Department of Economics
Course of Financial Mathematics

Deposit Guarantee Schemes: the option pricing approach to determine the fair premium

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“When national debts have once been accumulated to a certain degree, there is scarce, I believe, a single instance of their having been fairly and completely paid. The liberation of the public revenue, if it has ever been brought about at all, has always been brought about by a bankruptcy; sometimes by an avowed one, but always by a real one, though frequently by a pretended payment. The raising of the denomination of the coin has been the most usual expedient by which a real public bankruptcy has been disguised under the appearance of a pretended payment.”

Adam Smith*, “An Inquiry into the Nature And Causes of the Wealth of Nations”, *Book V, Chapter III, 1776

“Let me end my talk by abusing slightly my status as an official representative of the Federal Reserve System. I would like to say to Milton and Anna: Regarding the Great Depression. You're right, we did it. We're very sorry. But thanks to you, we won't do it again.”

Ben Bernanke, "Remarks by Governor Ben S. Bernanke at the Conference to Honor Milton Friedman, University of Chicago, Chicago, Illinois," federalreserve.gov (2002-11-08)

“The reason that the invisible hand often seems invisible is that it is often not there.”

Joseph Stiglitz, quoted in Daniel Altman, "Managing Globalization: Q & A with Joseph Stiglitz", The International Herald Tribune (2006-10-11)

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Introduction

That of deposit insurance is nowadays one of those themes everybody is talking about. The credibility of the financial sector has been severely undermined by a series of events that have put most of the developed countries to their knees, starting with the burst of the American housing bubble that opened a Pandora's vase and brought to light many of the imperfections of a system that used to base itself predominantly on virtual gains and creative finance and that now has to be rebuilt from scratch. This is not exclusively an American problem but it has been spreading all over the world since most of the biggest international banks used to hold in their portfolios derivatives which had as underlying assets those mortgages that could not be repaid by the over indebted American families. This is the so called "snowball effect", so that the contagion has affected not only all the western industrialized countries but the emerging eastern economies as well, these being the major creditors of the USA, whose commercial balance has been in deficit for many years.
In this situation one of the most important features is the protection of the depositors, in order to prevent another Great Depression, avoiding the bank runs and the panics that are self-fulfilling and consist in a massive withdrawal of deposits by unaware depositors that cannot be handled by the banks themselves , even in the case they are in good health. Mainly for these reasons, after the experience of the Great Depression, the USA have introduced a deposit-guarantee scheme, by giving birth to the FDIC (Federal Deposit Insurance Corporation) in 1933. They were followed by India (1962) and Canada (1967) at first and only in the 80s the European countries started setting the firsts national deposit

guarantee schemes, which still have to be completely harmonized at a European level.

The deposit insurance schemes are part of a wider safety net, which is composed also of capital requirements and the lending of last resort: these three instruments have different characteristics but are at the same time strictly interwoven among themselves. In particular, the capital requirements were systematically introduced in Europe by the two agreements of Basel and they mainly prevent ex-ante a state of illiquidity by forcing the national banks to hold certain deposits in the ECB (European Central Bank), the amount of which varies according to the level of risk of the single bank taken into consideration. The lender of last resort is an institution, most often the central bank of a country, that gives loans to other financial institutions that are in financial difficulty, most often near collapse. It distinguishes itself from the other two prudential regulation instruments for being the only one among the three to have a macroeconomic function, being the most suitable and timely remedy to a generalized liquidity crisis.

The aim of this work is to analyze the third instrument, which is the deposit insurance, that is the main remedy to liquidity crisis of single institutions and to maintain the commitments taken towards the depositors. Another important function of deposit insurance is to guarantee the soundness of the payment system, maintaining the banks' reliability also in difficult financial situations as the one we are just facing nowadays. Guaranteeing the maximum stability of the financial institutions is a goal that can be achieved only with strict controls, but taking this to the extremes, we could end up having on one hand a sound system but on the other hand no discretion at all for the managerial choices. Moreover, a certain amount of instability is inevitable due to the special kind of liabilities of banks themselves, having to operate with illiquid assets (loans) but at the same time with liquid liabilities (deposits) as well. The deposit insurance can contribute to the general stability of the financial system but it has to be well organized and supported by authorities. The main disadvantages of such instrument are the adverse selection and moral hazard issues, which are two phenomena of asymmetric information.

The adverse selection has been studied first by G. Akerlof[1] in his work "The Market for Lemons" (1970), in which he refers to the market of used cars; we have this problem when one of the parties has more information on the quality of the good that is being sold than the other party. The extreme consequence is that the entire market collapses because of the information asymmetry, but it can happen also that only the sellers of low-quality products remain in the market. Applying this to the insurance market, we can say that we have adverse selection when only those who are exposed to higher risks, given the contract conditions, buy an insurance: the consequence is that the insurance company's level of risk gets higher, so it has to raise the insurance price, but in this case those with lower levels of risk will not get insured unless they can signal[2] their level of risk or the company itself can force its clients to reveal their true risk situation through screening[3], offering them to choose from a menu of alternative contracts, where lower premiums can be exchanged for higher deductibles. This problem is emphasized when all the members of the deposit insurance scheme pay the same flat rate: a possible solution can be that of introducing premiums which vary according to the effective risk taken by the insured institution. Flexible rates are better than flat ones in reducing also the moral hazard and the cross subsidization problems. As for the latter, we can say that flat premiums oblige the safer banks to subsidize the unsafe ones, introducing an unwanted distortion in the market; the empirical studies, in fact, state that the distribution is asymmetric, so that most banks should be paying

[1] See Akerlof, G. (1970) – "The market for lemons: quality uncertainty and the market mechanism", *Quarterly Journal of Economics 84(3)*

[2] See Spence, A. M. (1973) – "Job market signaling", *Quarterly Journal of Economics 87(3)*

[3] See Stiglitz, J. (1975) – "The theory of 'screening', education and the distribution of income", *American Economic Review 64*

premiums which are inferior to the average one. As for the moral hazard, a deeper insight will be found hereunder. The main disadvantage of flexible premiums is though the difficulty of correctly estimating the risk level of the institution; concerning this problem, a lot of proposals have been expressed in the economic literature: the one we are going to look into more deeply in this work is the option pricing theory introduced by Merton-Black-Scholes[4].

As far as the moral hazard is concerned, it has to be said that it is an inevitable consequence of the guarantee schemes, even though there are many possibilities to reduce its strength. The moral hazard is another situation of asymmetric information; in this case the party that has more information in the transaction is the one insulated from risk, that knows better its intentions and future plans than the party bearing the negative consequences of the risk. In insurance markets, moral hazard occurs when the behavior of the insured party changes in a way that raises costs for the insurer, since the insured party no longer bears the full cost of that behavior. We can have both ex-ante and ex-post moral hazard, depending on which behavior is changed by the insured party. We have the former when the insured parties behave in a more risky manner, which brings to more negative consequences for the insurer. We have the latter instead, when the insured changes his behavior regarding the reaction to the negative consequences of risk, once they have already occurred and once their costs are covered by the insurance contract. This means that the insured would opt for more expensive solutions to the negative consequence, compared to those he would have chosen if he had not got insurance coverage for the costs.

The moral hazard problem is also significant in the finance system, since the banks themselves can behave recklessly, increasing the level of risk at which they are operating, since they know they will be saved in any

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[4] See Merton, R. C. (1973) - "Theory of Rational Option Pricing", *Bell Journal of Economics and Management Science 4(1);* and Black, F. and Scholes, M. (1973) - "The Pricing of Options and Corporate Liabilities", *Journal of Political Economy 81(3)*

case by the institutions of the deposit insurance schemes. This is the case in particular of the TBTF[5] institutions, which are aware of the role they play in the country's economy, so that the government has to rescue them to avoid bank runs, panics and a domino effect which will drag in all the other institutions of the sector. Being so, the risk is therefore socialized, because it has to be borne by the taxpayers, which will indirectly have to finance this insolvent institutions by paying higher taxes, while the eventual profits will remain privatized.

The solution to the moral hazard problem has to be found in specific contractual clauses, which lead to the automatic removal of the insurance coverage in case the insured party does not maintain a proper behavioral standard. This solution though cannot be used with a legally compulsory insurance, such as the deposit insurance schemes we are going to look into; in this case the only possible solution to limit the moral hazard is a continuous and strict monitoring over the insured party, but this has inevitable costs associated with it. Generally the deposit coverage is not full, but it is limited to a certain amount and to certain types of depositors and/or deposits, so that the negative consequences are shared by the parties and the moral hazard issue is indirectly limited.

Going back to the deposit insurance schemes, apart from the distinction between flexible and flat premia, there is another important one that attains the nature of the protection scheme itself: there are public insurance schemes, like the one used in the USA (FDIC); private ones, such as the Swiss case; and other ones with a mutual base, like in the Italian case. Many economists have argued that a private protection scheme can turn out being inefficient, not only because of the limited

[5] TBTF is the acronym for "Too Big Too Fail", a policy whose origins can be traced back to the case of Continental Illinois Bank in 1984, when bank regulators feared that the failure of this bank might have caused a systemic crises, involving the whole financial sector. In particular, this expression was coined after Todd Conover, who was the Comptroller of the Currency in charge, declared in the U.S. Congress of 1984 that Continental and ten other of the nation's largest banks were "too big to fail". The FDIC solved this delicate case through what is referred to as the "nationalization" of this bank in 1984. For further details see Benton E. Gup (2004) – "Too big to fail: policies and practices in government bailouts", *Greenwood Publishing Group*.

amount of money it can count on, which will surely be insufficient in cases of widespread financial crisis like the one we are just facing, but also because of the impossibility of it benefiting from the connections of the deposit insurance with the other prudential regulation issues, which are in charge of public authorities. Actually, to assert if a deposit insurance premium is fair, it is necessary to consider also the substitution and complementarities relations with the other regulation instruments, which can add implicit or explicit premia.

This work is organized as follows: in the first chapter the focus will be on the deposit insurance schemes, in particular there will be the comparison between the FDIC (USA) and the FITD (Fondo Interbancario di Tutela dei Depositi, Italy), presenting for each one of them the approach adopted to determine the insurance premium. Moreover, in the second chapter, the focus will be moved upon the market approach to define the flexible premium of a deposit insurance scheme that takes into account the risk level; in particular the reader will find a deeper insight on the Black-Scholes model for option pricing. Then, in the third chapter the reader will find a practical application of the model presented in chapter two to the deposit insurance case and some alternative approaches to the determination of a fair insurance premium. Finally in the Conclusions, it will be drawn a comparison between the current financial crisis and the Great Depression experience of the 1930s, trying to get some useful indications from the errors of the past; in addition to this, the reader will find some personal observations and a brief overview regarding the possible future scenarios on a worldwide base.

1. Deposit insurance schemes

1.1 Introduction

The first deposit insurance scheme has been introduced in the USA in 1933, as an answer to the Great Depression, that struck the country in the early 30s , bringing with it high rates of unemployment and a severe contraction of the national production. Originally the main reasons for introducing the FDIC are generally considered to be the following three[6]:

- the prevention of sudden contractions of the money stock due to exogenous shocks;
- the protection of small depositors, who are unaware of the risk levels with which the banks operate;
- the protection of the local banks, which is essential in order to efficiently manage the crisis from a microeconomic approach.

Regarding the first, the prevention of bank runs was crucial in the context of the 30s, but nowadays the risk of having again a panicking situation like the one experienced during the Great Depression is quite improbable, since the banks play a fundamental role in the modern economies' payment systems, being so very difficult to assist to a massive withdrawal of deposits and their conversion to currency. If a depositor withdraws money from his bank, then he will most probably deposit it in another bank, whom he thinks to be safer: the effect is only a transfer of funds from one bank to another, and from an economical point of view we will only have side effects on the monetary multiplier.

As for the second reason, starting from the 80s, we have assisted to a significant decrease of deposits percentage in the portfolio owned by

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6 See Benston, G.J. and Kaufman, G.G. (1988) – "Risk and solvency regulations of deposit institutions: past policies and future options", *Staff Memoranda 88-1,* Federal Reserve Bank of Chicago.

the families: they have been gradually replaced with alternative financial tools, that can be directly owned and managed, but are, in the vast majority of the cases, given to an institutional investor, who can protect their interests better, since he owns a bigger and better diversified portfolio and he can take legal actions against the bank and company management if these prove to be inefficient.

