Real Options and Bank Bailouts: how Uncertainty affects Optimal Bank Bailout Policy*

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Abstract

This paper develops a real options consistent bailout decision rule that specifies under which conditions it is optimal to liquidate or bail out a bank based on the amount of liquidity it creates. Due to its construction, the rule incorporates the option value of waiting stemming from the irreversibility of liquidation and bailout decisions and the possibility to delay. We apply the rule to various cases in order to evaluate the quality of bank bailout policy in the EU-15. The main contribution however lies in the application of real options analysis to the field of bank bailout policy.

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1 Introduction

During the recent financial crisis, large attention has been given to the sizeable bailouts used by governments to save distressed banks. Be it in the form of loans, recapitalizations, altered legislation or even nationalization, bank bailouts seem to be the most common policy response in times of financial turmoil. Many questions however remain concerning the validity of the various interventions. Do the benefits of bailout truly outweigh the significant direct and indirect costs? Do the receiving banks truly fit the too-big-to-fail or, more general, the too-important-to-fail label they receive? In this paper, we develop a real options consistent bailout decision rule that specifies under which conditions it is optimal - from a social welfare perspective - to liquidate or bail out a bank based on the amount of liquidity it creates. Due to its construction, the rule incorporates the option value of waiting stemming from the (at least partial) irreversibility of liquidation and bailout decisions and the possibility to delay. As such, it advocates a more cautionary approach that adequately deals with the uncertain economic environment accompanying a crisis. It also lends itself to practical applications, including the evaluation of past bailout decisions. Were the conditions met in case a bailout was observed? How well did e.g. the EU-15 perform? These and other questions can and will be answered by applying the developed rule to various cases from the past.

This paper is of course not the first attempt to guide optimal bank bailout policy. Cordella & Yeyati (2003) argue that a bailout regime has two offsetting effects, namely a moral hazard effect (bailout increases risk-taking incentives) and a value effect (bailout decreases risk-taking incentives). Given this trade-off, they argue that governments should commit ex-ante to bail out banks in adverse macroeconomic conditions - where the value effect is dominant - but not otherwise. Freixas (1999) on the other hand considers the cost difference between rescue and liquidation cost as the driving force behind a government's choice for bailout. If the bank under consideration has a large amount of uninsured debt (and consequently low deposit funding), the cost of rescue is much higher compared to the cost of liquidation as in the latter case, the uninsured debt does not have to be compensated. In general, one can then calculate "a critical level of uninsured debt beyond which the lender of last resort will not rescue any bank" (p. 24). Goodhart & Huang (2005) determine a critical value for a banks' deposit volume beyond which bailout is always optimal, with the main underlying assumption being that liquidation costs rise at a faster rate than bailout costs with respect to bank size. Acharya & Yorulmazer (2007) take a too-many-to-fail approach and determine a rule based on the amount of bank failures. Given that banking assets should ideally remain in the hands of a bank for most efficient use, they argue that bailout is only optimal when the total number of failing banks is so large that the surviving banks are not able to keep the assets in the industry via purchases and take-overs. Aghion, Bolton & Fries (1999) expand the analysis by taking the effects of bailout on the reporting incentives of bank managers into account while Gong & Jones (2010) characterize a three-tiered bailout rule based on the systemic costs a bank imposes in the case of failure.

The rule we develop here will contribute to this literature by introducing - to our knowledge for the first time - real options theory in the analysis of bank bailout decisions. In doing so, we are able to adequately deal with the uncertain economic environment accompanying a crisis via the incorporation of the option value of waiting - a key concept that has always been negliged in the aforementioned research. While a decision may indeed seem optimal at one point in time, neglecting the possibility of economic recovery/deterioration in the future may lead to suboptimal decisions from a dynamic perspective. Only when the value of waiting is completely accounted for - as in a real options consistent bailout decision rule - can this bias be avoided and efficient decisions be possible. This principle is key in our evaluation of the quality of bank bailout policy in the EU-15, the second main contribution of this paper.

In the following section we will start the development of the bailout decision rule by discussing the model setup. In section 3, the model is solved while section 4 applies the rule to various EU cases. Section 5 details some possible model extensions, while section 6 concludes.

2 Model Setup

We seek to formulate a real options consistent bailout decision rule that determines when a government should save or liquidate a failing bank. The starting point here is one of the economic functions banks perform in the economy, namely liquidity creation[1]. As described

[1] The other main function of banks is risk transformation: "banks transform risk by issuing riskless deposits to finance risky loans" (Berger & Bouwman, 2009, p. 3779-3780). Liquidity creation and risk transformation often coincide (riskless deposits are often more liquid than risky illiquid loans) but the relation is not perfect (Berger & Bouwman, 2009). For the simplicity of the analysis, we only focus on liquidity creation.

in the seminal article by Diamond & Dybvig (1983), banks create liquidity on the balance sheet by transforming illiquid assets[2] into liquid liabilities. In particular, due to the advantages of resource pooling and knowledge about the fraction of people that will require funds prematurely, banks are able to offer 'new' deposit contracts with a different, smoother pattern of returns over time than the existing illiquid assets offer. This is welfare-improving, as at least some losses associated with the premature selling of assets can be avoided and risk-averse depositors are basically insured against liquidity risk. The rule developed below assumes exactly this: welfare is increasing in the amount of liquidity a bank creates, with the quantification being based on the liquidity creation measures of Berger & Bouwman (2009). We also assume that liquidity creation is related to the financial health of the bank: the healthier a bank is, the better deposit contracts it can offer (e.g. because more and better investment opportunities open up as its health/financial strength increases) and the more liquidity it creates.

The model analyzes bailout decision making concerning a single bank, where the related decisions are taken by a government that has full control on central bank behavior. Let overall liquidity creation by the bank under scrutiny be denoted as L. This amount of liquidity creation is not constant, but varies over time due to different influences. In particular, we assume that L follows a Geometric Brownian Motion (GBM) (**?**):

$$dL = \alpha L dt + \sigma L dz. \tag{1}$$

In this expression, α - the drift parameter - and σ - the variance parameter - are known constants and dz is the increment of a Wiener process. The first term indicates the growth rate in liquidity creation over time. α is assumed to be negative in times of financial turmoil, positive in times of high economic activity or 0 in a neutral/baseline scenario. L on the other hand is always non-negative, which is a key characteristic of the GBM. The second term, which includes the Brownian motion process, captures normal fluctuation in liquidity creation due to factors such as fluctuations in asset prices on which the individual bank has no influence. These concern relatively small changes where a priori the sign of the change is unknown, making the Brownian motion with its zero mean a good modelling choice.

The government has an interest in the performance of banks as the liquidity they create -

[2] An illiquid asset is an asset where the premature selling of that asset results in a loss.

