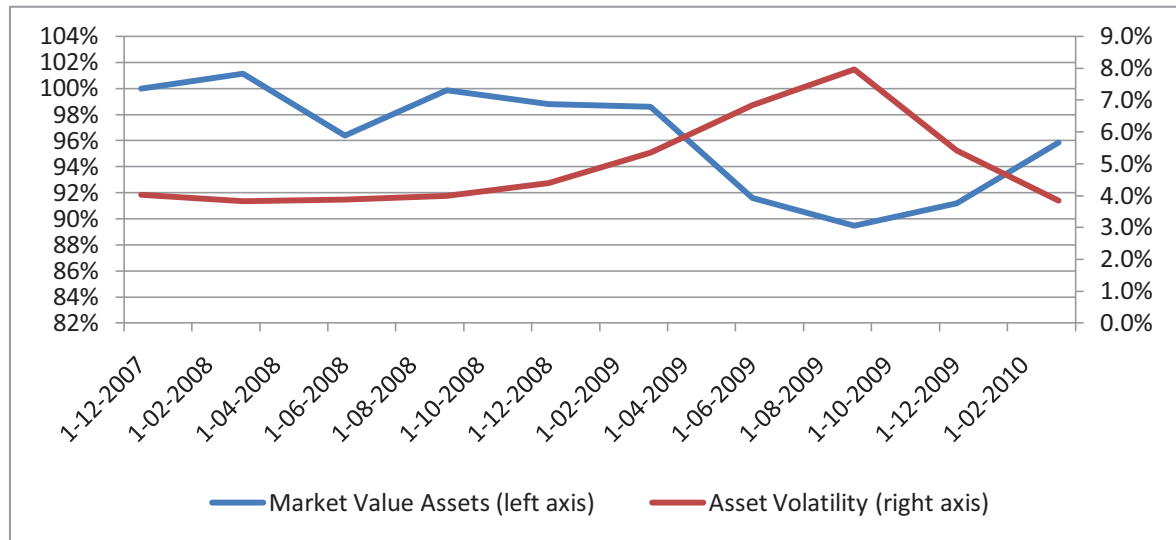is going to outline the model to estimate the value of this deposit insurance on a risk-adjusted basis.

Figure 4 - Market Value of Assets and Volatility

4. Model specification

Following closely the model developed by De Giuli, Maggi, & Paris(2009) the reference framework for this analysis is the German mutual guarantee system of private commercial banks. The Deposit Protection Fund covers any shortfall if one of their members goes bankrupt, up to the total solvency of its members. Due to the political promise of full deposit insurance, the government covers any residual losses. In order to find an estimate for the value of deposit insurance a contingent claim approach is applied, (Laeven, 2002). The isomorphic relationship between options and the value of deposit insurance is applied to three European options written on bank assets. The basic model of De Giuli, Maggi, & Paris (2009) considers a one-period ($t \in \{0, T\}$) arbitrage free model with n banks where all banks pay off their debts at T with the value of their assets. Table 3 clarifies the notation used in the models for each bank i ($with\ i = 1, \cdots, n$):

Names	Symbol
Number of banks in the consortium	n
Time horizon	T
Risk-free rate (German 1-year Treasury rate)	r
Market Value of Assets	$A_i(t)$
Covered Deposits	$D_i(t)$
Other liabilities	$P_i(t)$
Instantaneous standard deviation asset	$\sigma_{V\,i}$
Asset correlation coefficient	ρ_{ij}
Cumulative normal density function	$N(\cdot)$

Table 3 - Model Variables Definition

The net value of each bank can then be calculated as $N_i(t) = A_i(t) - [P_i(t) + D_i(t)]$. Preferred debts are not taken into consideration due to the lack of reliable data. The mutual guarantee framework is funded by its member banks where each bank contributes a share α_i

$$\alpha_i = \begin{cases} \dfrac{D_i(T)}{\sum_{j \in S} D_j(T)}, & if\ i \in S, \\ 0, & if\ i \notin S, \end{cases}$$