As for the third reason, at the beginning of the 80s, when European countries started introducing their first deposit insurance schemes, the European bank industry did not suffer from the same limitations imposed to the American banks. In fact, the latter were not allowed to open new branches in other states, so that they were not able to geographically diversify the risk, having to concentrate all their branches in the same state. In Europe, though, the banks did not have to respect these operative constraints; in addition to this, the introduction of the universal bank model and of the unique European license[7], contributed to help diversifying both assets and liabilities. Also in the USA, we have recently assisted to the removal of these geographical[8] and functional[9] restrictions, so that this original reason does not seem to work anymore in the USA as well.

Having seen that the original reasons that supported the introduction of the deposit insurance schemes do not seem to be valid any more, why are all industrialized countries still willing to apply these guarantee schemes?

The answer to this question is that deposit insurance schemes contribute to the stability of the financial system, since they guarantee the depositors' trust in the bank industry, avoiding a domino effect which could affect all the other banks if one of them collapses. Moreover,

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[7] EC Directive Number 89/646/EEC of December, 15th , 1989, which became effective on January,1st,1993. This was the Second Banking Co-ordination Directive, whose aim was that of removing the barriers to entry the banking system in all EU member countries, thus creating a sort of 'passport' for banking activities.

[8] Riegle-Neal Interstate Banking and Branching Efficiency Act (RNIBBEA), 1994

[9] Gramm-Leach-Bliley Act (GLBA), 1999

deposit insurance plays a leading role in the modern advanced economies' payment systems, since these can work only if the depositors rely on the bank itself.

In the following paragraph we will briefly recall the main features that need to be taken into account when designing a deposit insurance scheme. In paragraphs 1.3 and 1.4, instead, we are introducing respectively, the FDIC and the FITD scheme, drawing at the same time a comparison between the two schemes.

1.2 The design of a deposit insurance scheme

First of all, it has to be said that not all the countries have introduced an explicit deposit insurance scheme yet: the most striking example is that of Australia and New Zealand, that are currently considering the establishment of an "Early Access Facility", though not involving ex-ante funding and current depositor preference rules. There are also some countries that have only recently introduced these guarantee systems, such as Singapore and Hong Kong, which both established their deposit insurance scheme in 2006.

In the case of not explicit deposit insurance, the main problem is that there is not a clear border line between the insured categories and the not insured ones, so this may lead to think that the government will bail out any creditor, not only insured depositors. On the contrary, in explicit deposit insurance schemes, only insured depositors are protected, while the remaining categories are exposed to higher risks , such creating an incentive for them to monitor the bank's management.

The specific design of deposit insurance regimes in each single OECD country differs from the others, since such schemes have to be contextualized in the national banking environment. Nevertheless, the International Association of Deposit Insurers (IADI) has set some "Core

Principles for Effective Deposit Insurance Systems" (April 2008) , which can be followed by policy makers wanting to introduce a deposit insurance scheme ex novo or willing to reform an existing one.

As far as the funding is concerned, a deposit insurance system can be based on ex-ante or ex-post funding. The US FDIC is the most important example of the former, while most other countries have an ex-post funding scheme. In the latter, on the one hand there is the disadvantage of collecting funds after a bank has closed down, which can turn out being difficult if the crisis is not idiosyncratic but has instead affected the whole system; while on the other hand they will encourage cross monitoring among the banks themselves, since the duty of refunding depositors of insolvent banks falls upon the sound ones. On the contrary, in ex-ante funding schemes, there are always available funds, so that delays in refunding the depositors do not occur: in fact, in the US case complete refunding is immediate, while in the European schemes, only a small amount of money is provided on the nail. However, the disadvantage with ex-ante funding is the need to determine the insurance premium beforehand.

An ex-ante funding scheme can be based upon flat or risk-adjusted premiums; as we have already said in the introduction to this work, flexible premiums are to be preferred, since they limit the moral hazard and the cross subsidization issues. The only inconvenience, is the difficulty to correctly calculate the fair premium beforehand. In the United States, since 1993, premiums are related to the estimated risk category of the member institution.

As far as membership is concerned, an important distinction, which has already been discussed in the introduction, is between public and private schemes; the former being preferred since they seem to be more suitable for the purpose of strengthening public confidence in the safety of deposits. In the vast majority of the cases, a compulsory participation has been chosen, but there are also some voluntary participation schemes, such as the Swiss one, which is though only formally voluntary.

Another important issue when designing a deposit insurance scheme, is that of specifying the maximum coverage, which is the amount a depositor can claim from the deposit insurer in case of insolvency of a member institution. On this point, there are many differences between the various national deposit guarantee schemes, which are summarized in table 1:

Table 1: current coverage limits

Country Name	Coverage limits
France	EUR 70 000
Germany	EUR 50 000
Italy	EUR 103 291.38
Spain	EUR 20 000
United Kingdom	GBP 50 000
United States	USD 250 000

Source: information available from deposit insurance websites

Data in table 1 are approximate, since many temporary adjustments are currently being made to the maximum amount covered in order to face the financial crisis: for instance, the FDIC announced that the USD 250,000 coverage will remain effective through December 31, 2013; on January 1, 2014, the standard insurance amount will return to USD 100,000 per depositor. In the UK, the GBP 50,000 coverage is effective since October 7, 2008; before this date, the covered amount was GBP 35,000.

Moreover, the optimal coverage is still being debated, since there are pros and cons in increasing the maximum amount refunded. In theory, the higher the extent of the coverage is, the greater is the moral hazard issue to be faced, since on the one hand, the insured depositors are not incentivized neither to monitor the bank's management nor to make the correct choice when having to determine to which bank they want to entrust their deposits; on the other hand, the insured banks themselves do not need to remunerate the depositors with a higher interest rate when their investment policies become riskier.

On the contrary, when the coverage is too low, it turns out being ineffective, since it does not prevent bank runs, weakening the public confidence on the soundness of the financial system, nor does it adequately protect small depositors, who are not able to assess by themselves if a bank is healthy, due to the high costs implied.

A common measure to limit moral hazard is to adopt co-insurance arrangements, letting depositors bear a part of the failures' costs, but not all the authors agree on its effectiveness. Most of the times, this kind of arrangements are very complex and so, not comprehensible for the average depositor. For this reason, the public not always seems to realize the exact extent of the protection scheme.

1.3 The USA deposit insurance scheme: FDIC

The Federal Deposit Insurance Corporation (FDIC) is an independent agency of the United States government, which has been established in 1933 by the Banking Act and it has become effective on January 1, 1934. It's original aim was that of protecting small unaware depositors, restoring public confidence in the bank industry and increasing the stability of the financial system, which had been severely struck by the Great Depression. The FDIC proved to be an immediate success since only nine banks failed in 1934, compared to more than 9,000 in the preceding four years.

The original amount covered was USD 2,500 , but shortly after, on July 1, 1934, this was brought up to USD 5,000 for each depositor at an insured institution, except for certain mutual savings banks, whose coverage remained stable at the previous amount. In table 2 we briefly recall the variations of the FDIC coverage limits over its seven decades of activity:

Table 2: historical FDIC coverage limits

Year	Maximum coverage	Current relative value[10]
1934 (January)	USD 2,500	USD 32,652
1934 (July)	USD 5,000	USD 65,304
1950	USD 10,000	USD 74,080
1966	USD 15,000	USD 79,440
1969	USD 20,000	USD 93,929
1974	USD 40,000	USD 141,512
1980	USD 100,000	USD 227,185
2008	USD 250,000 *	USD 250,000

Source: FDIC (www.fdic.gov) and Bureau of Economic Analysis (www.bea.gov)

* the amount has been temporarily increased to face the current financial crisis and will go back to USD 100,000 from December 31, 2013

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[10] The following values have been found through the GDP Deflator, which represents an average measure of the price level regarding domestically and newly produced final goods and services. The formula used to calculate the deflator is the following:

$$GDP\ Deflator = \left({}^{Nominal\ GDP}/_{Real\ GDP}\right) 100 \ .$$

Another possible approach to calculate real values is the financial one, which takes into consideration the interest rates on US Government Treasury Bonds from 1934 to nowadays. All we have to do is capitalize the nominal values using the risk-free rates of return on Treasury Bonds. For each dollar of nominal value (NV) in 1934, for instance, we get the following real value (RV):

$$RV = \prod_{t=1934}^{2009} [1 + i(t, t+1)]$$

The FDIC is a public guarantee scheme which nowadays insures deposits at 8,246 institutions with an insurance fund totaling more than USD 17.3 billion. Moreover, as it is underlined in the FDIC introductory page from the official website[11], "FDIC insurance is backed by the full faith and credit of the United States government" and, "since the FDIC's creation in 1933, no depositor has ever lost even one single penny of FDIC-insured funds." The former statement does not seem to be very clear, since there are no strictly binding laws that force the government to intervene in case some insured liabilities are not met by the FDIC.

As far as the funding is concerned, the FDIC initially received USD 289 million from the US Treasury and the FRB, as it was decided in the 1933 Banking Act; while now it is only funded by premiums received from member institutions and by earnings on investments in US Treasury securities; it does not receive any kind of Congressional appropriation.

The first large-scale test for the FDIC was represented by the savings and loan crisis (S&L) in the late 80s and early 90s, after which the Savings Association Insurance Fund (SAIF) was created. The latter remained separated from the Bank Insurance Fund (BIF) till February 2006, when G. W. Bush signed into law the FDIRA (Federal Deposit Insurance Reform Act) of 2005, merging the two funds into the Deposit Insurance Fund (DIF).

The FDIC is managed by the Board of Directors, which is composed of five members, who have to be appointed by the President and confirmed by the Senate; to insure impartiality, no more than three of these members can belong to the same political party. Moreover, on the FDIC website, we can read that the mission of this agency is to "maintain stability and public confidence in the national financial system by:

- insuring deposits;

[11] www.fdic.gov

- examining and supervising financial institutions for safety and soundness and consumer protection;
- managing receiverships."

1.3.1 Limits to the FDIC protection

First of all, we have to specify that the USD 250,000 maximum coverage is referred to the total of all deposits that the account holders have at each FDIC-insured bank, assuming that all FDIC requirements are met. As for joint accounts, the limit is referred to each co-owner; while for revocable trust accounts the coverage regards only the interests of each beneficiary. For IRAs and several other retirement accounts, the limit of USD 250,000 is per owner. Accounts at different banks are insured separately, though considering all branches of a bank as a single bank.
More generally speaking, the FDIC covers all deposit accounts at insured banks and savings associations, including checking and savings accounts, money market deposit accounts and certificates of deposit (CDs). All the remaining financial products are excluded from the FDIC insurance, even in the case they have been bought through an insured institution. Among these excluded products, stocks, bonds, mutual and money funds' quotas are though insured by the Security Investor Protection Corporation (SIPC), but only in the event of brokerage failure.

1.3.2 Determination of the ex-ante contributions

Originally the FDIC scheme was based on flat premiums, but in 1993 it switched to risk-adjusted premiums. Until recently the scheme adopted a composed annual premium, whose flat part amounted to 0,0023% of each deposit unit, while the flexible part varied from 0 to an additional 0,0008%, according to the risk category the institution belonged to. These percentages operated both for the BIF and for the SAIF; moreover, when the minimum threshold of 1.25% of the total amount of insured deposits was reached, the flat contribution would become equal to zero.

On February 27, 2009, the FDIC adopted a final rule, modifying the risk-based assessment system and introducing initial base assessment rates beginning April 1, 2009. The current assessment rates are specified in table 3, where all rates are annual and in basis points, which are cents per USD 100,00 of assessable deposits:

Table 3: current rates

	Risk Category I	**Risk Category II**	**Risk Category III**	**Risk Category IV**
Initial Base Assessment Rate	12-16	22	32	45
Unsecured Debt Adjustment (added)	-5 to 0	-5 to 0	-5 to 0	-5 to 0
Secured Liability Adjustment (added)	0 to 8	0 to 11	0 to 16	0 to 22.5
Brokered Deposit Adjustment (added)	N/A	0 to 10	0 to 10	0 to 10
Total Base Assessment Rate	7 to 24.0	17 to 43.0	27 to 58.0	40 to 77.5

Source: www.fdic.gov/deposit/insurance/assessments.html

Risk Category I: Well Capitalized with generally a CAMELS composite of 1 or 2

Risk Category II: Well Capitalized with generally a CAMELS composite of 3; or Adequately Capitalized with generally a CAMELS composite of 1, 2 or 3

Risk Category III: Well or Adequately Capitalized with generally a CAMELS composite of 4 or 5; or Under Capitalized with generally a CAMELS composite of 1, 2, or 3

Risk Category IV: Under Capitalized with generally a CAMELS composite of 4 or 5.