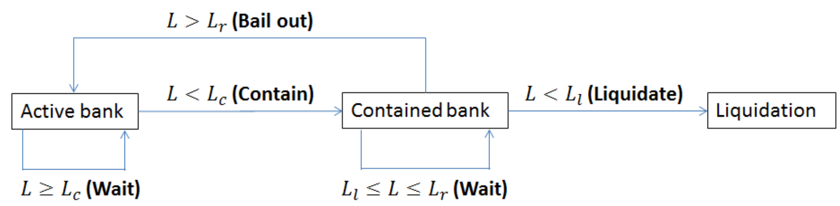

Figure 1: Bailout decision tree

simply by being active in the market and executing their core activity - contributes to social welfare (as discussed above). This is captured by W, which depicts the net social welfare contribution of the bank as a function of L and is strictly increasing in this variable:

$$W = f(L) \quad \text{with} \quad \frac{df}{dL} > 0. \tag{2}$$

Note however that this net welfare contribution by the bank (W) is not necessarily positive. This is only the case when $L > \bar{L}$, the latter being the amount of liquidity that is required to cover the opportunity value of a bank's operating cost, including its use of personnel that could have been employed in other welfare-creating activities. If $L < \bar{L}$, with $\bar{L} > 0$, we assume welfare to be negative due to the bank using resources without creating 'excess liquidity'.

As in Laeven & Valencia (2008), we make a distinction between the containment phase - in which "governments tend to implement policies aimed at restoring public confidence ..." - and the restructuring phase - which "involves the actual financial, and to a lesser extent operational, restructuring [in this case bailout or liquidation] of financial institutions and corporations". Within these phases, the authors find that emergency liquidity support (provided in 71% of the cases) and bank recapitalizations/bailouts (provided in 78.6% of the cases) are, among various other measures, the most observed policy responses, rendering them the most suitable decisions for use in the model. The practical implementation occurs by assuming that a bank can be in two different states: an active state - in which the bank follows the rules of the market - and a contained state - in which it receives emergency liquidity support. Three threshold values will determine the conditions under which it is optimal to transition from one state to the other or to engage in liquidation. These transitions can be schematically represented as in figure 1.

Every bank starts as an active bank that contributes to societal welfare for an amount W by achieving a certain liquidity creation level of L, which is also an indicator of a bank's health/financial situation. When such a bank gets into trouble due to negative evolutions on the asset market and/or the general economic situation, L will start taking on lower and lower values as the problem persists. As long as L remains larger than the critical threshold level $L_{containment}$ ($=L_c$) however, it is optimal to keep the bank active: its net social welfare contribution $W(L)$ is still positive or, in case it is negative, it is not so low as to justify the sunk costs associated with the transition. These costs emerge from the fact that the decision to provide liquidity support is at least partially irreversible (due to the nature of the support, it is quite unlikely that once given, it can be immediately reclaimed without some losses) and can be delayed, giving rise to an option value of waiting. Only when L becomes so low ($L < L_c$) that it produces negative excess liquidity *and* completely erodes the option value of waiting is it optimal to contain the bank in order to avoid the activity-related losses but still maintain the possibility of 'reactivation' (in case the situation improves) and liquidation (in case the situation worsens). For practical purposes this implies that contained banks, due to the support program, are able to produce exactly liquidity $\bar{L}$, so no activity-related welfare cost is incurred in containment. The support however does come at a constant monetary (= also welfare) cost of b, which is incurred each period the bank is in the contained state. Assuming that liquidity support takes the form of collateral loans[3], this opportunity cost of b could be interpreted as the difference between the return on investment the government would have received by using the funds on the best alternative project minus the expected monetary return of ELA, which percentage-wise is most likely lower. Intuitively, a larger liquidity gap would require larger government input, which would be reflected in an increasing b. However, if one assumes that the required monetary return on ELA also increases as more means are required to cover the liquidity gap, the use of a constant b is justified.

Depending on the previous situation, the bank now finds itself in an active or contained

[3] In the Eurozone, ELA [= Emergency Liquidity Assistance] can be defined as "emergency loans given by euro zone national central banks to strapped commercial banks. The loans are given at the discretion of the national central bank although they have to be approved by the ECB. [This implies, among others, that] national central banks may provide ELA 'against adequate collateral' and only to 'illiquid but solvent' credit institutions". Source: Suoninen, S., & Jones, M. (2013, March 21). Factbox - How ECB's emergency liquidity assistance works. Reuters. Retrieved from: http://uk.reuters.com/article/2013/03/21/uk-factbox-ecbs-emergency-idUKBRE92K0DT20130321

state. If it is still active, the liquidity creation of the bank is once again compared to the containment threshold in order to decide whether containment is appropriate. If it is not, the bank remains in the active state. Otherwise, it moves to the right. If the bank finds itself in a contained state, there are three possible transitions that can occur: reactivation, liquidation or continuation of the contained state. Reactivation/bailout is optimal whenever the liquidity creation of the bank outside containment is high enough to both compensate the bailout/recapitalization cost (B) required to make this transition as well as the option value of waiting associated with the partial irreversibility of the bailout and the possibility to delay the decision[4]. In more formal terms, this implies that reactivation is optimal when L exceeds the yet to be determined reactivation threshold (L_r). Liquidation on the other hand is advisable when L drops below the liquidation threshold (L_l), which signals the point where the sustained cost of liquidity support erodes the cost of liquidation as well as its respective option value, stemming from the *full* irreversibility of liquidation. Finally whenever L is situated between the threshold values, it is optimal to wait and continue the contained state in order to fully incorporate the possibility of economic recovery/deterioration in the future.

The values of the specific thresholds - which basically characterize the bailout decision rule - can be determined by using so-called value-matching and smooth-pasting conditions, similar to the ones used in the 'mothballing model' described in Dixit & Pindyck, 1994, section 7.2. Basically, the value-matching conditions are used to specify at which point the value of a firm in one state (e.g. active) is equal to the value of the same firm in the other state (e.g. contained), taking into account possible costs required to change from one state to the other. The smooth-pasting conditions on the other hand are technical conditions that require the respective derivatives to match at that point. In total, we have three sets of equations that characterize the different threshold values[5].

- For the transition from active bank to contained bank, we have:

$$W_a(L_c) = W_c(L_c), \tag{3}$$

$$W_a'(L_c) = W_c'(L_c), \tag{4}$$

[4] While we assume that a bailout is required to successfully complete the transition from contained to active bank, you can loosen this assumption by choosing a very low value for B.

[5] To keep the calculations as simple as possible, we currently make no mention of moral hazard or contagion effects. These issues are however touched upon in section 5.

where W_a is the social value of the active bank when it is operating freely in the market and W_c is the social value of the bank when it is contained. In normal situations, banks are most productive when they are active, as W_a contains the present value of the bank's future welfare contributions and the option value of containing the bank. The exogenously specified discount rate is hereby depicted by ρ. In times of distress however, the welfare contributions may turn negative ($L < \bar{L}$) so that W_c - which consist of a) the negative present value of the liquidity support assuming it lasts forever ; b) the option value of reactivating the contained bank and c) the option value of liquidation - can become higher than W_a. In general, one can therefore say that the value-matching condition (3) basically determines the point where this switch from normal conduct (LHS) to containment is desirable, which starts being the case from L_c and lower[6].