S being the set of solvent banks. The asset backed deposits ratio $L_i(t)$ defined as

$$L_i(t) = max\left(\frac{A_i(t)}{D_i(t) + P_i(t)}, 0\right) = \left(\frac{A_i(t)}{D_i(t) + P_i(t)}\right)^+ \qquad [5]$$

determines the amount by which each bank can pay for its debt and can be employed to measure the amount of insolvency on each banks deposits as $D_i(T)[1 - L_i(T)]$. The amount of aggregate insolvency in the mutual guarantee system is then measured as

$$H(T) = \sum_{i=1}^{n} D_i(T)[1 - L_i(T)]^+$$

The remaining solvent banks have to fund the consortium. Thus, the consortium itself is constrained in its effective maximum coverage by the sum of all banks net asset values

$$M = \sum_{i=1}^{n} [N_i(T)]^+ \qquad [6]$$

Whenever $H(T)$ exceeds M the government has to cover the residual loss. In contrast to De Giuli, Maggi, & Paris (2009), who analyse the Italian mutual guarantee system, the German system does not have a global coverage amount K of the consortium. Instead, the German system insures up to 30 percent of the relevant liable capital of the respective institution per depositor as stated in their last financial statement. Garcia (1999) defined this as "comprehensive coverage" and the Association of German Banks (2010) stated that almost no depositor exceeds this limit, because large clients tend to diversify their funds. Equations [5] and [6] both show that the amount of insolvency as well as the effective maximum coverage of the consortium depends on the dynamics of bank assets.

De Giuli, Maggi, & Paris (2009) apply an option-pricing framework in this setup, to measure the economic value of the following three option positions:

1. A long position with respect to the consortium regarding coverage of deposits

$$p_{1i} = \begin{cases} min(m, 1)D_i(T)[1 - L_i(T)]^+, & if\ H(T) \neq 0 \\ 0, & if\ H(T) = 0 \end{cases} \qquad [7]$$

$m = \dfrac{M}{H(T)}$ being the share of aggregate insolvency covered by M

2. A long position with respect to the government regarding coverage of any losses exceeding those funded by the consortium

$$p_{2i} = \begin{cases} [1 - min(m, 1)]D_i(T)[1 - L_i(T)]^+, & if\ H(T) \neq 0 \\ 0, & if\ H(T) = 0 \end{cases} \qquad [8]$$

3. A short position with respect to the consortium regarding consortium funding

$$p_{3i} = -min\left(\alpha_i M, \alpha_i H(T), [N_i(T)]^+\right) \tag{9}$$

When a certain bank is not able to cover its contribution to the consortium ($-p_{3i} > [N_i(T)]^+$), the missing contributions are refunded by an increase of contributions by the remaining banks according to their net asset value until $min\left(M, H(T)\right) + \sum_{j=1}^{n} p_{3j} = 0$. The proper funding of the mutual guarantee framework together with the promise of full deposit insurance by the government ensures that depositors can regard their deposits as risk-free.

The mutual guarantee framework as presented by De Giuli, Maggi, & Paris (2009) considers not only a single bank's assets, but also the interaction between all members of the interbank fund. Thus, the analysis is based on a multi-asset contingent claim analysis. Due to the correlation between bank assets a closed-form solution of the Black & Scholes (1973) partial differential equations

$$\frac{\partial v_{ki}}{\partial t} + r \sum_{h=1}^{n} A_h \frac{\partial v_{ki}}{\partial A_h} + \frac{1}{2} \sum_{h=0}^{n} \sum_{j=1}^{n} [\Sigma\Sigma']_{hj} A_h A_j \frac{\partial^2 v_{ki}}{\partial A_h \partial A_j} - r v_{ki} = 0$$

$$k = 1,2,3,$$

with Equations [7], [8] and [9] as boundary conditions, cannot be explicitly computed. These position values are computed by Monte Carlo simulation, generating 10,000 runs of the correlated bank asset values, as in De Giuli, Maggi, Paris (2009).

5. Deposit Guarantee evaluation

The period covered by the data series includes two dates that stand out in this analysis. The data point closest to the announcement of full deposit insurance on October 5th, 2008 (base case) and the data point corresponding to the maximum deposit insurance value for the government (max case) on September 30th, 2009. The inputs for the valuation are given in Table 4. The data show that the capital structure remained relatively stable. There are however significant changes in the size of the consortium, the risk-free rate and asset volatility. A smaller consortium reduces the coverage of the consortium, because potential losses have to be covered by fewer banks and therefore leaves a larger residual to be covered by the government. The lower risk-free rate drives up the put premium for the government, because the value of liabilities is less discounted which is why their present value is higher. Higher asset volatility reflects greater fluctuations in the market value of assets and thus can lead more banks to insolvency, reducing their contributions to the consortium and calling for funding by the government. This two-sided effect of a volatility increase lets the government premium rise.