The rate schedule above is effective since April 1, 2009; these rates have been applied for the first time for the invoice paid on September 30, 2009.

At this point a deeper insight on the CAMELS rating system is needed, it being the main criteria for the classification of the member institutions in the above risk categories. CAMELS ratings represent the nation's 8,500 banks' overall condition, assessed through six components, whose initial letters gave the name to this US supervisory rating system. In fact, the acronym CAMELS stands for Capital adequacy, Asset quality, Management, Earnings potential, Liquidity and Sensitivity to market risk. The assessments are primarily based on the results of on-site examination by regulators such as the Fed, the OCC and FDIC itself; the results of these assessments are directly disclosed only to senior bank management and to the appropriate supervisory personnel, not being released to the public. Ratings are assigned for each component in addition to the overall rating of a bank's financial condition. Moreover, the rating scale adopted considers a range of results from 1 to 5, where 1 and 2 are attributed to banks whose conditions present few, if any, supervisory concerns, while 3, 4 and 5 to those ones whose conditions present moderate to extreme degrees of supervisory concern.

In addition to the CAMELS ratings, the FDIC also bases its rates on the capitalization level of each bank, dividing them into five groups, which are:

- Well Capitalized
- Adequately Capitalized
- Under Capitalized
- Significantly Under Capitalized
- Critically Under Capitalized

The criteria adopted for the above classification are summarized in table 4 :

Table 4: Capitalization categories

	TOTAL RISK-BASED RATIO	TIER 1 RISK-BASED RATIO	TIER 1 LEVERAGE RATIO
Well Capitalized (all three conditions have to be satisfied)	≥ 10 %	≥ 6 %	≥ 5 %
Adequately Capitalized (all three conditions have to be satisfied)	≥ 8 %	≥ 4 %	≥ 4 % (*)
Under Capitalized (the occurrence of a single condition is enough)	≤ 8 %	≤ 4 %	≤ 4 % (*)
Significantly Under Capitalized (the occurrence of a single condition is enough)	≤ 6 %	≤ 3 %	≤ 3 %
Critically Under Capitalized	(**)		

Source: FDICIA

(*): the value is equal to 3% if the firm has not experienced an excessive growth in the last years

(**): tangible shares / total assets ≤ 2

Total risk-based ratio: % total capital / % risk weighed assets

Tier 1 risk-based ratio: Tier 1 capital / risk weighed assets

Tier 1 leverage ratio: Tier 1 capital / total assets

1.3.3 Alternative crisis solution methods

The supervisory activity of the FDIC is in charge of the peripheral offices and can be divided in two categories:

- on site examinations: the supervisory personnel makes its inspection in the bank

- off site examinations: the supervisory personnel continuously monitors the bank

by analyzing the periodical reports sent by the bank itself.

When a member institution is insolvent, the FDIC can manage the case in many different alternative ways, but the criteria to keep in mind when choosing the most suitable resolution are the following: primarily the preference has to go to the resolution implying the least duty on the financial system's behalf, but other aspects that do not have to be neglected are the maintenance of the public confidence, the respect of market discipline and the impartiality of treatment towards uninsured depositors and other creditors.

In the following paragraphs we will briefly explore the main and different alternative resolutions to FDIC's disposal.

1.3.3.1 Straight Deposit Pay-Off (SDPO) and Insured Deposit Transfer (IDT)

The Deposit Pay-Off is, under no shadow of doubt, the most extreme alternative, consisting on the one hand, in refunding the single insured depositors, and on the other hand in selling the insolvent banks' assets and consequently refunding the other creditors. Two alternatives are possible: with the SDPO, depositors are directly refunded, while with the IDT, their deposits are transferred to another institution.

The former brings along with it higher costs, both because the FDIC has to directly repay each insured depositor and face the social costs implied in this operation. In fact with this method, all the previous relationships between the insolvent bank and its clients are to be interrupted, causing a significant loss of information on both sides.

The latter, instead, is generally preferred, since it creates some advantages not only to the new bank, whose amount of deposits increase, but to the insured depositors as well, since they do not have to undergo long and expensive researches to find a new bank. In addition to this, another important difference is that in the first case the depositor gets refunded only for the maximum amount covered by the deposit insurance scheme, while, in the second case, he gets the whole deposit transferred, with no upper limits. With the IDT method, from the depositors' point of view, the insolvency of the member institution does not have any effect.

1.3.3.2 Purchase & Assumption (P&A)

This is probably the most followed resolution method, consisting in the assignment of both assets and liabilities to another institution. This solution offers the highest level of protection to all depositors, not considering whether they are insured or not. This procedure differs from the IDT, since in the latter only deposits are transferred to the other institution, while in this one both parts of the balance sheet are purchased by the receiving institution.

Practically, the FDIC takes over the insolvent institution as a whole, with the intent of selling it to another institution that guarantees a recovery prospective. The insolvent bank's creditors are totally covered, and at the same time the services to the clients are not interrupted. There are many possible forms of P&A, according to the percentage of assets and liabilities transferred; the main options are: a Basic P&A, where only liquid assets and insured deposits are transferred; a Modified P&A, in which, in addition to the assets involved in the Basic P&A, also part of the credits portfolio and part of the mortgage loans are transferred; a Whole Bank P&A, where all assets and liabilities are transferred "as is" to the receiving institution at a discount price.

1.3.3.3 Bridge Bank and Open Bank Assistance (OBA)

With the first of these two solutions, the insolvent bank is closed down and all its assets and liabilities are temporarily transferred to the Bridge Bank, whose operations will be supervised by the FDIC and whose intent is that of selling the whole assets and liabilities to a third institution. This

method is a particular form of P&A, having though the disadvantage of raising more costs for the FDIC, since two transfers have to take place before the procedure can come to an end.
In the OBA solution, instead, the insolvent bank is not shut down, since this can bring negative consequences to the financial system, activating the domino effect. In this case the FDIC tries to make the sale of the whole insolvent bank to another more attractive institution, by issuing credit or warrants in favor of the buyer institution, or buying shares or part of the assets itself.

1.3.3.4 Prompt Corrective Action (PCA)

This crisis resolution procedure consists in the timely intervention of the FDIC in favor of the troubled bank, before it becomes technically insolvent. The FDIC operates a reengineering action, trying to obtain a complete recovery of the troubled institution, by restructuring it or by favoring mergers and acquisitions before the economic value goes under a certain minimum level. If this method is successful, than all the relationships with the clients are saved and the troubled bank does not have to undergo liquidation procedures. In this case the time component is essential, since it can transform an ex ante risky condition in a ex post loss. The importance of this timely procedure is that the social costs raised by the closing of insolvent institutions are avoided or, at least, limited. According to Matute and Vives[12] (1996), in fact, this social cost we have been talking about consists in:

- loss of informational capital;
- destruction of long-term relationships between banks and borrowers;
- illiquidity costs of deposit holders;
- disruption in the payment system;
- contagion effects.

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[12] See Matutes, C. and Vives, X. (1996) – "Competition for Deposits, Fragility and Insurance", *Journal of Financial Intermediation*

1.4 The Italian deposit insurance scheme: FITD

In Italy the guarantee scheme for depositors is composed by two complementary funds, which are called: "Fondo Interbancario di Tutela dei Depositi" (FITD) and "Fondo di Garanzia dei Depositanti del Credito Cooperativo" (FGDCC). The latter insures exclusively the mutual banks ("Banche di Credito Cooperativo", BCC), which are therefore not obliged to participate in the FITD fund. This FGDCC fund has many members but the amount of money managed is quite low, since the BCC banks are mainly operating on a local scale, being much smaller than their other competitors. For this reason, the analysis we are going to do hereunder involves only the FITD, which is the most important of the two and which is more likely to be compared to the FDIC.

First of all we have to draw back to the origins of the FITD: it was established in 1987 as a private voluntary consortium, but the scheme has undergone many changes since then. The main reform has been issued in 1996 (d.lgs. n. 659/1996), when the 94/19/CE Directive was assimilated into the Italian law system. Thanks to this act, the fund has become a private compulsory consortium, which is disciplined by the Regulations and the Statute, which establishes the expiry date of the fund in December 31, 2050. At this date, the Assembly can decide either to prorogate the terms or to liquidate the fund, appointing at the same time one or more liquidators and defining their powers. When a question is not disciplined by these legislative sources, then the Libro V, Titolo X, Capo II of the Italian Civil Code regarding the consortiums has to be applied whenever its provisions are compatible with the other sources. The aim of the FITD, as it is expressly stated in ART 1 of the Statute, is to protect the depositors of the member institutions.

As far as the membership is concerned, all Italian banks, which are approximately 300, have to adhere to the FITD, except the mutual ones. The Regulations state that membership is open also to the branches of

EU banks operating in Italy, aiming at integrating the different national coverage systems; as for the branches of non-EU banks operating in Italy, they can participate to the FITD if authorized and in case they are not already members of an equivalent national depositors' guarantee scheme. So the insured depositors, are those who hold deposits in an Italian bank, a EU branch of an Italian bank, an EU or non-EU bank's branch operating in Italy. This is one of the main differences between the FITD and the FDIC, since only national banks can be members of the latter.

As for the coverage limit, it has been defined a maximum amount of EUR 103,291.38 per depositor and per institution, which is applied to the aggregate deposit amount held in each institution. If we look at the maximum amount covered in relation to the per capita gross domestic product (GDP), Italian coverage turns out being one of the highest. Regarding joint accounts, the limit is to be intended per co-owner, and the amount has to be divided by the number of co-owners, each quota being then added to the total of personal accounts and quotas of other joint accounts belonging to each co-owner. According to the Statute, the FITD covers only deposits, bank drafts and nominative certificates of deposits (CD), aiming at protecting exclusively unaware depositors. Bonds, shares and other financial instruments, even if issued by the member institution itself, are not covered by the FITD; even in case of insolvency, though, these financial products will still be belonging to the depositor, not being counted when defining the total assets and liabilities of the liquidated bank.

1.4.1 FITD contribution quotas

Here we come to the most important difference between FDIC and FITD: as for contribution quotas, in fact, the FITD does not ask the member institutions to pay periodical ex-ante fees in order to create a set fund beforehand, like in the FDIC case, but it just asks them to proportionally intervene ex-post, only in case one of these member institutions becomes insolvent.

The annual ex-post contribution is established by the Assembly, upon the proposals of the Board, between 0.4 % and 0.8 % of the repayable funds from all member institutions referring to June, 30 of the previous year. In case the amount of resources at FITD's disposal is inferior to 0.4 % due to interventions, the re-establishment of the minimum percentage will have to be made within the following four years. An important difference between FDIC ex-ante quotas and FITD ex-post ones, is that the former are fiscally deductible, while the latter are not. The ex-post quotas, as well as the initial contributions and the operating expenses' quotas, are based on the contributive basis of each member, whose details we will recall in the following paragraph.

1.4.2 Contributive basis

The contributive basis has to be periodically reported by the member institutions; in particular, unless there are different indications on the Bank of Italy's behalf, the deadlines are the following:

- April, 30 referring to the period going from July, 1 to December, 31 of the previous year;
- October,31 referring to the period going from January, 1 to June, 30 of the current year.

The contribution ex-post quotas for the intervention's expenses are annually calculated with reference to the balance sheet as of June, 30 and have to be communicated to the member institution they refer to. The members who have undergone special administration or compulsory administrative liquidation are excluded from the calculation as well as those benefiting from the intervention. In order to determine the quotas, all the contributive basis of the member institutions are summed together

and then the result is converted into thousandth proportional quotas, corresponding to the single member contributive basis divided by the summation of all members' contributive basis.
The contributive basis are proportional to the dimension of the member institution, resulting from the sum of the total amount of deposits and assets of each institution, to which we have to deduce the amount of equity of the single institution taken into consideration. The consequence is that, among those banks having the same amount of deposits, the ones that will have to pay higher quotas are those with less equity and more loans issued. There are also corrections to be made to these results according to the risk level of the single institution.

1.4.3 Cases of intervention and alternative crisis resolution procedures

The FITD intervenes only if previously authorized by the Bank of Italy in the following cases:

- a member institution has undergone special administration;
- a member institution has undergone compulsory administrative liquidation.