- For the transition from contained bank to active bank, one gets:

$$W_c(L_r) = W_a(L_r) - B, \tag{5}$$

$$W_c^{'}(L_r) = W_a^{'}(L_r), \tag{6}$$

where W_c and W_a are as defined above and B is the sunk bailout cost expressed in welfare terms. Value-matching condition (5) thus basically requires that L should be large enough so that market liquidity creation outperforms liquidity creation under containment with a margin at least as large as the net bailout cost, which occurs from L_r and onwards. Only then is it optimal to execute the bailout.

- For the transition from contained bank to liquidation, one obtains:

$$W_c(L_l) = -\varpi D, \tag{7}$$

$$W_c^{'}(L_l) = 0. \tag{8}$$

Here, the value-matching condition requires that one should liquidate the bank when the option value of waiting - encompassed in W_c - is eroded by the sustained cost of liquidity

[6] Note that, similar to Dixit & Pindyck (1994), one could also include a sunk policy development cost in the value-matching condition in order to stress the partial irreversibility of the containment decision.

support in such a way that it becomes lower than the amount of deposit insurance the government has to pay out in case of liquidation. In clearer terms, D stands for the total amount of deposits held by the bank, while $\varpi \in [0, 1]$ refers to the extent deposits are guaranteed: if $\varpi = 1$, there is a full guarantee while a value of $\varpi = 0.4$ would imply that only 40% of the deposits are guaranteed. Only when $W_c(L)$ falls below the net cost of liquidation is it optimal to liquidate the bank ; which starts being the case from L_l and lower.

In the following section, we will use dynamic programming techniques to analytically solve for W_a and W_c. This will clear the way for the determination of the thresholds L_c, L_r and L_l.

3 Solving the model

The first step in the determination of the threshold values consists of the determination of the value of the bank in the different states. This is done with the help of standard dynamic programming techniques as e.g. found in Dixit & Pindyck (1994), which among others involve the use of the Bellman equation, Ito's lemma and solving differential equations. The calculations can be found in appendix A and result in the following propositions:

Proposition 1 *The social value of the active bank is given by*

$$W_a(L) = A_2 L^{\beta_2} + \frac{L}{(\rho - \alpha)} - \frac{\bar{L}}{\rho} \tag{9}$$

with A_2 being a constant to be determined and

$$\beta_2 = \frac{1}{2} - \frac{\alpha}{\sigma^2} - \sqrt[2]{(\frac{\alpha}{\sigma^2} - \frac{1}{2})^2 + \frac{2\rho}{\sigma^2}}. \tag{10}$$

The first term in (9) represents the value of the option to contain while the second part can be interpreted as the expected present value of the bank if it continues operations forever.

Proposition 2 *The social value of the contained bank is given by*

$$W_c(L) = B_1 L^{\beta_1} + B_2 L^{\beta_2} - \frac{b}{\rho} \tag{11}$$

with B_1 and B_2 being two constants to be determined and

$$\beta_1 = \frac{1}{2} - \frac{\alpha}{\sigma^2} + \sqrt[2]{(\frac{\alpha}{\sigma^2} - \frac{1}{2})^2 + \frac{2\rho}{\sigma^2}}. \tag{12}$$

Here, the first term in (11) represents the value of the option to reactivate the contained bank ; the second term represents the value of the option to liquidate the bank and the last term represents the present value of the liquidity support cost assuming the support lasts forever.

Substituting the social value of both the active as well as the contained bank in the value-matching and smooth-pasting conditions [(3), (4), (5), (6), (7), (8)] yields the following six equation system:

$$\begin{cases} A_2 L_c^{\beta_2} + \frac{L_c}{(\rho-\alpha)} - \frac{\bar{L}}{\rho} = B_1 L_c^{\beta_1} + B_2 L_c^{\beta_2} - \frac{b}{\rho}, \\ A_2 \beta_2 L_c^{\beta_2 - 1} + \frac{1}{(\rho-\alpha)} = B_1 \beta_1 L_c^{\beta_1 - 1} + B_2 \beta_2 L_c^{\beta_2 - 1}, \\ B_1 L_r^{\beta_1} + B_2 L_r^{\beta_2} - \frac{b}{\rho} = A_2 L_r^{\beta_2} + \frac{L_r}{(\rho-\alpha)} - \frac{\bar{L}}{\rho} - B, \\ B_1 \beta_1 L_r^{\beta_1 - 1} + B_2 \beta_2 L_r^{\beta_2 - 1} = A_2 \beta_2 L_r^{\beta_2 - 1} + \frac{1}{(\rho-\alpha)}, \\ B_1 L_l^{\beta_1} + B_2 L_l^{\beta_2} - \frac{b}{\rho} = -\varpi D, \\ B_1 \beta_1 L_l^{\beta_1 - 1} + B_2 \beta_2 L_l^{\beta_2 - 1} = 0. \end{cases}$$

Note that this is a six equation system with six unknowns, namely A_2, B_1, B_2, L_c, L_r and L_l. As such, the system can be solved, although numerical tools are required. In particular, we make use of the FindRoot function found in Mathematica 9 in order to arrive at a solution. Given the complexity of the system however, it takes a three-step procedure before one is able to (efficiently) obtain the results. The procedure basically encompasses a reduction from a six equation system via a four equation system to a two equation system of which the results are extrapolated to arrive at a solution for all unknowns. More detailed information can be found in appendix B. The end result is that we now possess a methodology that can be utilized to evaluate bailout decisions from the past. In particular, use of case study data will lead to the determination of the different threshold values, thus specifying the conditions under which liquidity support, bailout and/or liquidation could be deemed optimal. The position of the bank vis-à-vis these thresholds can then be found by using a liquidity creation measure: if this measure is larger(lower) than the calculated reactivation(liquidation) threshold, the bailout(liquidation) under scrutiny can be deemed justified[7]. In the next section, we illustrate the application of this rule.

4 Case studies

4.1 The case of Dexia

We start our study with the case of Dexia, a Franco-Belgian bank insurer oriented towards retail and commercial banking as well as public finance. In 2008 (September 30), Dexia fell victim to the financial crisis and was saved by the Belgian, French and Luxembourgian government by means of a bailout/ recapitalization amounting to €6.376 billion[8]. While this was not the only bailout the bank received (the European sovereign debt crisis led to a second and even a third bailout in 2011 and 2012 respectively), it is the most interesting one to study, given that it started the question whether it was justified to save them. The goal here is to scrutinize whether - if we should face the same situation today - a bailout would effectively be the most appropriate choice: was the liquidity creation of Dexia sufficiently high compared to the reactivation threshold at that time?