Names	Symbol	30-09-2008 (base case)	30-09-2009 (max case)
Number of banks in the consortium	n	182	174

Time horizon	T	1	1
Risk-free rate (German 1-year Treasury rate)	r	3.0445%	0.6820%
Market Value of Assets (normalised)	$A_i(0)$	$1\ \forall i$	$1\ \forall i$
Covered Deposits	$D_i(0)$	$0.4381\ \forall i$	$0.4505\ \forall i$
Other liabilities	$P_i(0)$	$0.5042\ \forall i$	$0.5019\ \forall i$
Instantaneous standard deviation asset	σ_{V_i}	$3.099\%\ \forall i$	$7.958\%\ \forall i$
Asset correlation coefficient	ρ_{ij}	$0.7, i \neq j$	$0.7, i \neq j$

Table 4 - Parameter values base case & max case

The development of the average value of deposit insurance premium per Euro over time is shown in Figure 5. The figure shows that within the financial crisis the cost of deposit insurance for the government has risen from almost zero to a maximum of 0.3715% for every insured Euro. v_{1i} and v_{3i} mirror each other, because everything that can be paid out by the consortium first has to be funded by solvent member banks. The figure reveals that the largest part of implicit costs to the government by deposit insurance occurred after the political promise was given.
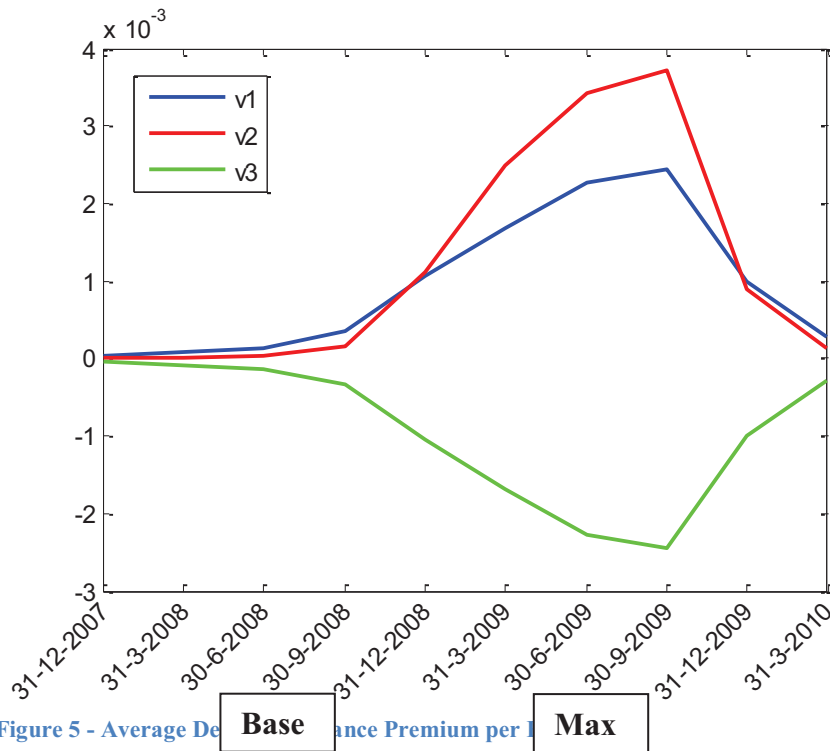

Figure 5 - Average De **Base** ance Premium per   **Max**

The Deutsche Bundesbank (2010) in their statistics section provides aggregate information about all private commercial banks, almost all of which are members of the Deposit Protection Fund. Moreover, there are four banks that are, due to their size and business volume, classified as "big banks" by the Association of German Banks (2010). In 2004, these four made up for a total market share of 18%, measured in terms of assets, of the whole German banking market, (Association of German Banks, 2010). Unfortunately, the Italian UniCredit Bank does not publish separate book values for its German operation of HypoVereinsbank. The remaining banks are Deutsche Bank, Commerzbank, and Postbank. Table 5 lists the value of implicit costs of 1-year full deposit insurance in million Euro to the

German Government for each of these banks as well the costs for all banks in the consortium in quarterly steps. Thus, Table 5 illustrates part of the results from Figure 5 in absolute terms.