The alternative methods at FITD's disposal are the following:

- direct refunding in favor of all protected depositors;
- support in operations involving the transfer of assets and liabilities;
- recovery interventions.

The criteria to choose the most suitable alternative is that of economic convenience for the FITD fund. For this reason, some of its critics have claimed that these measures end up being in practice a violation of depositors' rights, since the refunding will hardly be the less expensive solution for the fund. However, this has to be considered as the last option, since it raises those social costs we have already discussed in the FDIC case.
As far as direct refunding is concerned, there is a substantial difference between the FDIC and the FITD. In fact, while in the former it immediately takes place, in the latter, instead, this will be much more

diluted: within the first three months of the liquidation, which can be prorogated to a maximum period of nine months, EUR 20,000 will be refunded; as for the remaining part, this will be paid according to what is established by the bank's liquidators. In any case, the amounts the FITD has to refund are not considered to be interest bearing.

1.4.4 Monitoring ratios

The FDIC evaluates each member's position according to some balance sheet ratios, which are also used in order to determine the exclusion of those institutions not meeting certain requirements. For each indicator we have four possible classes into which the signaled value should be put, and according to the class, the FDIC takes suitable measures. The coefficients applied to each class are summarized in table 5:

Table 5: coefficients for the determination of the synthetic index

	RATIO & COEFFICIENT	
CLASS	B1, C, D1, D2	A1
Normal	0	0
Attention	1	2
Warning	2	4
Violation	4	8

Source: FITD Statute, March 2006

The summation of all coefficients, each one representing a single ratio, gives us as a result the aggregate index, which is calculated each time the data is reported by the members. According to the value of this aggregate index, the member institution is classified in one of the six categories in table 6:

Table 6: Determination of the statutory position

Value of the aggregate index	Statutory position
0 - 3	Normal
4 – 5	Attention
6 – 7	Warning
8 -10	Penalty
11 - 12	Severe Imbalance
≥ 12	Expulsion

Source: FITD Statute, March 2006

When the aggregate index is:

a) ≥ 6 then the institution will have to quarterly report to the FITD the data referring to all the ratios to the FITD;

b) ≥ 8 then the institution will be automatically penalized;

c) ≥ 12 then the member will be excludible, as it is stated in ART 6, comma 1 letter a) of the Statute.

The FITD also calculates a weighted average aggregate index, based on the last three half-yearly reports, weighing each aggregate index as explained in table 7 :

Table 7: Weighted average aggregate index

Reference period of the aggregate index	Weight
June,30 current year	4
December,31 previous year	2
June,30 previous year	1

Source: FITD Statute, March 2006

The purpose of this weighted average aggregate index (w.a.a. index), is that of adjusting the contribution quotas of each member, in fact, when it is:

a) > 3, then the bank's quota shall be increased (the percentage increase is equal to the weighed average aggregate index);
b) 0 < w.a.a.index ≤ 3, then the bank's quota shall remain the same;
c) = 0, then the bank's quota shall be decreased (the percentage decrease is equal to the ratio between the total increases resulting from letter a) and the total contributions paid by the bank).

The single ratios that are taken into consideration by the FITD are the following:

A1= Bad Debts / (Equity + Subordinated Loans)

B1= Supervisory Capital / Total Supervisory Capital Requirement

C1= (IMMOB + PART) ≤ (PATRIM)

C2= (ATTL+50%ATTM) ≤ [AV1+FP+PASSL+50%PASSM+25%(PACBR+INTERB)]

D1= Operating Expenses / Gross Income

D2= (Loan losses – Loan Recoveries) / EBIT

Notes to C1 and C2 ratios:

IMMOB Real estate assets

PART Equity participations held in the portfolio

PATRIM Supervisory capital

ATTL Long-term assets (time to maturity > 5 years)

AV1 Surplus/deficit resulting from rule 1

FP Permanent provisions

PASSL Long-term liabilities (time to maturity > 5 years)

PASSM Medium-term liabilities (18 months < time to maturity ≤ 5 years)

PACBR Short-term liabilities (time to maturity ≤ 18 months)

ATTM Medium-term assets (18 months < time to maturity ≤ 5 years)

AV2 Surplus/deficit resulting from rule 2

INTERB Interbank liabilities with 3 months < time to maturity ≤ 18 months

Table 8: Thresholds

	A1	**B1**	**D1 ***	**D2 ***
Violation threshold	≥ 50 %	≤ 90 %	≥ 90 %	≥ 60 %
Warning threshold	≥ 30 %	≤ 100 %	≥ 80 %	≥ 50 %
Attention threshold	≥ 20 %	≤ 110 %	≥ 70 %	≥ 40 %

Source: FITD Statute, March 2006

* As for D1 and D2, the ratio can be calculated this way only in case both numerator and denominator are positive; when they do not meet this requirement the FITD attributes a coefficient that can be equal to 0 or 4, according to their signs.

As for C1 and C2, the coefficient is calculated by counting the number of rules that have not been respected; further explanation can be found in table 9 :

Table 9: C1 and C2 ratios

Number of rules not being respected	**Coefficient**
0	0
1	1
2	2

Source: FITD Statute, March 2009

2. The Black-Merton-Scholes model: a market approach to estimate the deposit insurance premium

2.1 Introduction

In this chapter we introduce a market approach to estimate the deposit insurance premium: the Black-Scholes model, which is named after Fischer Black and Myron Scholes[13], who first articulated their model in their 1973 paper, “The Pricing of Options and Corporate Liabilities”. Robert C. Merton[14], independently from the other two authors, published in 1973 his paper “Theory of Rational Option Pricing”, and coined the name “Black-Scholes” option pricing model. Merton’s intuition, as we will see in Chapter 3 of this work, has been that of applying this model to the deposit insurance case, in order to find the fair premium as the price of a put option. Merton and Scholes were awarded in 1997 with the Sveriges Riksbank Prize in Economic Sciences in memory of Alfred Nobel for these and other related works. Black was not awarded since he died in 1995, but nevertheless, he was mentioned as a contributor by the Swedish Academy. Section 2.2 introduces the hypothesis of this model, briefly explaining them, and Section 2.3 derives the Black-Scholes formula. Section 2.4 shows its main applications, while Section 2.5 explains its main limits; finally, Section 2.6 introduces some possible extensions.

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[13] See Black, F. and Scholes, M. (1973) - "The Pricing of Options and Corporate Liabilities", *Journal of Political Economy 81 (3).*

[14] See Merton, R. C. (1973) - "Theory of Rational Option Pricing", *Bell Journal of Economics and Management Science 4 (1).*

2.2 Underlying hypothesis of the option pricing model

The Black-Merton-Scholes model gives the unique no-arbitrage cost of European call and put options basing itself on market information. This model has been applied by Merton to the deposit insurance case, thinking of the insurance premium as the financial equivalent of a put option on the bank assets, having strike price equal to the amount of deposits and expiration time equal to the insurance coverage contractual expiry date. Merton developed a simple model[15], which has been a strong basis for further expansions by other authors in the following years. Further explanation of the Merton model for the determination of the fair insurance premium will be presented in Chapter 3 of this work.

Going back to the model itself, it has to be said first of all, that it is based on several strong assumptions, many of which have been criticized by the following economic literature for being far from the markets' reality. These working hypothesis are valid both for the option market and for the market of the underlying asset, in this case being a share:

- the price of the security follows a geometric Brownian motion (GBM) with drift parameter μ and volatility parameter σ [16];
- the strike price X is known and timely constant;
- it is allowed to hold naked positions and there are no constraints to the use of its related profits;
- taxes or transaction costs do not exist; or, if they do exist, they are the same amount for each market operator;
- the shares are perfectly divisible;

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[15] See Merton, R. C. (1977) – "An analytic derivation of the cost of deposit insurance and loan guarantees: an application of modern option pricing theory", *Journal of Banking & Finance,* Elsevier, vol. 1 (1), pages 3-11, June; and Merton, R. C. (1978) – "On the cost of deposit insurance when there are surveillance costs", *Journal of Business,* University of Chicago Press, vol. 51 (3), pages 439-52, July

[16] This assumption is supported by the fact that the normal distribution seems, at a first gross approximation, to be a suitable model for describing the stock's price variations, due to the fact that the latter is the result of a large number of factors, which are approximately independently and identically distributed.

- the underlying asset does not pay any dividend
- risk free arbitrage opportunities do not exist
- the stocks are continuously traded;
- the short period instantaneous risk free interest rate, *r*, is the same for all expiries.

Particular attention has to be paid to the first assumption: saying that the price of the share follows a GBM, it means that it follows a continuous-time stochastic process in which the logarithm of the randomly varying quantity follows a Brownian motion, also called a Wiener process. We can imagine the stock's price that follows a GBM with drift as a "particle that is subject to constant bombardment by smaller particles in the form of stock trades, or other local events"[17]. More generally, a stochastic process S_t is said to follow a GBM if it satisfies the following stochastic differential equation:

$$dSt = \mu\, St\, dt + \sigma\, St\, dWt$$

Where μ and σ are constants and W_t is a Wiener process, characterized by three facts:

1. $W_0 = 0$;
2. W_t is almost surely continuous ;
3. W_t has independent increments with distribution:

$$(W_t - W_s) \sim N\,(0, t - s) \qquad for\ 0 \leq s < t$$

The consequence of these facts is that a quantity following a GBM may take only positive values.

Before introducing the Black-Scholes formula, which will be the topic of the following paragraph, it is necessary to briefly recall the main characteristics of options and the factors that influence their prices. First of all, we talk about European options if the striking can only be done at

[17] Citation taken from: Roman, S. (2004) – "Introduction to the mathematics of finance: from risk management to options pricing", *Springer*

the expiry date established by the contract; otherwise, if the striking can also be executed before that fixed date, we talk about American options. The factors that influence the price of a stock option are:

1. the underlying asset's current price, S_0 ;
2. the strike price, K ;
3. the time to maturity, T ;
4. the volatility of the share's price, σ ;
5. the risk free interest rate, r ;
6. the expected dividends throughout the life of the option, whose present value is D.

Given the working hypothesis of the Black-Scholes model, the only risk factor is the share's price, being all the other factors assumed as constant. The variations of the share's price influence both the share's price and the option's price: as a consequence, it is possible to create a risk free portfolio, composed both of options and shares, through the delta hedging coverage strategy. In every short time interval, the gain (loss) on the shares' position is always balanced by the loss (gain) on the opposite options' position, so that the value of the whole portfolio is always known and immunized from risk. Having no arbitrage opportunities by hypothesis, the return rate of the portfolio has to be equal to the risk free interest rate, r. Though, the portfolio remains risk free only for a short time interval: in order to keep it risk free it has to be frequently readjusted or rebalanced.

For further explanation on the composition of this optimal risk-free portfolio see the following paragraph. Having made all these preliminary remarks, we can now introduce the Black-Scholes model.

2.3 The Black-Merton-Scholes option pricing model

In this paragraph we will derive first the Black-Merton-Scholes partial differential equation (PDE) and then the evaluation formula, which is the result obtained by solving the Black-Merton-Scholes PDE for a European call option.

2.3.1 The Black-Merton-Scholes PDE

Let's assume that the share's spot price, *S*, follows a Wiener process:

$$dS = \mu S\, dt + \sigma S\, dz \qquad (2.1)$$

Being *f* the price of a call option or of any other derivative depending on *S*, the variable *f* has to be a certain function of *S* and *t*, so that, applying Itô's Lemma[18], we have:

$$df = \left(\frac{\partial f}{\partial S}\,\mu S + \frac{\partial f}{\partial t} + \frac{1}{2}\frac{\partial^2 f}{\partial S^2}\,\sigma^2 S^2\right)dt + \frac{\partial f}{\partial S}\,\sigma S\, dz$$

(2.2)

The discrete versions of the (2.1) and (2.2) Equations are the following:

$$\Delta S = \mu S\, \Delta t + \sigma S\, \Delta z \qquad (2.3)$$

and

$$\Delta f = \left(\frac{\partial f}{\partial S}\,\mu S + \frac{\partial f}{\partial t} + \frac{1}{2}\frac{\partial^2 f}{\partial S^2}\,\sigma^2 S^2\right)\Delta t + \frac{\partial f}{\partial S}\,\sigma S\, \Delta z$$

(2.4)

where ΔS and Δf are the variations of *f* and *S* in a small time interval Δt. The Wiener processes that influence *f* and *S* are the same (the Δz in the 2.3 and 2.4 Equations are the same). The consequence is that the

[18] An "Itô's process" can be defined as a generalized Wiener process, where the parameters *a* and *b* depend both on the time, *t*, and on the value of the underlying variable, x, The formula is the following: $dx = a(x,t)dt + b(x,t)dz$.