In order to determine the three threshold values, we need to gather information concerning 8 parameters, namely: α, σ, ρ, ϖ, b, B, D and $\bar{L}$. In order to simplify interpretation later on, we normalize $\bar{L}$ - the amount of liquidity that is required to cover the opportunity value of a bank's operating cost - to one. Its corresponding 'real' value is approximated by its monetary equivalent, namely the operating costs of Dexia in 2008 that amounted to € 4.1178 billion[9]. Using this as a reference, one can easily arrive at the parameter values of B and D. In particular, customer borrowings and deposits (D) amounted to €114.728 billion in 2008, resulting in a normalized value of 27.8615 (=114.728 / 4.1178) while the bailout/recapitalization amount (B) is normalized to 1.5484 (=6.376/4.1178). In accordance to Directive 2009/14/EC, deposits are insured for up to €100,000. For an initial estimate of

[7] Here, one assumes that emergency liquidity support is already provided, i.e. the bank is in the contained state. As such, in order for this particular decision rule to work, one needs to have evidence that liquidity support is provided, which in practice is often the case.

[8] See e.g. http://www.telegraph.co.uk/finance/financialcrisis/3108159/Financial-crisis-Dexia-gets-5bn-bailout-from-Belgium-France-and-Luxembourg.html .

[9] Dexia. (2008). Annual report 2008. Retrieved from http://www.dexia.com/EN/shareholder_investor/individual_shareholders/publications/Documents/annual_report_2008_UK.pdf

ϖ - the degree of deposit insurance - we therefore base ourselves on the following statement found on the website of the National Bank of Belgium:

> “As a result of the increased guarantee level of €100,000, individuals in Belgium now have virtually complete coverage. At the beginning of 2010 they held an average of around €22,500 in bank deposits. Although the deposit balances are unevenly distributed, with a small percentage of the population holding very large amounts, that average nevertheless indicates a high level of coverage implying that roughly 95% of deposits are fully guaranteed” [10].

If we assume that the average savings and the distribution of savings is more or less the same for France and Luxembourg, we can safely set ϖ to 0.95. With respect to b - the cost incurred for each period the bank is in the contained state - we base ourselves on the collateral loan interpretation discussed above. Key ingredients are therefore the return on investment of the best alternative project - which we approximate by the average return on large-cap stocks between 1926 and 2008, namely 9.62% per annum[11] - and the average interest rate charged on ELA, which is estimated to be 100-150 basis points above the ECB's overnight lending rate[12]. The size of the support is approximated by the balance sheet post 'liabilities due to the central bank'. Given that the marginal lending facility of the ECB in September 2008 amounted to 5.25% per annum[13], b amounts to (9.62% - 6.25%)* 120,559 million = €4.0628 million. Normalization would then yield $b = 0.001$.

Finally, we assume α - the drift parameter - to be negative due to the financial crisis with α = -0.05. σ - the variance parameter - and ρ - the discount rate - take on values as often found in the real options literature, namely 0.2 and 0.1 respectively though these and all other parameters will be varied in the robustness section below. The above discussion can

[10] NBB (2010). The Belgian deposit guarantee scheme in a European perspective. Retrieved from: http://www.nbb.be/pub/01_00_00_00_00/01_06_00_00_00/01_06_01_00_00/20101206_edepositogarantiestelsel.htm

[11] Paulson, E. (2009). Long Term Average Returns: Lessons from the Past. Retrieved from: http://blog.ctnews.com/paulson/2009/09/08/long-term-average-returns-lessons-from-the-past/

[12] Suoninen, S., & Jones, M. (2013, March 21). Factbox - How ECB's emergency liquidity assistance works. Reuters. Retrieved from: http://uk.reuters.com/article/2013/03/21/uk-factbox-ecbs-emergency-idUKBRE92K0DT20130321

[13] ECB (2014). Key ECB interest rates. Retrieved from: http://www.ecb.europa.eu/stats/monetary/rates/html/index.en.html

Variable	Value	Variable	Value
α	-0.05	$\bar{L}$	1
σ	0.2	B	1.55
ρ	0.1	D	27.86
ϖ	0.95	b	0.001

Table 1: parameter values Dexia case

be summarized by taking a look at table 1, which depicts all parameter values used in this baseline scenario. With this information, we are able to determine the relevant threshold values, which are $L_c = 0.845003$ and $L_r = 1.66765$. L_l turns out to be non-existent[14], i.e. it is never optimal to liquidate.

In order to determine the social desirability of this particular bailout, we also need to measure the liquidity creation of Dexia at that point in time, which we do by constructing the cat fat and cat non-fat measures[15] of liquidity creation proposed by Berger & Bouwman (2009). This methodology follows a three-step approach, with the first step involving a classification of all bank assets and liabilities as 'liquid', 'semi-liquid' or 'illiquid' and summing them within each category. For the case at hand, this is done by making use of the consolidated balance sheet as well as the accompanying notes found in the annual reports of Dexia of 2008. Afterwards, a weighting is applied based on the main theoretical principle of liquidity creation: illiquid assets(+1/2) are used to create liquid liabilities(+1/2) while liquidity is destroyed when liquid assets(-1/2) are transformed in illiquid liabilities(-1/2). Semi-liquid assets and liabilities are weighted by 0. Summing up the weighted categories constitutes the last step and results in a practical measure of liquidity creation. In the case of Dexia, one finds a cat fat score of €196,455.5 million (normalized: €196,455.5 million / €4117.8 million = 47.7088) and a cat non-fat measure of €146,459 million (normalized: €146,459.5 million/ €4117.8 million = 35.5674). More details can be found in Appendix C, in which the classification as well as the calculation is documented. Seeing that both measures exceed the reactivation threshold by a large margin, we can conclude that the bailout executed to save Dexia was effectively justified. Additionally, when looking at the situation for the period

[14] This result stems from the fact that L, due to it following a GBM cannot drop below 0. A negative value for L is however required to render liquidation optimal in this particular case.

[15] The difference between 'fat' and 'non-fat' lies in the inclusion of off-balance sheet activities in the fat measure (?). The 'cat' part refers to a category-based classification system rather than a maturity-based one ('mat').

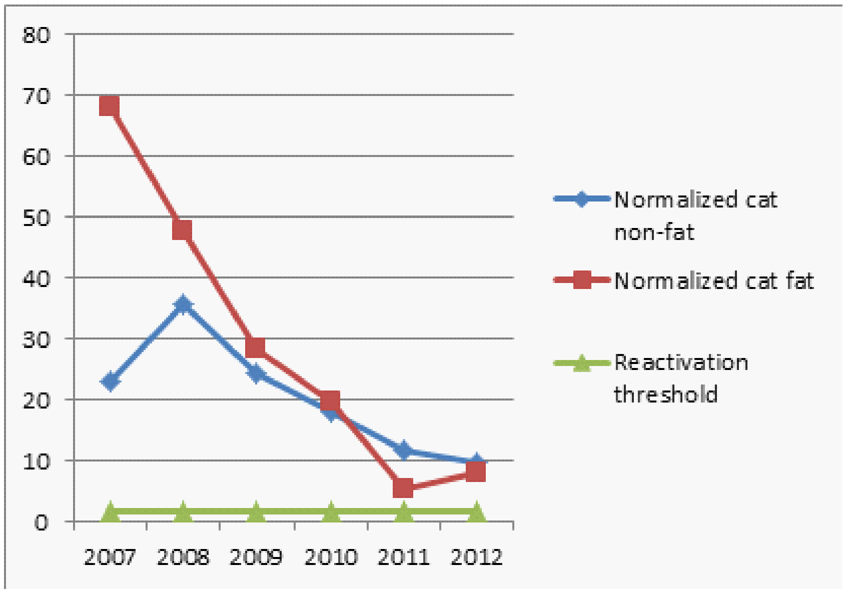

Figure 2: Liquidity creation of Dexia over time

2007-2012 (see figure 2), one can see that the bank merited to stay active in the market in all those years.