Date	Average Deposit Premium per Euro	Deutsche Bank	Commerzbank	Postbank	Whole Consortium
31-12-2007	0.000457%	2.09	0.73	0.51	5.15
31-03-2008	0.001659%	7.29	2.67	1.87	19.41
30-06-2008	0.003451%	14.58	5.69	3.90	40.26
30-09-2008	**0.016386%**	**70.15**	**28.24**	**18.96**	**194.08**
31-12-2008	0.111839%	442.38	190.35	131.38	1397.02
31-03-2009	0.249060%	985.46	772.66	309.41	3163.98
30-06-2009	0.342749%	1263.14	1016.66	445.02	4401.07
30-09-2009	**0.371456%**	**1355.72**	**1025.09**	**496.48**	**4715.17**
31-12-2009	0.089462%	307.95	236.73	118.08	1115.74
31-03-2010	0.012458%	45.60	32.44	16.72	154.48

Table 5 – Government deposit insurance premium in million Euro

Table 5 shows that at the start of the political promise on October 5th, 2008, the costs to the government were relatively moderate. Nevertheless, the German state missed the opportunity to specify a final maturity of its political promise. The failure to do so renewed this guarantee from quarter to quarter for the public and let its implicit value rise within one year from €194 million to €4715 million. Due to the mutual guarantee framework, the German government did not have to bear the complete burden of full deposit insurance. All solvent member banks have the obligation to contribute to the consortium, which is resembled by their short position towards the consortium. The costs of this implicit commitment to the member banks are shown in Table 6. The table outlines that a mutual guarantee system significantly lowers the cost of full deposit insurance for the government. From the total insurance value, the government only has to cover the residual part that is not covered by the consortium.

Date	Average Deposit Premium per Euro	Whole Consortium in mio Euro
31-12-2007	0.00289%	32.61
31-03-2008	0.00887%	103.81
30-06-2008	0.01433%	167.21
30-09-2008	**0.03451%**	**408.75**
31-12-2008	0.10542%	1316.83
31-03-2009	0.16767%	2130.06
30-06-2009	0.22669%	2910.80
30-09-2009	**0.24466%**	**3105.60**
31-12-2009	0.10031%	1251.08
31-03-2010	0.02902%	359.84

Table 6 - Consortium deposit insurance premium in million Euro

Figure 6 demonstrates the development of position values of the three option positions on each measurement day based on bank assets for bank i's assets. The figure graphically illustrates that v_{1i} and v_{2i} indeed represent long puts, whereas v_{3i} shows the shape of a short