Wiener process can be eliminated by choosing a portfolio composed of the share and the derivative. The portfolio we are talking about is the following:

-1 : derivative

$+\frac{\partial f}{\partial S}$: share

This means that we are holding a short position on the derivative for 1 unit and a long position on the share for $\frac{\partial f}{\partial S}$ units.

Being π the portfolio's value, we have:

$$\pi = -f + \frac{\partial f}{\partial S} S$$

(2.5)

The variation, $\Delta\pi$, of the portfolio's value in the time interval Δt is the following:

$$\Delta\pi = -\Delta f + \frac{\partial f}{\partial S} \Delta S$$

(2.6)

By substituting Equations (2.3) and (2.4) into Equation (2.6), we obtain:

$$\Delta\pi = \left(-\frac{\partial f}{\partial t} - \frac{1}{2}\frac{\partial^2 f}{\partial S^2} \sigma^2 S^2\right) \Delta t$$

(2.7)

In Equation (2.7) we do not have the Δz : this means that during the time interval Δt, the portfolio is risk free. Recalling the working hypothesis of the preceding paragraph, we have that the portfolio's return in the next time instant has to be equal to the short period risk free return rate; if this is not true there will be arbitrage opportunities. The consequence is that:

$$\Delta\pi = r\,\pi\,\Delta t \qquad (2.8)$$

where *r* is the risk free interest rate. By substituting the values of π and $\Delta\pi$ given by Equations (2.5) and (2.7) into Equation (2.8), we obtain:

$$\left(\frac{\partial f}{\partial t} + \frac{1}{2}\frac{\partial^2 f}{\partial S^2}\sigma^2 S^2\right)\Delta t = r\left(f - \frac{\partial f}{\partial S}S\right)\Delta t$$

(2.9)

so that

$$\frac{\partial f}{\partial t} + rS\frac{\partial f}{\partial S} + \frac{1}{2}\sigma^2 S^2 \frac{\partial^2 f}{\partial S^2} = rf$$

(2.10)

Equation (2.9) is the Black-Merton-Scholes PDE we are looking for; it has many solutions, one for each derivative depending from *S*. The specific solution depends on the boundary conditions, which determine the derivative's value for extreme values of *S* and *t*. In the case of a European call option, the main boundary condition is the following:

$$f = \max(S - K, 0) \quad when\, t = T \tag{2.11}$$

In the case of a European put option, it is instead the following:

$$f = \max\left(\mathbf{K} - S, \mathbf{0}\right) \quad when\, t = T \tag{2.12}$$

As we said at the end of paragraph 2.2, the portfolio we obtained remains risk free only for an infinitesimal time period. When *S* and *t* change, also $\frac{\partial f}{\partial S}$ changes, so that the relative quantities of the derivate and the share have to be continuously readjusted in order to keep the portfolio risk free.

2.3.2 The Black-Scholes evaluation formulas

The Black-Scholes evaluation formulas for the prices at time 0 of a European call and a European put option on a share that does not pay any dividends are the following:

$$c = S_0 N(d_1) - K e^{-rt} N(d_2) \tag{1.13}$$

and

$$p = K e^{-rt} N(-d_2) - S_0 N(-d_1) \tag{1.14}$$

where

$$d_1 = \frac{\ln \left(S_0/K\right) + \left(r + \sigma^2/2\right) T}{\sigma \sqrt{T}}$$

$$d_2 = \frac{\ln \left(S_0/K\right) + \left(r - \sigma^2/2\right) T}{\sigma \sqrt{T}} = d_1 - \sigma \sqrt{T}$$

Notation:

N(x) is the distribution function of a normal variable with average equal to 0 and standard deviation equal to 1

S_0 is the share's price at time 0

K is the strike of the option

r is the risk free interest rate, continuously compounded

σ is the volatility of the share's price

T is the time to maturity of the option.

In the case of a European call option, when S_0 is very high, the value of d_1 and d_2 becomes very high as well, while the value of $N(d_1)$ and $N(d_2)$ is approximately 1: the consequence is that the call option will almost surely be struck. Instead, in the case of a European put option, when S_0 is very high, the option's price tends to 0, being $N(-d_1)$ and $N(-d_2)$ approximately equal to 0.

2.4 Black-Scholes formula: some practical applications

In this paragraph we introduce some of the applications of the formula we have derived in the preceding paragraph. We will first give a closer look to the delta hedging strategy, which we have already briefly introduced in the preceding paragraph, and then we are going to show an application that concerns more closely the theme of this work: the portfolio insurance.

2.4.1 Delta hedging strategy

One of the main Black-Scholes formula applications is for delta hedging strategies, that are particularly adopted for risk management in options sales by both market makers operating in markets with regulation and financial institutions operating in over the counter markets. Given the perfect correlation between the derivative and the underlying asset, it is possible to immunize the position in call (put) options from the underlying asset's volatility of the price by holding a position of the opposite (same) sign on the share itself. Under the assumption of geometric Brownian motion, the return from a call option having strike price *K* and exercise time *T* can be replicated by the following investment strategy: $C\,(S_0\,,T,K)$ will be the investment capital and $\frac{\partial}{\partial s}\;C\,(s,t,K)$ the delta quantity of shares to hold when the security's current price is *s* and time *t* remains before the option expires.

The performance of these strategies depends on the frequency of the rebalancing actions, being the portfolio, thus obtained, only immunized for an infinitesimal time period. Having to face the problem of transaction costs in real markets, a good compromise between the coverage's precision and the rebalancing frequency has to be found.

The rebalancing actions emphasize the upward or downward trends of the underlying asset's price, having to purchase the underlying asset when its quotation is increasing and having to sell it in case of a decrease. The paradox in this case is that the coverage strategies on the one hand limit the risk at a macroeconomic stage, while on the other hand, they emphasize the risk itself at a microeconomic stage.

2.4.2 Portfolio insurance

In this paragraph we are going to introduce another important application of the Black-Scholes formula, that is the portfolio insurance. This strategy is adopted by the market operators wanting to insure their portfolios from the downside risk, which is the risk of negative variations in the prices of the shares composing the portfolio itself. There are two main alternatives: the market operator can choose to buy either an insurance contract or a stock option.

An insurance contract guarantees a payoff that depends on the final value of the insured portfolio, W_T. Being X the value guaranteed by the insurance company, the payoff of an insurance contract will be the following:

X if $W_T \leq X$

W_T if $W_T > X$

The other alternative consists in buying a put option on the share the market operator is holding in his portfolio, having a strike price equal to the value he wants to have guaranteed. If the security's price decreases till it goes under the strike price, then the portfolio's value will diminish, but, at the same time, the option becomes in-the-money and by exercising it, the market operator will have the desired guaranteed profit. In this way, it is possible to replicate the payoff of an insurance contract.

In real markets, the kind of insurance contracts we are talking about is rather seldom issued by the insurance companies, so that the most adopted strategy for portfolio insurance is to buy stock options. The main problem is that an option for each different security held in the portfolio is not available on the market, and even if it had been, the transaction costs would have been far too high. The easiest solution is to buy an option on an index.

2.5 Black-Scholes formula: the most significant limitations

Most of the parameters of this formula can be directly observed in the financial markets: together with the calculus simplicity, this is the main reason of its success, even though it has many limitations that have been underlined by the economic critics over the years.

The only variable that cannot be taken directly from the market information is the volatility of the share's price. In this model it is assumed to be constant, but this does not represent reality in a correct way. Volatility is often calculated on a historical base, taking into account the standard deviation of a historical series of prices; typically the time horizon chosen varies from a three month to a one year period, due to the fact that considering older data could turn out being misleading. The limitation in this case is that, by using historical volatility, often the market price differs from the value we obtain using this formula, due to the fact that most probably the market believes that the stock's volatility over the life of the option will not remain the same as it was historically.

A more accurate estimate of the stock's volatility can though be obtained using the Black-Scholes formula in a different manner, finding the so called implied volatility. This is the value of σ that, together with the other parameters of the option pricing formula, makes the result found with the Black-Scholes formula equal to the market cost of the option. A common occurrence, though, is that the volatility of the underlying asset's price has different values for different expiry dates, and, for the same expiry date, has different values for different strike prices.

The first effect is indicated as the *temporal structure* of the implied volatility: the main reason for this is that the Black-Scholes model underlying assumption of constant volatility is unrealistic, actually it has a

decreasing temporal structure in real markets, that present high volatility on short expiries along with low volatility for longer ones.
The second effect is the so called *Smile*, or *Skew*, effect: this occurs when the implied volatility distribution is highly asymmetrical if compared with its relative strike prices. The Black-Scholes model assumes that the underlying asset's return follows a normal distribution, but in reality it has greater variations, so that the distribution is characterized by high tails.
Another limitation of this model is that it works only for European options not paying dividends, for which we know exactly the exercise date beforehand, not being contractually possible to anticipate the strike. The model can be extended in order to evaluate the price of an American call option that does not pay any dividend, since in this case the anticipated exercise will not be profitable; but it does not work in the American put option case.
Moreover, the most significant limitation is that the authors assume the underlying asset follows a geometric Brownian motion, which is instead only an approximation to reality that can be improved: for instance, Merton himself criticized some years later this unrealistic preliminary hypothesis, proposing other solutions for the stochastic process, that we will recall in the following paragraph.
Also the assumption of the absence of taxes and transaction costs is very strong and turns out being unrealistic: if we admit the presence of these costs, then the delta hedging strategy will have a certain cost and can become not profitable in several cases.
In spite of all these limitations though, the Black-Merton-Scholes model is still widely used in practice, especially as a basis for more refined models, being a reasonable approximation that can be easily calculated and improved. In fact, this model can be adjusted in order to deal with some of its significant failures: rather than considering some parameters as constants, it is better to consider them as variables, such as to introduce other potential risk sources that had been ignored in the original model.

2.6 Black-Merton-Scholes model: main extensions

In this paragraph we are going to introduce some of the main extension of the option pricing model: their common characteristic is to remove one or more of the preliminary assumptions done by Black-Merton-Scholes in order to adjust the model and make it become closer to reality. We will collect the extensions according to the hypothesis they have removed.

First of all, we are removing the assumption that the security pays no dividends nor other forms of periodical payments, but we continue working only with European options. We can consider their price as composed by two elements: we have on the one hand the risk free part and on the other hand the risky one. We assume that the former one is used to pay the periodical dividends, so we can think of it as the summation of the dividends' present values, actualizing them with the risk free interest rate. At the expiry date, the dividends will have already been entirely paid, so that the risk free part of the price does not exist anymore. The Black-Scholes formula will then be correct when S_0 is equal to the risky part and σ is this latter's volatility. We can then use this formula if we deduce the present value of the dividends' summation from the share's price.

We can now try to remove another strong assumption of the model and work with American options as well, them being the most common in the financial markets. In case the American call option does not pay any dividend, it is not necessary to make any correction to the original formulas, since the anticipated exercise will not be profitable. In most cases though, American options do pay dividends and they are frequently exercised before the expiry date: the right to exercise the option before the expiry date, has thus a certain value, that has to be considered in order to find the correct price. An extension of the original model to include the American call options that pay dividends has been proposed by Black[19], and is known as "Black's approximation". He considers two European call options having expiry dates *T*, which is the same expiry date as the American option, and t_n , which represents, instead, the instant preceding the payment of the last dividend; the price of the American call option will then be equal to the biggest one between the two European options' prices. This easy approximation works in the majority of the cases, though more refined models have been proposed as well.

For instance, Roll, Geske and Whaley proposed another model called RGW[20], where they work under the assumption of a bi-varied normal distribution. In his paper "Valuation of American Call Options on Dividend Paying Stocks: Empirical Tests" (1982), Whaley[21] has empirically tested on a sample of 15.582 options commercialized in the Chicago Board, three alternative models, which are: the RGW model, Black's approximation (AB) and finally the original Black-Merton-Scholes (BMS) model. The average evaluation error for each model was: 1,08% for RGW, 1,48% for AB and 2,15% for BMS. The typical bid-ask spread of a call option is more than 2,15%, so that we can say that all the three models worked sufficiently well.