4.2 Robustness

Here we investigate to what extent results remain the same if some of the parameter values of the baseline scenario were altered. In particular, we perform a robustness check, the results of which can be found in tables 2-4. These tables depict the value of the various thresholds (L_c in table 2, L_r in table 3 and L_l in table 4) in a variety of scenarios where compared to the initial situation a key parameter (e.g. α, σ, ...) as well as b - our most unreliable parameter estimate - is altered. In doing so, we are able to determine the movements in threshold values arriving from changes in a single parameter value while also controlling for the potential disrupting impact of a badly estimated b. From the tables we can conclude that:

1. The threshold values are relatively stable when faced with changing parameter values. In almost all cases, the decision advocated above (bailout is justified) is still taken while the values do not differ that much from the initial ones.

2. Most changes are rational: if α increases (economic situation improves), it is better to delay containment (lower L_c) and speed up bailout (lower L_r). Likewise, a higher uncertainty (σ) increases the option value of waiting, thus delaying both containment and bailout decisions (lower L_c and higher L_r). This relationship is however not monotonic: for higher values of σ, the relation is inverse due to the existence of the liquidation option. The intuition here lies in the fact that, as argued by e.g. Kwon (2010), a higher volatility also implies an increase in the option value of exit/liquidation, rendering the value of the bank in (and as such the attractiveness of) the contained state higher. On the other hand, a higher discount rate ρ (and therefore a lower valuation of the future) accelerates containment (higher L_c due to a decreasing periodic cost) and delays bailout (higher L_r due to immediate cost and future benefits). The relation between ρ and L_c is however also not monotonic. One possible explanation may lie in the fact that when the discount rate is still low, an increase in ρ will have a larger impact on the immediate cost of emergency liquidity support (which grows larger in comparison with the future benefits) than on the cost 'savings' achieved on future payments. When ρ starts to take on higher values, the latter savings override the former effect, resulting in a positive relationship between ρ and L_c.

3. The threshold values are not greatly influenced by b, our most 'random' estimate. Even when the periodic cost of emergency liquidity support would be 100 times as large (from the initial 0.001 to 0.1) ; there are no big changes. In addition, the movements make sense: as the cost of liquidity support increases, it becomes less desirable to contain the bank (lower containment threshold) and it becomes more attractive to bail out the bank (reactivation threshold decreases). Only when the cost of emergency support becomes very high (0.5 for example equals half of the operating cost of the bank), it is optimal for government to never intervene unless α, ρ or B are high.

4. The containment threshold and reactivation threshold do not depend on the size of the bank or, more generally, the liquidation cost. The containment threshold however does respond to changes in the bailout amount (B), highlighting the fact that the irreversibility of containment is (at least partially) determined by the reactivation cost. The movements are rational: the higher the cost of bailout (B) , the better it is to avoid it (lower L_c and higher L_r).

5. The liquidation threshold exists for very low values of ϖ and/or D but not otherwise[16]. As such, liquidation seems to be a sub-optimal decision in many situations.

In general, we can thus conclude that our results are relatively robust and do not significantly depend on the different parameter estimates. The largest changes are due to changes in B or D, both of which we have exact information on. Given this result, we can further investigate the implications of this rule by considering a (much) larger sample of banks, namely the top 5 banks for each country within the EU-15.

4.3 Bailout performance in the EU-15

One advantage of our model is that the methodology can be easily applied to a large number of banks: almost all of the required data are found on the balance sheet - an integral part of the annual report that each bank is forced to make public. Additionally, the standardization w.r.t. the operating cost within each bank provides a simple answer to the issue of different currencies or unit sizes and allows for safe comparisons. To illustrate the wider appeal of the model, we now examine the quality of bailout policy observed during 2008 in all EU-15 countries. In particular, we consider for the five largest banks in each of these 15 countries[17] whether the observed decisions (liquidation, bailout or nothing) are justified by the model: a bailout would be justified if liquidity creation would be larger than the reactivation threshold ; liquidation would be commendable in case liquidity creation lies below the liquidation threshold and the absence of any bailout policy would be optimal in case liquidity creation never fell below the containment threshold. A higher proportion of correct decisions would imply a higher quality of bailout policy for the respective country. This way, inter-country differences in bailout performance can be observed and displayed.

In order to perform this analysis, we make use of the Bankscope database, which provides detailed information about banks and financial institutions around the globe. This allows for easy access to the financial data required to calculate the liquidity creation measures. The database is also used to identify our sample of banks: in a first step, we use the database to sort all banks in each considered country by total asset size. The five banks with the largest

[16] We did not report the robustness check for D as it works via the same channel as ϖ (i.e. it affects the liquidation cost).

[17] 'Largest' refers to the banks which have the highest number of total assets on the balance sheet.

	$b = 0.0001$	$b = 0.001$	$b = 0.01$	$b = 0.1$	$b = 0.5$
$\alpha = -0.09$	0.8596	0.8589	0.8520	0.7853	/
$\alpha = -0.05$	0.8455	0.8450	0.8397	0.7940	/
$\alpha = 0$	0.8276	0.8272	0.8232	0.7902	/
$\alpha = 0.05$	0.7642	0.7637	0.7588	0.7098	/
$\alpha = 0.5$	0.2663	0.2658	0.2617	0.2215	0.6548
	$b = 0.0001$	$b = 0.001$	$b = 0.01$	$b = 0.1$	$b = 0.5$
$\sigma = 0.01$	0.9989	0.9980	0.9890	0.8991	/
$\sigma = 0.1$	0.9221	0.9213	0.9132	0.8326	/
$\sigma = 0.2$	0.8455	0.8450	0.8397	0.7940	/
$\sigma = 0.5$	0.8618	0.8621	0.8656	0.9360	/
$\sigma = 1$	/	/	/	/	/
	$b = 0.0001$	$b = 0.001$	$b = 0.01$	$b = 0.1$	$b = 0.5$
$\rho = 0.01$	/	/	/	/	/
$\rho = 0.1$	0.8455	0.8450	0.8397	0.7940	/
$\rho = 0.2$	0.8355	0.8347	0.8278	0.7591	0.5030
$\rho = 0.5$	0.8596	0.8589	0.8512	0.7742	0.4340
$\rho = 0.9$	0.8847	0.8840	0.8760	0.7964	0.4426
	$b = 0.0001$	$b = 0.001$	$b = 0.01$	$b = 0.1$	$b = 0.5$
$\varpi = 0$	0.8455	0.8450	0.8397	0.7940	/
$\varpi = 0.2$	0.8455	0.8450	0.8397	0.7940	/
$\varpi = 0.5$	0.8455	0.8450	0.8397	0.7940	/
$\varpi = 0.95$	0.8455	0.8450	0.8397	0.7940	/
$\varpi = 1$	0.8455	0.8450	0.8397	0.7940	/
	$b = 0.0001$	$b = 0.001$	$b = 0.01$	$b = 0.1$	$b = 0.5$
$B = 0.1$	0.9995	0.9995	1.0000	1.0052	/
$B = 1.55$	0.8455	0.8450	0.8397	0.7940	/
$B = 2$	0.8294	0.8288	0.8227	0.7643	/
$B = 5$	0.7959	0.7952	0.7883	0.7192	0.4155
$B = 20$	0.7829	0.7822	0.7751	0.7047	0.3918