call, all of which with strike price equal to each banks total liabilities. The figure shows clearly that at the beginning of the financial crisis, the mutual guarantee framework was well able to deal with insolvent banks by itself. The contributions for each member bank were low even if their asset values would have allowed for higher contributions. As the financial crisis progressed, firstly the contributions of banks with higher asset values, v_{3i}, increased (became more negative), because there were more banks that were at the margin of becoming insolvent, and could thus not fund the consortium. The financially stronger banks therefore had to take on higher contributions than before. In the next step, after those banks were no longer able to bear this risk to an adequate degree, the government had to step in and take the residual risk.
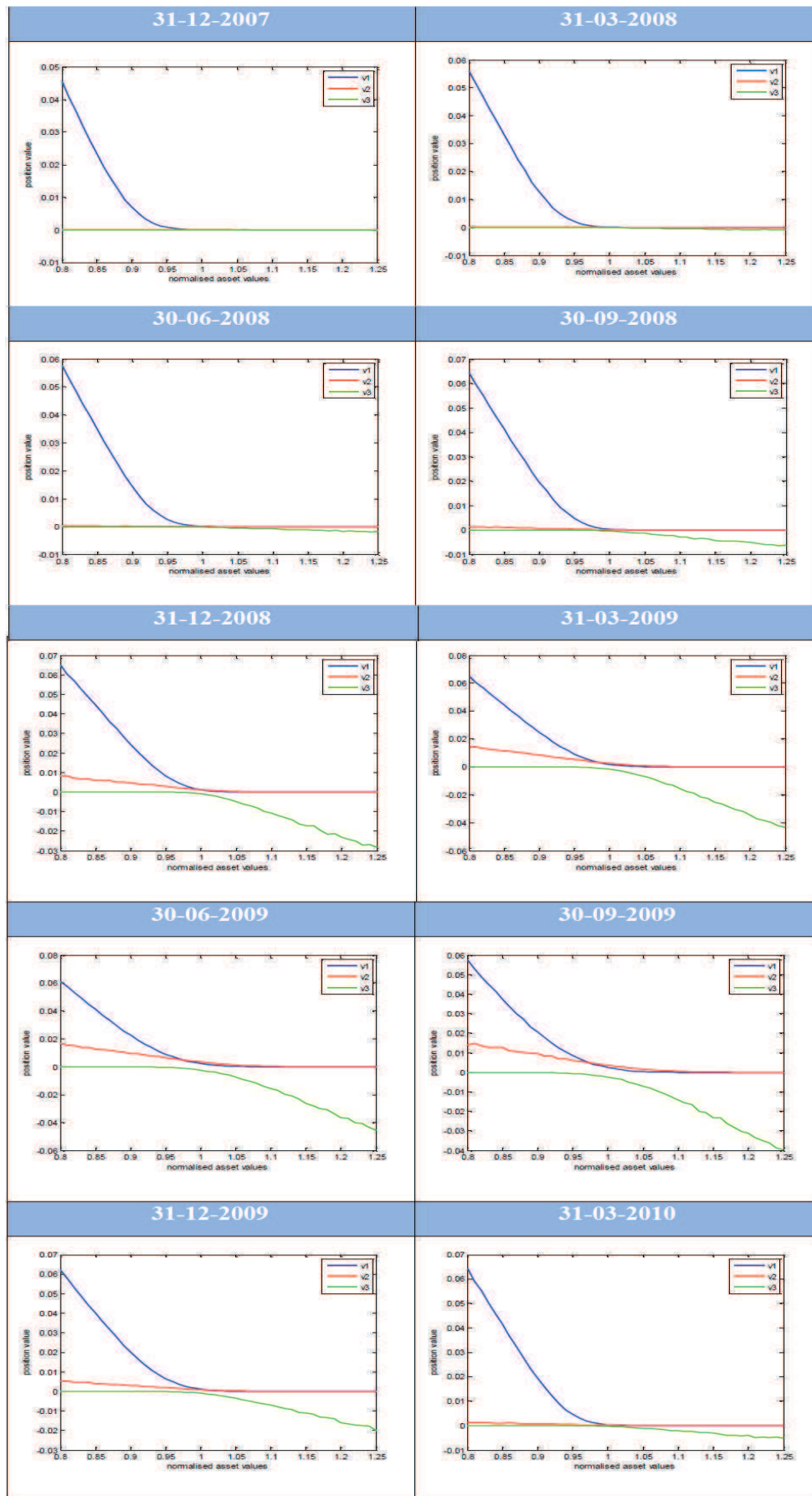
31-12-2007	31-03-2008
30-06-2008	30-09-2008
31-12-2008	31-03-2009
30-06-2009	30-09-2009
31-12-2009	31-03-2010

Figure 6 - Position values with respect to normalised asset values over time

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To be able to derive appropriate policy recommendations from this analysis, it needs to be determined to what extent the value of deposit insurance reacts to changes in the model inputs.