As far as American put options are concerned, we can say that if they pay dividends, then the anticipated exercise will most probably not be profitable, although we do not have any explicit formula to calculate their price. The only case in which we have an explicit formula, which

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19 See Black, F. (1975) – "Fact and fantasy in the use of options", *Financial Analysts Journal, 31, pages 36-41 and 61-72.*

20 See Roll, R. (1977) – "An analytic formula for unprotected American Call Options on stocks with known dividends", *Journal of Financial Economics, 5, pages 251-8;* Geske, R. (1979) – "A note on an analytic valuation formula for unprotected American Call Options on stocks with known dividends", *Journal of Financial Economics, 7, pages 375-80;* Whaley, R. E. (1981) – "On the valuation of American Call Options on stocks with known dividends", *Journal of Financial Economics, 9, pages 207-1;* Geske, R. (1981) – "Comments on Whaley's note", *Journal of Financial Economics, 9, pages 213-5.*

21 See Whaley, R. E. (1982) – "Valuation of American Call Options on Dividend Paying Stocks: Empirical Tests", *Journal of Financial Economic 10.*

has been proposed by Merton[22] in 1973, is when the American put options are perpetual and the underlying security does not pay any dividend. Apart from this specific case, in all the other cases the price has to be calculated with indirect methods.

Another assumption that should be removed from the original model is the absence of taxes and transaction costs in the markets: M. Scholes[23] (1976) expanded the original model in order to consider the effects of taxation on the options' prices; while the transaction costs have been introduced in the model by H. E. Leland[24] (1985), who assumes that the delta hedging strategy has a certain cost, as a consequence of the presence of transaction costs in the market. In particular, the author studied the impact of transaction costs on the performance of the covered portfolio, considering them proportional to the value of the underlying asset's transaction. The result of these studies is that, considering transaction costs, an hedger estimates a long (short) position less (more) than the value found using the Black-Scholes formula.

The last extension we are going to introduce regards what is probably the most fundamental but unrealistic hypothesis made in the option pricing model: the stochastic process followed by the underlying security's price. The geometric Brownian motion is considered to be only an approximation to reality because it assumes that future price changes are independent from past prices; while, on the contrary, past prices can be studied to draw useful indications of an upward or downward trend in future prices.

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[22] See Merton, R. C. (1973) - "Theory of Rational Option Pricing", *Bell Journal of Economics and Management Science 4 (1).*

[23] See Scholes, M. (1976) – "Taxes and the pricing of options", *Journal of Finance,* American Finance Association, vol.31 (2), pages 319-32, May

[24] See Leland, H. E. (1985) – "Option pricing and replication with transaction costs", *Journal of Finance 40*

A possible alternative to GBM is the one introduced by J. C. Cox, S. A. Ross and M. Rubinstein[25] (1979), who maintain in their CRR model all the preliminary hypothesis made by Black and Scholes, apart from the stochastic process followed by the underlying asset's price: they adopt a binomial approach to evaluate options' prices in a discrete time. R. C. Merton, instead, has criticized the hypothesis that the exchanges occur in continuous time in the markets, proposing in 1976 a mixed model[26], where the share's price follows a discontinuous and a diffusion process at the same time.

[25] See Cox, J. ; Ross, S. A. and Rubinstein, M. (1979) – "Option Pricing: A Simplified Approach", *Journal of Financial Economics 7*

[26] See Merton, R. C. (1976) – "Option pricing when underlying stock returns are discontinuous", *Journal of Financial Economics, Elsevier, vol. 3 (1-2), pages 125-44*

3. Deposit Insurance Pricing Models

3.1 Introduction

In this chapter we are going to use the option pricing model we have been discussing in Chapter 2, in order to determine the fair deposit insurance premium. This approach has been originally proposed by R. Merton[27] (1977), who had the intuition of applying the Black-Scholes model to the insurance case, giving birth to a method which has been named "à la Merton". The basic Merton (1977) model has then been developed by several other authors to deal with some of its main practical limitations. In particular, we are going to have a deeper insight at Marcus and Shaked[28] (1984) model and Ronn and Verma[29] (1986) model, which can be considered as the improved versions of Merton

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27 See Merton, R. C. (1977) – "An analytic derivation of the cost of deposit insurance and loan guarantees: an application of modern option pricing theory", *Journal of Banking & Finance,* Elsevier, vol. 1 (1), pages 3-11, June.

28 See Marcus, A. J. and Shaked, I. (1984) – "The valuation of FDIC deposit insurance using option pricing estimates", *Journal of Money, Credit, and Banking,* 4, pages 446-60.

29 See Ronn, E. I. and Verma, A. K. (1986) – "Pricing Risk-Adjusted Deposit Insurance: An Option-Based Model", *Journal of Finance,* 41, pages 871-95.

model. Merton himself in 1978, proposed a new version, transforming his limited-term model into an unlimited-term one and considering some more features, mainly auditing costs.

The most important limitation of the option pricing approach, as we will see further in this chapter, consists in its dependence on market values, which can be considered to be reliable inputs for our formulas only in case we are dealing with market-oriented countries. On the contrary, if we are dealing with developing countries or under-developed ones, this approach is not likely going to produce significant results.

For this reason, after having discussed the option pricing approach, we are going to introduce two alternative ones, which are the expected loss pricing and the microeconomic approach, which overcome the limitation we have just explained.

This chapter is organized as follows: in section 2 we will introduce Merton model, considering first the original 1977 version and then the 1978 improved version. In the following two sections we will show its two main developed versions, which are: Marcus and Shaked model (Section 3) and Ronn and Verma model (Section 4). Finally, in Section 5, we will discuss the main limits of the option pricing approach, introducing some alternative methods for the determination of the deposit insurance premium.

3.2 Merton model

In this paragraph we will introduce first Merton (1977) limited-term put option model of deposit insurance (3.2.1) and then the (1978) extended version (3.2.2), considering an unlimited-term model.

3.2.1 Merton (1977) limited-term model

Merton approach to determine the fair premium for a deposit insurance scheme is based on the option pricing theory. Firstly, he demonstrates that the payoff issued by a perfectly credible[30] third-party guarantor to the bondholders of a firm can be considered financially equivalent to that of a put option with strike price equal to the promised repayment and the underlying asset being represented by the value of the firm's assets.

In order to apply this result to the deposit insurance case, we can consider the bank as a corporate, whose debts are represented by customers' deposits[31]. To simplify our reasoning, let us assume that total banking debts equal the total amount of deposits and that the latter are totally insured.

Let us then define the market value of the bank's assets as V and the face value of the bank's liabilities as D; under these assumptions, the repayment the insurance company will have to provide is the following:

$$R = \max\ [0, D - V] \tag{3.1}$$

where R represents the bank's net liabilities, which is the amount the insurance company has to cover. Equation (3.1) considers the two possible scenarios:

a) V ≥ D : in this case the bank will not be insolvent, so the insurance company's repayment is equal to $[0]$;
b) V < D: in this case, instead, the bank will undergo liquidation for being insolvent; the insurance company has to repay depositors an amount equal to $[D - V]$, which represents the obligations remained unmet after the liquidation procedure has come to an end.

[30] By perfectly credible we mean that there is no uncertainty whether the obligation will be met or not: the bondholders rely on the guarantor, thinking that under no circumstances the latter will not be able to meet its obligations. As far as the credibility is concerned, public guarantee schemes are generally considered to be much more credible than private ones, as we have already discussed in the introduction to this work.

[31] Mainly bank deposits are due on demand; the consequence of this is that the maturity of banking liabilities is generally shorter than that of other corporations.

Considering that D is a constant[32] and V is a stochastic variable, we can think of Equation (3.1) as the payoff of a European put option, with a strike price equal to V, the underlying asset being represented by D, and the expiration date equal to the contractual expiry date of the insurance coverage. Assuming that V follows a geometric Brownian motion with volatility equal to σ, we can now determine the insurance premium simply applying the Black-Scholes formula for put options:

$$P = D\, e^{-rT}\, N(x_2) - VN(x_1) \tag{3.2}$$

where

$$x_1 = \frac{\ln\frac{D}{V} - \left(r + \frac{1}{2}\sigma^2\right)T}{\sigma\sqrt{T}}$$

$$x_2 = x_1 + \sigma\sqrt{T}$$

Notation:

P: value of the deposit insurance guarantee per unit of insured deposit[33]

D: face value of the bank's liabilities

r : risk-free interest rate[34]

T: time to maturity of the bank's debts

V: market value of the bank's assets

σ: volatility of V

N(●): cumulative probability density function for a standard normal distribution

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[32] As we have previously said D stands for the liabilities' face value, which remains fixed throughout the whole debts' life. On the contrary, the market value can be considered as a stochastic variable, being influenced by the market operators' expectations on the bank's performances.

[33] If we want to compare deposit insurance premiums across countries, the value of P has to be normalized on a single currency unit.

[34] Merton does not consider the risk premium since one of the assumptions of the Black-Scholes model is the absence of arbitrage opportunities: the consequence of this assumption is that the return on a risk-free portfolio must equal the risk-free interest rate. For further explanations see Chapter 2, paragraph 2.2.

In Equation (3.2) the unknown variables are represented by V and σ, so the fair insurance premium can be calculated after having determined their values through market research.

As far as time to maturity is concerned, Merton (1977) assumes that this can be considered as the time until the next audit regarding the bank's assets will take place. To simplify the calculus he also assumes that the next audit will take place in one-year's time and that the time to maturity of the bank's debts is equal to one year as well. From this, it follows that the deposit insurance scheme has been modeled as a limited-term contract, having a fixed finite time period in between two subsequent audits. In the following paragraph, we will introduce Merton's (1978) extension to the unlimited-term model.

3.2.2 Merton (1978) unlimited-term model

This model can be considered as an extended version of the (1977) one: in fact, the main difference is that the auditing time can be randomly chosen by the auditor itself; in addition to this, Merton[35] explicitly takes into account surveillance or auditing costs.

Having assumed that the audit procedure can randomly take place, we can describe the event of an audit with a Poisson distribution, where the λ parameter represents the audit rate[36] and successive audit times are independently and identically distributed. Having done all these preliminary considerations, Merton demonstrates that, in a competitive banking system, with neither transaction costs nor entry barriers for newcomer banks, the equilibrium deposit insurance premium per unit of deposits can be found solving the following equation:

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[35] See Merton, R. C. (1978) – "On the cost of deposit insurance when there are surveillance costs", *Journal of Business,* University of Chicago Press, vol. 51 (3), pages 439-52, July.

[36] By audit rate we mean the probability of an audit taking place; moreover, $\lambda \, dt$ will represent the probability of an audit taking place over the next time instant.

$$P(x) = 1 - \frac{k-1}{\delta + k} x^{-\delta} \qquad\qquad \textit{with } x \geq 1$$

(3.3)

where

$x = \frac{V}{D}$, which is the assets-to deposits-ratio ;

$k = \frac{1}{2} \left\{1 - \delta + [(1+\delta)^2 + \gamma]^{\frac{1}{2}}\right\}$;

$\delta = \frac{2 \lambda K}{\sigma^2}$;

$\gamma = \frac{8 \lambda}{\sigma^2}$

Notation:

P: deposit insurance premium per unit of deposit

V: market value of the bank's assets

D: face value of the bank's liabilities

σ: volatility of V

K: audit costs

δ: annualized dividend yield

The premium we find by solving Equation (3.2) in the 1977 limited-term model is a monotonically decreasing function of the assets-to-deposits ratio, which we have indicated as x in Equation (3.3). On the contrary, the premium we find through the 1978 unlimited-term model does not follow a similar relation, due to the introduction of the audit costs. In this model, in fact, we have to consider that the total amount paid by the bank can be divided in two parts: a first one, (A), which is equal to the insurance premium on the bank's liabilities we find in the 1977 limited-term model; and a second one, (B), which is equal to the audit costs. The latter is a monotonically increasing function of the assets-to-deposits ratio, while the former, as we have already stated, is a monotonically increasing function of x. The result is a trade-off between these two components, which shifts in A's direction for small values of x and in B's direction when the value of the ratio is approximately equal to 1 or higher.

3.3 Marcus and Shaked model

Marcus and Shaked[37] proposed an improved version of the original Merton model of 1977 in their 1984 working paper called "The valuation of FDIC deposit insurance using option pricing estimates", where they adopt their new model for conducting empirical research on fair insurance premia for U.S. banks. In particular, they took a sample consisting in 40 main U.S. banks and then calculated the fair insurance premia for the period 1979-1980, comparing their results with the rates actually charged by the FDIC. They finally drew the conclusion that FDIC was over-pricing the deposit insurance premia, since they found through their model that the average fair amount to be charged was nearly a half of that effectively charged by the FDIC itself.