Table 2: Values of the containment threshold (Lc) for varying combinations of parameter values (unmentioned parameter values are those detailed in table 1)

	$b=0.0001$	$b=0.001$	$b=0.01$	$b=0.1$	$b=0.5$
$\alpha=-0.09$	1.8221	1.8208	1.8070	1.6645	/
$\alpha=-0.05$	1.6692	1.6676	1.6525	1.4875	/
$\alpha=0$	1.5179	1.5165	1.5024	1.3528	/
$\alpha=0.05$	1.4364	1.4352	1.4236	1.3072	/
$\alpha=0.5$	1.2026	1.2017	1.1923	1.0986	0.6551
	$b=0.0001$	$b=0.001$	$b=0.01$	$b=0.1$	$b=0.5$
$\sigma=0.01$	1.5152	1.5141	1.5033	1.3960	/
$\sigma=0.1$	1.5806	1.5795	1.5684	1.4554	/
$\sigma=0.2$	1.6692	1.6676	1.6525	1.4875	/
$\sigma=0.5$	1.6086	1.6051	1.5703	1.1988	/
$\sigma=1$	/	/	/	/	/
	$b=0.0001$	$b=0.001$	$b=0.01$	$b=0.1$	$b=0.5$
$\rho=0.01$	/	/	/	/	/
$\rho=0.1$	1.6691	1.6676	1.6525	1.4875	/
$\rho=0.2$	1.8484	1.8472	1.8352	1.7153	1.1513
$\rho=0.5$	2.2615	2.2604	2.2492	2.1368	1.6325
$\rho=1$	2.8563	2.8552	2.8445	2.7374	2.2606
	$b=0.0001$	$b=0.001$	$b=0.01$	$b=0.1$	$b=0.5$
$\varpi=0$	1.6692	1.6677	1.6525	1.4875	/
$\varpi=0.2$	1.6692	1.6677	1.6525	1.4875	/
$\varpi=0.5$	1.6692	1.6677	1.6525	1.4875	/
$\varpi=0.95$	1.6692	1.6677	1.6525	1.4875	/
$\varpi=1$	1.6692	1.6677	1.6525	1.4875	/
	$b=0.0001$	$b=0.001$	$b=0.01$	$b=0.1$	$b=0.5$
$B=0.1$	1.0207	1.0188	1.0000	0.8390	/
$B=1.55$	1.6692	1.6676	1.6525	1.4875	/
$B=2$	1.8126	1.8113	1.7974	1.6557	/
$B=5$	2.5571	2.5557	2.5424	2.4085	1.7960
$B=20$	5.6209	5.6193	5.6042	5.4518	4.7573

Table 3: Values of the reactivation threshold (Lr) for varying combinations of parameter values (unmentioned parameter values are those detailed in table 1)

	$b = 0.0001$	$b = 0.001$	$b = 0.01$	$b = 0.1$	$b = 0.5$
$\alpha = -0.09$	/	/	/	/	/
$\alpha = -0.05$	/	/	/	/	/
$\alpha = 0$	/	/	/	/	/
$\alpha = 0.05$	/	/	/	/	/
$\alpha = 0.5$	/	/	/	/	/
	$b = 0.0001$	$b = 0.001$	$b = 0.01$	$b = 0.1$	$b = 0.5$
$\sigma = 0.01$	/	/	/	/	/
$\sigma = 0.1$	/	/	/	/	/
$\sigma = 0.2$	/	/	/	/	/
$\sigma = 0.5$	/	/	/	/	/
$\sigma = 1$	/	/	/	/	/
	$b = 0.0001$	$b = 0.001$	$b = 0.01$	$b = 0.1$	$b = 0.5$
$\rho = 0.01$	/	/	/	/	/
$\rho = 0.1$	/	/	/	/	/
$\rho = 0.2$	/	/	/	/	/
$\rho = 0.5$	/	/	/	/	/
$\rho = 0.9$	/	/	/	/	/
	$b = 0.0001$	$b = 0.001$	$b = 0.01$	$b = 0.1$	$b = 0.5$
$\varpi = 0$	0.2253	0.3719	0.6102	0.9338	/
$\varpi = 0.2$	/	/	/	/	/
$\varpi = 0.5$	/	/	/	/	/
$\varpi = 0.95$	/	/	/	/	/
$\varpi = 1$	/	/	/	/	/
	$b = 0.0001$	$b = 0.001$	$b = 0.01$	$b = 0.1$	$b = 0.5$
$B = 0.1$	/	/	/	/	/
$B = 1.55$	/	/	/	/	/
$B = 2$	/	/	/	/	/
$B = 5$	/	/	/	/	/
$B = 20$	/	/	/	/	/

Table 4: Values of the liquidation threshold (Ll) for varying combinations of parameter values (unmentioned parameter values are those detailed in table 1)

balance sheets are selected, though additional procedures are taken into account. For each bank it was checked on their annual report whether the asset size was the same (in order to 'guarantee' the correctness of the data) and whether reporting was done in millions rather than thousands (in case of the latter, the bank was dropped in favour of the next in line). Secondly, additional factors like the specific activity of the bank (e.g. retail banking) and the company structure (i.e. already being part of a previously considered group) were also taken into account in order to avoid double counting and keep the sample as relevant as possible. Priority was given to the parent company (in case multiple branches were active in the country) as well as to banks which had a clear relation with the country under scrutiny (e.g. for the United Kingdom, we opted to include "HBOS plc" rather than "Credit Suisse International", even though the latter was ranked higher on the charts). The final selection of banks, listed by country, can be found in appendix D.

Inspired by Xu (2010), a method is used to efficiently calculate the cat fat measure. This methodology does not consider the full balance sheet of the bank but rather elects to focus on the key components. Given that the cat fat measure is calculated as:

$$\begin{aligned} L &= cat\ fat = 0.5 * illiquid\ assets + 0 * semi - liquid\ assets - \\ &\quad 0.5 * liquid\ assets + 0.5 * liquid\ liabilities + 0 * semi - \\ &\quad liquid\ liabilities - 0.5 * illiquid\ liabilities - \\ &\quad 0.5 * equity + 0.5 * illiquid\ guarantees \end{aligned}$$

and these components consist of the elements described in table 5, one can easily determine the liquidity creation measures of the banks in the sample[18]. Compared with the full analysis performed earlier, this method results in a normalized cat fat score of 58.4024 for Dexia, which is not too far from the 47.7088 we found above.