6. Sensitivity analysis

The model employed in this study depends largely on the proper estimation of its inputs. Figure 7 is based on the data of the max case and shows that the cost of deposit insurance for the government as well as for the consortium increases with the volatility of bank assets and shows that riskier banks benefit more from this guarantee. Therefore, an incentive exists for banks to exploit the guarantee, because in case of bankruptcy, their deposits are secured by the government and the consortium, but they do not have to pay the costs by funding the consortium.
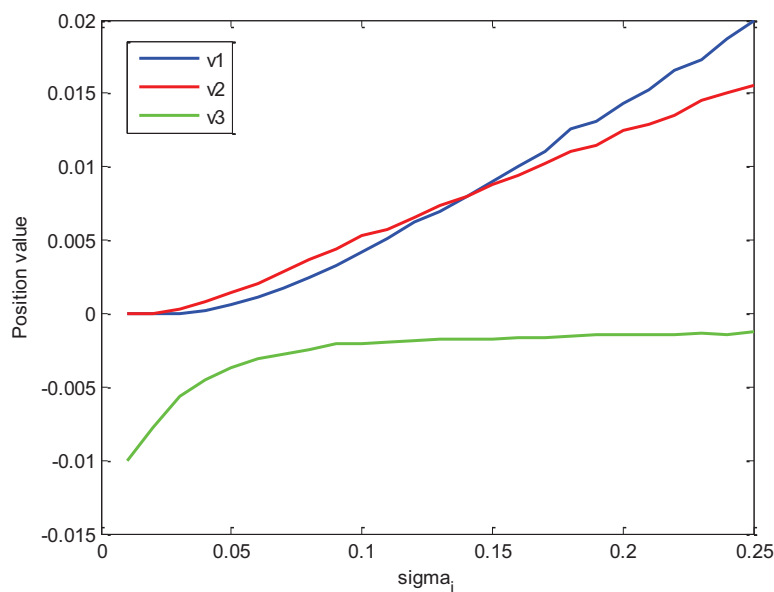

Figure 7 – Position values per insured Euro with respect to bank asset volatility

Figure 8 is also based on the data of the max case and illustrates that a lower bank asset correlation can even in the most unfavourable market environment decrease the burden of full deposit insurance to the government. At the point where banks are fully uncorrelated the cost to the government are virtually zero, because the consortium will have enough solvent members to cover the deposits at bankrupt banks. Therefore, it is desirable to establish rules that ensure a diversified banking system and highlights the importance of proper parameter estimation for the pricing of deposit insurance.
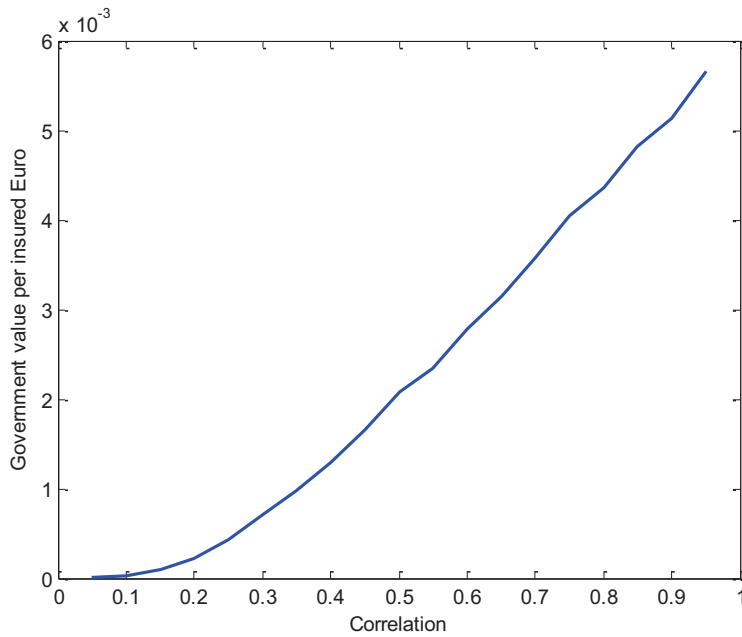
Figure 8 - Average government value per insured Euro and correlation

The amount of forbearance granted to banks by the government has an immediate effect on the value of deposit insurance that has to be covered by the government, which is shown in Figure 9. If the deposit insurer temporarily allows banks to operate with insufficient assets to cover liabilities ($\rho < 1$), the value of deposit insurance, provided by the government to banks, increases accordingly. Therefore, the government needs to be aware that granting forbearance to banks will not only put debt holders of banks at risk, but will increase its own implicit guarantee obligation as well.
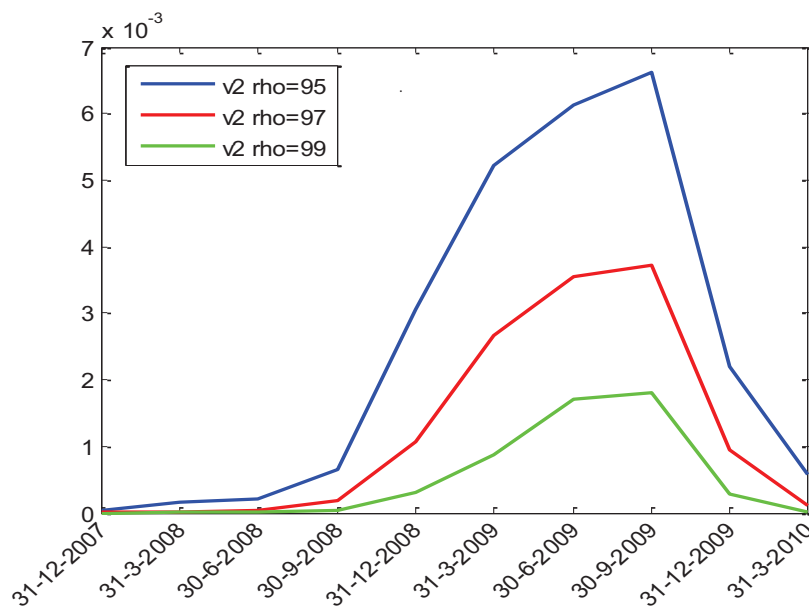