Moving our focus on the Marcus and Shaked model (MS), we have to say that it has basically been built adopting the option pricing approach, originally proposed by Merton. The two authors, though, introduce some important corrections: first of all, they consider the difference between the bank assets' value before and after having obtained the deposit insurance. We will call V the former value and V+P the latter, where P stands for the value of the deposit insurance.

[37] See Marcus, A. J. and Shaked, I. (1984) – "The valuation of FDIC deposit insurance using option pricing estimates", *Journal of Money, Credit, and Banking,* 4, pages 446-60.

Assuming that V follows a GBM with volatility parameter equal to σ_V, the value of P can then be found with the following formula:

$$P = D\, e^{-r\,T} N(x_2) - V\, e^{-\delta\,T} N(x_1) \qquad (3.4)$$[38]

where

$$x_1 = \ln\frac{D}{V} - \frac{\left(r - \delta + \frac{1}{2}\sigma_V^2\right)T}{\sigma_V\,\sqrt{T}}$$

$$x_2 = x_1 + \sigma_V\,\sqrt{T}$$

Equation (3.4) is basically equivalent to Equation (3.2) from the Merton limited-term model; the only difference is that we have introduced another issue in the formula, which is the effect of dividend distribution on the internal reserves. The parameter δ, in fact, represents the dividend rate: when dividends are distributed, the bank's internal reserves decrease. We can then consider Equation (3.4) as a more general version of Equation (3.2), thinking of the latter as the limit case in which the dividend rate, δ, equals to 0.

In order to estimate the values of our two unknown variables, V and σ_V, we now have to introduce two more relations, which are the following:

$$V + P = D + E$$

(3.5)

and

$$\sigma_E\, E = \sigma_V V\, \frac{\partial E}{\partial V}$$

(3.6)

Notation:

P: value of the deposit insurance

E: market value of the bank's equity, which can be found multiplying

[38] For the complete notation see page 49, Notation to Equation (3.2); hereunder, in the notation to the remaining equations, we will only explain the new parameters we add.

the market value of the bank's shares by the total number of ordinary shares issued by the bank.

σ_E: volatility of the present value of the bank's equity, which can be estimated with the historical approach, drawing the result from the past series of data regarding the shares' price.

Equation (3.5) is a general rule taken from accounting: it simply tells us that in our bank's balance sheet, the sum of all assets must be equal to the sum of all liabilities. At this point, to simplify the calculation, Marcus and Shaked assume that, as far as the bank's debts are concerned, the face value is equal to the present value.

Equation (3.6), instead, is given by simply applying Itô's lemma, thinking that the market value of the bank's equity, E, depends on both the market value of the bank's assets, V, and this latter's volatility, σ_V :

$$E = f(V, \sigma_V)$$

We now have to substitute Equation (3.4) into Equation (3.5):

$$E = V - D + P = V - D + De^{-r\,T}N(x_2) - Ve^{-\delta\,T}N(x_1) \qquad (3.7)$$

Then, we have to substitute Equation (3.7) and its differential form into Equation (3.6):

$$\sigma_V = \sigma_E \left[1 - {De^{-r\,T}\{1 - N(x_2)\}}\big/{Ve^{-\delta\,T}\{1 - N(x_1)\}}\right] \qquad (3.8)$$

The three unknown variables we have to find are then P, V and σ_V : all we have to do is contemporarily solving Equations (3.4), (3.5) and (3.8).

3.4 Ronn and Verma model

Ronn and Verma[39] (1986,1989) adopt the "à la Merton approach" to determine the fair insurance premium, introducing, though, some more elements in the original model. The greatest difference between their model and the MS model we have discussed in the previous paragraph, is that the former takes into account the value of the bank's assets after having obtained the deposit insurance, while, on the contrary, Marcus and Shaked considered the value of the bank's assets before the deposit insurance. We will then call V* the assets' value in Ronn and Verma model (RV), to maintain the differentiation we have just discussed:

$$V^* = V + P$$

where V^* is the market value of the bank's assets in RV model and it can be thought as the result of adding the value of the deposit insurance to the market value of the bank's assets in MS model.

Another difference with the MS method is that RV do not use the relation shown in Equation (3.5), but they substitute it with the following relation:

$$E = V^* N(y_1) - \rho\, D\, N(y_2) \tag{3.9}$$

where

$$y_1 = \frac{\ln\left(V^*/\rho D\right) + \frac{1}{2}\,\sigma_V^2\, T}{\sigma_V \sqrt{T}}$$

$$y_2 = y_1 - \sigma_V \sqrt{T}$$

with $0 < \rho \leq 1$

[39] See Ronn, E. I. and Verma, A. K. (1986) – "Pricing Risk-Adjusted Deposit Insurance: An Option-Based Model", *Journal of Finance,* 41, pages 871-95; and Ronn, E. I. and Verma, A. K. (1989) – "Risk-Based Capital Adequacy Standards for a Sample of 43 Major Banks", *Journal of Banking and Finance,* 13, pages 21-9.

In Equation (3.9) we are defining the market value of the bank's capital through the option pricing approach: we can imagine it, in fact, as the price of a call option, whose underlying asset will be the bank's assets, V^*, and whose strike price will be represented by the future value of the bank's liabilities, $D\ e^{rT}$, where D stands for the face value of the bank's liabilities.

What is interesting about Equation (3.9) is that RV introduce for the first time the parameter ρ, which indicates the capital forbearance given by the supervisory authorities, which are here represented by the FDIC. To use Ronn and Verma's words, forbearance is a "temporary reprieve from closure"[40]. In Merton model (1977), we have built deposit insurance as a limited-term contract, assuming that the following audit was supposed to take place in one-year's time and that the debts' maturity was fixed on that same date. Actually, this assumption seems too restrictive, since the government is used to give some forbearance after having found that the bank is undercapitalized. With the introduction of the regulatory forbearance parameter, ρ, we are taking into account that the longer the forbearance is, the higher the value of the deposit insurance will be, due to the fact that, after having found the bank undercapitalized, the FDIC might provide financial assistance or exercise forbearance instead of ordering the bank's closure straight away.

Under this model, the bank's closure is not ordered until V^* equals ρD, which is less than D, being the value of ρ between 0 and 1. This means that when V^* is equal to D, even though the bank is in a net debt position, the closure is not ordered by the FDIC, which takes as a closure rule $V^* \leq \rho D$. We can then interpret ρ as the market operators' expectations on the possibility of the FDIC giving forbearance to the audited undercapitalized bank. RV found through empirical analysis on the U.S. banks that the most realistic value for ρ is 0.97, this meaning that

[40] Quotation taken fro: Ronn, E. I. and Verma, A. K. (1986) – "Pricing Risk-Adjusted Deposit Insurance: An Option-Based Model", *Journal of Finance,* 41, pages 871-95.

the FDIC will order the bank's closure only when the assets' market value is equal to or less than the 97% of the liabilities' face value.

As in MS model, RV adopt the relation given by Equation (3.6), but they do not rearrange it in the form of Equation (3.8). On the contrary, they first partially differentiate Equation (3.6) into Equation (3.9), getting the following result:

$$\frac{\partial E}{\partial V^*} = N(y) \qquad (3.10)$$ [41]

Then, substituting Equation (3.10) into Equation (3.6), they derive the following relation:

$$\sigma_V = \frac{\sigma_E}{V\ N(y)} \qquad (3.11)$$

Apart from the capital forbearance, another new relevant issue introduced by RV in their model is the difference between the insured liabilities and those who are not insured. Having previously defined the face value of all bank's liabilities as D, we are going to represent the face value of the insured liabilities as D_1 and the face value of those uninsured as D_2, where obviously the sum of the two categories has to give us as a result D:

$$D = D_1 + D_2$$

We are now going to assume at first that all liabilities are covered by deposit insurance[42], so that the hypothetical deposit insurance premium, P^*, can be determined as follows:

[41] See footnote number 38.

[42] We are assuming that $B_1 = B$, with $B_2 = 0$, as in Merton model (1977) and in MS model (1984).

$$P^* = D\ N(x_2) - V^* e^{-\delta\ T} N(x_1) \tag{3.12}$$

where

$$x_1 = \frac{\ln\frac{D}{V} + \left(\delta - \frac{1}{2}\sigma_V^2\right)T}{\sigma_V\ \sqrt{T}}$$

$$x_2 = x_1 + \sigma_V\sqrt{T}$$

Finally we can remove the assumption of total coverage for all liabilities, setting a maximum coverage as it happens in reality, so that the deposit insurance premium can be calculated with the following formula:

$$P = \frac{D_1}{D}\ P^* = D_1 N(x_2) - \frac{V^* e^{-\delta\ T} D_1}{D} N(x_1)$$

(3.13)

We can then derive the insurance rate, d, as follows:

$$d = \frac{P}{D_1} = N(x_2) - \frac{V^* e^{-\delta\ T}}{D} N(x_1)$$

(3.14)

3.5 Alternative approaches: the expected loss pricing and the microeconomic approach

The option pricing approach introduced by Merton (1977) has become widely adopted since it offers a simple method to evaluate deposit insurance premia, basing itself on market data. Another relevant characteristic of this approach, is that it is very robust to changes: it has actually been developed over the years thanks to the contributions of many authors, each one of them introducing every time a new issue in the basic model, in order to overcome its main limitations and to reduce the level of approximation.

This approach, though, has a very important limitation: it can be applied only in case the bank's evaluation made by market operators is available. This means that the option pricing based models can be applied to determine only the deposit insurance premia regarding listed banks. In the U.S. case this not a great limitation, but if we think about developing countries, such as India and China, the availability of market data is not something we can take for granted. In Italy as well, only recently, due to its entry in the EU, the number of listed companies has been increasing, but we cannot say that Italy is a market oriented country that can be compared to U.S. or U.K., since the vast majority of companies are family run and their average size is medium-small.

For these reasons, we are now introducing some alternative approaches to determine deposit insurance premia, which are not based on the option pricing framework. In paragraph 3.5.1 we are discussing the microeconomic approach and then in paragraph 3.5.2 we will show the expected loss pricing approach.

3.5.1 The microeconomic approach

The microeconomic approach was proposed by Klein-Monti in 1971 and has been generalized by Dermine[43] (1986), who introduced in the model deposit insurance and the risk attitude of the single bank. Before

[43] See Dermine, J. (1986) – "Deposit rates, credit rates and bank capital: the Klein-Monti model revisited", *Journal of Banking and Finance,* vol.10, number 1, March 1986, pages 99-114.

introducing this approach, though, we first have to show a model that allows us to determine the probability of the bank turning out being insolvent.

The model we are going to use for this purpose is the Cogger-Emery[44] one (1982): these two authors originally applied it to the context of industrial companies; anyway, with some corrections, we can apply this model to banks[45]. We consider the bank ending up in a default situation when all its liquid assets are over. To be more precise, we assume that the bank's liquidity trend can be described with a GBM with absorbent barrier in the origin: if the bank runs out of liquid assets, then the process touches the barrier and causes the bank to be insolvent.

Moreover, Cogger-Emery consider the time interval $I = [0; T_0]$ so that, neither endogenous factors, such as the bank's Board of Directors, nor exogenous ones, such as the competent monetary policy authorities, can intervene and modify or reintegrate the bank's liquidity.

Assuming that the period in which the bank is under observation goes from 0 to *t*, its default probability, F(t), is given by the following formula:

$$F(t) = N\left(\frac{-D_0 - \mu t}{\sigma\sqrt{T}}\right) + e^{\frac{2\mu D_0}{\sigma^2}} N\left(\frac{\mu t - D_0}{\sigma\sqrt{T}}\right)$$

(3.15)

Notation

N: standard normal distribution;

D_0: liquidity at disposal at the beginning of the observation period;

μ: average periodical net cash flow;

σ: standard deviation of the periodical net cash flow

[44] See Cogger, K. O. and Emery, G. W. (1982) – "The measurement of liquidity", *Journal of Accounting Research* 20, pages 290-303.

[45] For the application of Cogger-Emery model to banks, see Foschini, G. (2008) – "La copertura assicurativa dei depositi bancari: criteri per la determinazione della tariffa", *Economia, impresa e mercati finanziari 2008/3.*

In Equation (3.15) the first part, $N\left(\frac{-D_0 - \mu t}{\sigma\sqrt{T}}\right)$, represents the probability that the bank runs out of liquid assets exactly at time *t*, while the second part, $e^{\frac{2\mu D_0}{\sigma^2}} N\left(\frac{\mu t - D_0}{\sigma\sqrt{T}}\right)$, can be interpreted as a corrective factor, that allows us to calculate the probability of the bank turning out illiquid within the time interval that ends in *t*. The values for μ, σ and D_0 that we have to input in Equation (3.15) can be taken from the financial statements of the preceding years.