To consider whether the observed decision was the appropriate one, we compare the cat fat measure of liquidity creation with the respective thresholds of each bank. These thresholds are calculated the same way as before, taking into account the considered bank's

[18] Compared to Xu (2010), we a) redefined the 'illiquid loans' portion ; b) ignored the separate posts of "non-listed securities" and "commercial deposits" (the latter should be found among the other categories) and c) assume that "treasury bills", "other bills" and "bonds" are part of total securities. All elements can be directly obtained from bankscope or be derived from the formulas between brackets. Semi-(il)liquid assets were not calculated due to the weighting coefficient of 0.

Illiquid assets = Illiquid loans (=Residential mortgage loans + Other mortgage loans + Other consumer/retail loans + Corporate & financial loans + Other loans) + Other investments (= At-equity investments in associates + Investments in property) + [Non-earning assets – Cash and due from banks] + Fixed assets
Liquid assets = Total securities + Cash and due from banks + Equity investments (= Equity investments deducted from regulatory capital)
Liquid liabilities = Demand deposits (=Customer deposits-current) + Savings deposits (= Customer deposits-savings) + Deposits with banks (=Deposits from banks)
Illiquid liabilities = Other funding + Total loan loss and other reserves (= loan loss reserves + other reserves) + Other liabilities + Total equity
Illiquid guarantees = Guarantees + Committed credit lines + Other contingent liabilities

Table 5: Composition of illiquid assets, liquid assets, liquid liabilities, iliquid liabilities and illiquid guarantees; partially adapted from Xu (2010, p. 131)

operating costs (w.r.t. the normalization) and the differing bailout amounts and deposit sizes. Additionally, for those banks who did not receive a bailout, B was set to the average of bailout amounts that were effectively observed.

Both the cat fat score and the threshold values can be found in appendix E, together with their evaluation. From this we learn that, generally speaking, the EU-15 has performed admirably during the financial crisis: from the 75 cases that were scrutinized, 70 decisions could be deemed optimal. Mistakes were made with respect to:

1. the bailout to BNP Paribas by the French government (cat fat $< L_r$; as such, no bailout should have been given)

2. the nationalization of ABN Amro by the Dutch government (cat fat $> L_r$; as such, a normal bailout would have sufficed. In the model, nationalization is indeed interpreted as a situation where both L_l and L_r do not exist, i.e. a situation of eternal containment where the bank continues to operate with the help of government funding)

3. the negligence of the financial situation at Argenta Spaarbank (Belgium), Deutsche Bank (Germany) and Barclays Bank (United Kingdom) (cat fat $< L_c$; as such the banks should have gone into containment).

In general however, based on this (relatively small) sample of cases, we can conclude that the EU-15 countries have executed optimal bank bailout policy in the crisis year of 2008.

5 Possible model extensions

While the model presented above incorporates the main mechanisms involved in bailout decision making, the framework is flexible enough to allow for the incorporation of additional elements. For instance, up to now, no mention was made concerning so-called contagion effects - the impact of the failure of a bank on the other banks in the industry - and moral hazard. Another issue may lie in the use of a GBM, which has a fixed trend, even though the financial situation of banks may turn abruptly. In this section, we will show how one could incorporate these elements.

5.1 Accounting for moral hazard and contagion

Up to now, we have only considered the direct cost of bailout and liquidation decisions, namely the monetary costs involved in their execution. Bailout and liquidation however also bring along indirect costs, the most important of which are moral hazard and the possibility of contagion to other banks. A simple way to incorporate these elements in the model is by altering the value-matching conditions. For example, the value matching condition that governs the transition from contained to active bank (5) could be rewritten as:

$$W_c(L_r) = W_a(L_r) - B(1 + pN), \tag{13}$$

where N is the exogenous number of assumed to be symmetric[19] banks in the industry and p is the expected fraction of banks that will require bailout in the future due to increased risk-taking incentives following the current decision [20]. By introducing this last term, one basically enlarges the bailout cost by taking into account the cost of additional bailout cases in the future. As such, the indirect costs of moral hazard are captured, though it may prove difficult to find a good approximation for p.

In order to capture contagion effects, one can write value matching condition (7) as:

$$W_c(L_l) = -\varpi D - \lambda N B, \tag{14}$$

where λ can be defined as the expected fraction of banks of which the financial soundness depends on the survival of the bank under consideration. If the government liquidates the bank, it will likely encounter additional bailout cases in the future with their own costs. This implicitly drives up the cost of the current liquidation decision and increases the option value of waiting. As in the case of moral hazard, it may be difficult to arrive at good values for λ. By using a large enough range of values however, the impact of its inclusion can be assessed.

Once one has replaced value-matching conditions (5) and (7) by the previously mentioned substitutes, one can recalculate the model using the same procedure as before. This

[19] Note that the symmetry is in size and not in liquidity. In particular, note that the other banks are still unaffected by the problems faced by the bank under scrutiny ; reminiscent of the situation where a general crisis only really starts when the first ‘domino brick’ falls.

[20] This formulation of moral hazard is reminiscent to the one used in Goodhart & Huang (2005).

time however, the resulting thresholds will have taken into account both moral hazard and contagion effects. As such, one would expect a lower containment threshold (as the decision becomes more costly to reverse), a lower liquidation threshold (taking into account the increased cost of liquidation) and a higher reactivation threshold (taking into account the increased cost of bailout).

5.2 Allowing for conjunctural variation

Here we relax the assumption that α is constant, i.e. that the trend is eternally upward or downward sloping. We do so by recognizing two specific states the general economy may be in, namely in a normal situation - characterized by a positive growth trend α - or in a crisis/bank run, in which α turns negative. The normal situation is hereby labeled with 0 while a bank run is indicated by the number 1. If we are in a normal situation, the occurrence of a bank run (moving from state 0 to state 1) occurs with probability $\lambda_1 dt$ while an economic recovery (moving from state 1 to state 0) occurs with probability $\lambda_0 dt$. In fact, the bank now faces two sources of uncertainty, namely the basic GBM from above, as well as a Poisson process, which governs the transitions between the normal and bank run 'state'.

Redoing the calculations with this additional uncertainty process would now result in six thresholds, namely a containment, reactivation and liquidation threshold for both the normal and the bank run state. Generally speaking, the thresholds found in state 0 would typically be lower than their counterparts in state 1 due to the impact of a higher α, which delays containment and liquidation (lower L_c and lower L_l) and hastens bailout (lower L_r). However, all thresholds would also be affected by the change in the option value of waiting that originates from the possibility of economic recovery/deterioration. In state 1 for example, there is a probability $\lambda_0 dt$ that the trend becomes positive, which would most likely result in a decrease of the containment threshold relative to the constant growth rate scenario due to the larger option value of waiting. Similarly, one would expect a decrease in the liquidation threshold and an increase in the reactivation threshold. As a similar effect is likely to be observed in state 0, it is rather difficult to determine the relative positions of the six threshold values without executing the associated numerical exercises. This will require a specification of both λ_0 and λ_1, for which a wide range of values should be considered.