Figure 9 - Average Deposit Insurance Premium per Euro for the Government at different levels of ρ

In crisis times, correlations as well as volatility of bank assets tend to increase, thereby also increasing the value of the government commitment to full deposit insurance. Therefore, it is important to devise regulations that ensure the burden to the government is kept as minimal as possible especially in crisis times. Furthermore, the direct effect of forbearance on the

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deposit insurance government position should incentivise the government to declare banks insolvent close to the point when assets do no longer cover liabilities.

7. Conclusion

The analysis has shown that the German government supported private commercial banks organized in the Deposit Protection Fund by an estimated amount of up to EUR 4.7 billion per 1-year period by its promise of full deposit protection. Due to the mutual guarantee system, an additional amount of EUR 3.1 billion was already covered by the member banks of the Deposit protection fund. The government missed the opportunity to limit their promise to a pre-defined time period. A 1-year guarantee on the date of the first promise would only have implied a cost of EUR 194 million. That is why, the German government should devise and communicate a clear set of rules for full deposit insurance before the next crisis, including specific timelines for its support. Moreover, the government failed to make banks participate at the costs of this guarantee in a risk-adjusted way. One suggestion of this study would therefore be to modify the existing mutual guarantee framework, by adding a rescue fund that charges premiums, which accumulate from year to year until the next crisis draws on its funds. Banks should have no right to discontinue payments if they feel the rescue fund is sufficiently funded, because within a financial crisis they would have difficulties to generate the capital necessary to cover the losses of others. In addition, the amount of the premium charged for this rescue fund should be based on the riskiness of each bank separately as discussed in this study. This would reduce the incentives for banks to increase risk, as discussed in the sensitivity analysis, thereby reducing moral hazard.

The model presented in this paper is essentially suited for this task as it addresses one of the main practical problems in determining risk-adjusted premiums for banks, the assignment of premiums based on observable and objective criteria. The inclusion in this mutual guarantee framework should be mandatory for all banks that want to operate in Germany in order to prevent adverse selection. In order to reduce contagion effects of banks, the interconnectedness between banks and asset correlations should be as low as possible. The sensitivity analysis has shown that there is no need for the government to step in and stabilize the system in times of crisis when the correlation among bank assets is sufficiently small. To this extent, it is useful to dismiss the model of large universal banks, which essentially all follow the same business model and are too correlated and "too-big-to-fail" in times of crisis, in favour of a system with smaller more specialized banks. This could be achieved for example by a tax on bank metrics such as the balance sheet sum. Furthermore, the government should only grant limited forbearance to banks, because it results in unwanted incentives for banks and it increases the premium of deposit insurance for the government position.

The limitations of this study are foremost based on the proper estimation of the parameter inputs to the model. Firstly, historical volatility can only be a proxy for the true forward-looking volatility of bank assets used in this model. Secondly, forward looking asset correlation can best be estimated by regulators that get access to banks books. Thirdly, regulators need to specify explicitly their tolerated level of forbearance as input to the Ronn & Verma (1986) model. Further research, should deal with the proper estimation of these parameters as well as different regulatory provisions that could be used to deal with the goals of risk-adjusted premiums and a more diversified banking system. In addition, an application to different time frames might shed more light on the risk-taking incentives of banks outside of a financial crisis. The model can then be used to define a new set of rules for the German

deposit insurance system to improve its stability and help to prevent the adverse effects of the next financial crisis.

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