Having calculated the default probability, we can then define the deposit insurance premium as follows:

$$P_t^i = F^i(t) C_t^i \qquad \text{with } i=1,2,\ldots..,n \qquad (3.16)$$

Equation (3.16) tells us that the deposit insurance premium that the i^{-th} bank has to pay in order to insure its deposits for the period [0,t], depends on both the bank's default probability, $F^i(t)$, and the default costs, C_t^i. If we assume that the bank insures all its deposits, then, in case of default, it will receive from the insurance company a refunding for $D^i - A^i$, which is the result of subtracting the bank's assets, A^i, to the amount of insured deposits, D^i. In order to take this assumption into consideration, the insurance premium defined in Equation (3.16) will then have to be changed in the following way:

$$P_t^i = F^i(t)\,[D_t^i - A_t^i] \qquad (3.17)$$

Equation (3.17) represents the premium that the bank has to pay to the insurance company for covering all of its deposits. Actually, a total coverage is not provided under any of the deposit insurance schemes, which have defined maximum limits to the coverage of each deposit, as we have already discussed in Chapter 2 of this work. Equation (3.17), then, can be substituted by the following one:

$$P_t^i = F^i(t)\,[\alpha D_t^i - A_t^i] \tag{3.18}$$

In Equation (3.18) we introduce the parameter α, representing the percentage of deposits which are insured.

3.5.2 Expected loss pricing

Another alternative approach for the determination of the deposit insurance premium is the expected loss pricing. The main difference between this approach and the option pricing based models is that we remove the assumptions of normal distribution and GBM, starting to consider asymmetrical distributions for the expected loss probability. Actually, empirical researches have proven that the probability of incurring into extreme losses is much higher than that one implied in a normal distribution. Deposit insurance schemes, therefore, should take into account that the insurance agency will have to face on the one hand a relatively high probability of limited losses, due to the default of small banks, and on the other hand, a relatively low probability of huge losses, because of the default of a single large bank or more.

We are now going to introduce the expected loss pricing model, where the expected loss can be defined as the average value of the losses' distribution. The formula to calculate the expected loss is the following:

$$EL = AE \cdot PD \cdot (1 - RR) \tag{3.19}$$

where

$$RR = 1 - LGDR$$

Notation:

EL: Expected Loss

AE: Adjusted Exposure

PD: Probability of Default

RR: Recovery Rate

LGDR: Loss Given Default Rate

Equation (3.18) tells us which are the key variables that determine the expected loss. We are now going to have a deeper insight at each one of them, first from the point of view of the single bank and then from that one of the deposit insurance agency.

The Adjusted Exposure (AD) represents the amount of insured deposits and it can be estimated through the following relation:

$$AE = DP + UP + UGD \tag{3.20}$$

Notation:

DP: drawn portion

UP: undrawn portion

UGD: usage given default

Equation (3.19) tells us that the Adjusted Exposure (AE) is the result of the summation of three components: the drawn portion (DP), which is the part of the loan that the counterpart has already used; the undrawn portion (UP), representing the part of the loan still to be used, and the usage given default (UGD), which stands for the percentage of the UP which the bank presumes will be used by the debtor when he becomes insolvent.

As far as the Probability of Default (PD) is concerned, instead, the estimation methods are usually based on historical data referring to a period of at least five years. The minimum level of PD which can be assigned is 0.03%, except for the loans given to countries' governments[46], for which there is no minimum limit. Insolvency occurs in one of the following two cases:

a. Subjective insolvency: the bank thinks it is highly improbable that the debtor will meet all of his obligations;
b. Objective insolvency: the counterpart is delaying more than 90 days the repayment of one of its obligations[47].

There are basically three approaches to find the expected level of PD:

1) Fundamental analysis: this method involves the use of U.S. CAMEL ratings or their equivalents for other countries;
2) Market analysis: this approach, on the contrary, is based on interest rates or yields on uninsured bank debt, such as, for instance, interbank deposits and subordinated debt;
3) Rating analysis: this method involves evaluations made by rating agencies, among which the most known ones are surely Moody's and Standard and Poor's (S&P).

Moving the focus on the Loss Given Default Rate (LGDR), we have to say that it represents the loss rate referred to a certain exposure which the creditor will have to face in case the debtor becomes insolvent. The LGDR can be found through the following formula:

$$LGDR = 1 - \frac{(ER - AC)/_{EAD}}{(1+i)^t}$$

(3.21)

Notation:

ER: Expected Recovery, which represents the amount of money the bank thinks to recover from the debtor;

[46] According to Basil 2, the exposures of the single banks have to be divided into five categories in order to calculate the capital requirements. These five categories are the following: corporate, retail, banks, governments, equity.

[47] In Italy the required delay period in order to consider an exposure as objective insolvency consists in 180 days.

AC: Administrative Costs, which stand for the internal and external administrative costs implied in the recovery procedure;

EAD: Exposure At Default, which represents the expected exposure when the insolvency state occurs.

The second part of Equation (3.20), $\frac{(ER - AC)/_{EAD}}{(1+i)^t}$, represents the Recovery Rate (RR); therefore, the LGDR rate can be defined as the complement to one of the RR. Moreover, the LGDR represents a useful indicator of the severity of the loss.

Up to this point, we have considered the expected loss from the bank's viewpoint, referring to the management evaluations on the loans portfolio. If we now consider the insurance agency point of view, we can basically use the same model we have just presented, changing only the initial input data: while we have referred to loans as the bank's exposures, we now have to refer to the total amount of insured deposits as the insurance agency's credit exposure. The rest of the reasoning we have previously done is valid also for the case of insurance agencies. The Expected Loss can be thought as representing the cost of the insurance coverage for the agency. As a consequence of this, in order to reach the breakeven point (BEP), the insurance company has to set the deposit insurance premium per unit of insured deposit to the expected loss price.

If on the one hand, this model is very general, allowing us to adapt it to fit each country's peculiar characteristics, on the other hand it has a relevant limitation, which is the fact that deposit premia are greatly influenced by monetary policy decisions and for this reason, the estimated default probabilities might not reflect the real default probabilities.

Conclusion

In this work we have been discussing about the various characteristics of deposit guarantee schemes and how to determine the fair premium. What is interesting at the moment, is to see how these schemes have reacted to the spread of the financial crisis we have been facing since the last trimester of 2008 and draw a comparison with the Great Depression experience, in order to evaluate which lessons can be taken from such a catastrophic past experience.

A very interesting comparison between the Great Depression and the present financial turmoil, has been proposed by Jeffrey Frankel[48], professor at Kennedy School of Government, Harvard University,

[48] See Frankel, J. (2009) – "A new depression? The lessons of the 1930s", Jeffrey Frankel's Weblog, February 22nd, 2009.

according to whom "there are plenty of analogies between now and then:

(i) A crisis in the US financial sector that had its roots in long excessive booms in real estate and the stock market;
(ii) The spreading of the crisis from the financial sector to the real economy and throughout the world; and even
(iii) Popular American disillusionment with a Republican president perceived as too passive and too beholden to the rich, which then helps elect a charismatic and activist new Democrat."

On the other hand, though, there are also plenty of differences between the present situation and that one of the 1930s: the Great Depression brought to the creation of the first Deposit Guarantee Schemes, which were followed by the introduction of minimum banking capital requirements and supervisory institutions, thanks to the two Agreements of Basil. The main problem, though, remains that of regulating the non-bank financial institutions, which have been rapidly developing throughout the last decade. They are now competing with banks, offering the same services but acting more freely, since the regulation of this sector is not comparable with that of banks, the latter being penalized as a consequence.

An important lesson we have learnt from the Great Depression, concerns trade policy: actually historians agree on defining the Smoot-Hawley Tariff Act as the crucial step leading to the burst of the depression. This Act was signed by President Hoover in 1930 and introduced an aggressive protectionism policy in the U.S., raising duties on some 20,000 imported goods. The chain reaction caused by this Act was that of convincing the other countries to emulate this policy, leading to a tragic collapse of world trade over the following years and facilitating the rise of nationalism in Germany and Japan, thus putting the basis for the burst of the Second World War.

As far as the monetary and fiscal policy are concerned, we have learnt from the Great Depression that the competent authorities should counterbalance the losses on the demand side with aggressive monetary expansive policies and suitable fiscal easing policies. According to Milton Friedman and Anna Jacobson Schwartz[49], the roots of the depression have to be traced in the "great contraction" of credit caused by the domino effect of bank failures. These two authors state that the Fed should have conducted open-market operations, cutting rates, making loans and buying bonds, with the result of pumping liquidity in the worn out financial sector. On the contrary, the Fed started putting into action large-scale open-market purchases only on April 1932, when the situation was already irretrievable, thus not being able to prevent a final wave of bank closures at the end of that year.

Another interesting opinion on this theme, is that of Warren Brussee[50], a retired General Electric quality assurance engineer expert, who predicted the present financial crisis in 2005, in his book "The Second Great Depression". For instance, in a passage of this book, we can read the following prediction, which turned out to be dramatically true: "Come 2008 the number of people giving up on making house payments will skyrocket. Since many of the recent mortgage loans were adjustable rate, or had little or no collateral, banks will be forced to foreclose on homes and sell them, causing a glut of homes on the market and a deflation of home values". Apart from predicting the burst of the housing bubble, Brussee indicates the real problem in the over-indebt American families, who could have found some cushion through reducing the savings amount; on the contrary, for the last few years they have had negative savings rates. In addition to the American families' excessive debt, U.S. have been experiencing a very large deficit of the commercial balance, together with a $11 trillion national debt.

Nevertheless, the situation is not that bad as it could appear at a first sight: unemployment has not reached the 10% threshold yet, which is a

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[49] See Friedman, M. and Schwartz, A. J. (1963) – "A monetary history of the United States, 1867-1960", National Bureau of Economic Research, *Princeton University Press.*

[50] See Brussee, W. (2005) – "The Second Great Depression: Starting 2007 Ending 2020", *Booklocker.com* .

relatively small amount if compared with the 25% peak of the Great Depression, which was reached in 1933. Moreover, the current average living standard is much higher than that one of the 1930s, which is a point worth to be stressed. Another fact that needs to be highlighted is that the experience of the Great Depression has left us plenty of lessons to be learnt in order to avoid reaching once again that catastrophic situation. In particular, the Fed Chairman, Ben Bernanke, is one of the top experts in the monetary history of the 1930s: for these reasons, since the beginning of the credit crunch, he has repeatedly cut the federal-funds rate, pumping money in the financial system through a variety of channels.

Moving the focus on the Italian situation, we have to say that the situation is less tragic than the American one: the main reason is that Italian families have always been keen on saving and they will probably never reach the debt levels of the American ones. The great problem in Italy, though, is the overwhelming national debt, whose parameter is far above the European standards. On the other hand, though, it has to be said that Italian banks have not bought plenty of these junk bonds deriving from the securitization of the subprime mortgages, of which the American banks' balance sheets are full.

As far as the role of the deposit guarantee schemes is concerned, we can now trace some possible future scenarios. First of all, within 2010, all European schemes must increase their maximum coverage up to € 100,000, which is a "psychological and political amount: to put depositors entirely at rest as regards protection of the vast majority of their deposits and as a response to a crisis situation."[51] In addition to this, the harmonization of the various national deposit insurance schemes is currently being debated: if on the one hand, this seems to be the next step towards the creation of a unique European market, on the other

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[51] Quotation taken from: European Commission (2009) – "Informal experts roundtable on Deposit Guarantee Schemes (DGS) on 31 March 2009 in Brussels", Draft Minutes, Brussels, 27 April 2009.

hand, though, substituting the national schemes with a pan-EU scheme is much easier to say than to put into practice, since this will weaken the national schemes and the credibility of the banking system could be affected as well. The best way to implement this unique European scheme is that of gradually introducing it, by allowing banks to participate in it, while contemporarily letting them remain members of their national scheme. Moreover, this pan-EU scheme, if well designed, can be useful in preventing failures of cross-border operating banks and in covering the gaps of national guarantee schemes, thus operating as a sort of reinsurance system.

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