6 Conclusion

In this paper, we have formulated a real options consistent bailout decision rule that determines when a government should save or liquidate a failing bank. This rule - based on the liquidity creation function of banks - takes into account the option value of waiting associated with the uncertain environment surrounding impending bank failures. As such, it advocates decisions that take into account the possibility of economic recovery/deterioration to ensure an optimal solution from a dynamic perspective.

The rule has numerous advantages. Compared to its (mostly static) competitors, the real options construction ensures a full incorporation of the uncertain economic environment. Secondly, data requirements are pretty low, given that almost all of the required data are found on the balance sheet - an integral part of the annual report that each bank is forced to make public. Thirdly, obtained results are quite stable w.r.t. changes in exogenous parameters, reinforcing their robustness. Lastly, the framework is flexible: while the basic model only includes the main mechanics involved in bailout decision making, it is relatively easy to expand the model to render it more realistic.

Application of the rule to 75 bailout cases in the EU-15 has shown that governments seem to have consistently made the correct decision in times of financial turmoil. The rare 'mistakes' consist of the bailout of BNP Paribas, the nationalization of ABN Amro and the negligence of the financial situation at Argenta Spaarbank, Barclays Bank and Deutsche Bank. In general however, the rule suggests that government are able to make the right decisions when bank bailouts are considered.

7 Appendix A

7.1 Proof of proposition 1

To determine the social value of the active bank, we start from the corresponding Bellman equation, which splits the value of the bank in the current welfare contribution ($= L - \bar{L}$) and its continuation/future value :

$$W_a(L) = (L - \bar{L})dt + E[W_a(L + dL)e^{-\rho dt}]. \quad (15)$$

As $E[dW_a(L)] = E[W_a(L + dL)] - E[W_a(L)]$, one can write (15) as

$$W_a(L) = (L - \bar{L})dt + \{E[dW_a(L)] + E[W_a(L)]\}e^{-\rho dt}. \tag{16}$$

Making use of Ito's lemma for an Ito process as well as equation (1), one can then expand $E[dW_a(L)]$ as follows (Dixit & Pindyck, 1994, p. 80):

$$E[dW_a(L)] = [\frac{\partial W_a}{\partial t} + \alpha L \frac{\partial W_a}{\partial L} + \frac{1}{2}\sigma^2 L^2 \frac{\partial^2 W_a}{\partial L^2}]dt, \tag{17}$$

where $\frac{\partial W_a}{\partial t} = 0$ and $\frac{\partial W_a}{\partial L}$ and $\frac{\partial^2 W_a}{\partial L^2}$ will be denoted as $W_a^{'}$ and $W_a^{''}$ respectively. Substituting (17) in (16) while writing $e^{-\rho dt}$ as $(1 - \rho dt)$ by using the approximation of an e-power yields:

$$W_a(L) = (L - \bar{L})dt + [\alpha L W_a' + \frac{1}{2}\sigma^2 L^2 W_a'']dt + W_a(L) * (1 - \rho dt). \tag{18}$$

Dividing by dt and rearranging yields the following non-homogeneous linear second-order differential equation :

$$\frac{1}{2}\sigma^2 L^2 W_a'' + \alpha L W_a' - \rho * W_a(L) + (L - \bar{L}) = 0. \tag{19}$$

This equation can be solved in three steps:

- Step 1) solving the homogeneous equation

The homogeneous part of the equation is

$$\frac{1}{2}\sigma^2 L^2 W_a'' + \alpha L W_a' - \rho W_a(L) = 0. \tag{20}$$

Given the particular form of the equation, one might guess the form of the solution, namely $W_a(L) = A * L^\beta$ with $W_a^{'}(L) = \beta * A * L^{\beta-1}$ and $W_a^{'}(L) = \beta(\beta - 1) * A * L^{\beta-2}$. Substituting this in (20) yields that:

$$\frac{1}{2}\sigma^2 L^2 \beta(\beta - 1)AL^{\beta-2} + \alpha L \beta A L^{\beta-1} - \rho A L^\beta = 0, \tag{21}$$

$$\Leftrightarrow \frac{1}{2}\sigma^2 \beta(\beta - 1) + \alpha\beta - \rho = 0. \tag{22}$$

This is a quadratic equation which can be solved using the basic discriminant rule and yields the following two roots:

$$\beta_1 = \frac{1}{2} - \frac{\alpha}{\sigma^2} + \sqrt[2]{(\frac{\alpha}{\sigma^2} - \frac{1}{2})^2 + \frac{2\rho}{\sigma^2}}, \tag{23}$$

$$\beta_2 = \frac{1}{2} - \frac{\alpha}{\sigma^2} - \sqrt[2]{(\frac{\alpha}{\sigma^2} - \frac{1}{2})^2 + \frac{2\rho}{\sigma^2}}. \tag{24}$$

The general solution to the homogeneous equation is therefore

$$W_a(L) = A_1 L^{\beta_1} + A_2 L^{\beta_2}. \tag{25}$$

- Step 2) finding a particular solution to the non-homogeneous equation

For a particular solution, propose $W_a^p(L) = uL + v$ with $W_a^{p'}(L) = u$ and $W_a^{p''}(L) = 0$. Putting this in the non-homogeneous differential equation (19) yields:

$$0 + \alpha L u - \rho(uL + v) + (L - \bar{L}) = 0. \tag{26}$$

This is only true if:

- Terms related to L are 0:

$$\Leftrightarrow [u(\alpha - \rho) + 1)L = 0, \tag{27}$$

$$\Leftrightarrow u = \frac{1}{(\rho - \alpha)}. \tag{28}$$

- Terms unrelated to L are 0:

$$\Leftrightarrow -\rho v - \bar{L} = 0, \tag{29}$$

$$\Leftrightarrow v = -\frac{\bar{L}}{\rho}. \tag{30}$$

This implies that the particular solution to the non-homogeneous differential equation is

$$W_a^p = \frac{L}{(\rho - \alpha)} - \frac{\bar{L}}{\rho}. \tag{31}$$

- Step 3) finding the general solution to the non-homogeneous equation

The general solution is found by simply summing up the solution of the homogeneous equation and the particular solution. Hence the social value of the active bank is equal to

$$W_a(L) = A_1 L^{\beta_1} + A_2 L^{\beta_2} + \frac{L}{(\rho - \alpha)} - \frac{\bar{L}}{\rho}. \tag{32}$$

In this expression, $\frac{L}{(\rho-\alpha)} - \frac{\bar{L}}{\rho}$ is the expected present value of the bank if it continues operations forever. The first two terms on their turn can be interpreted as the value of the option to contain. Note that the bank remains active for $L \in (L_c, \infty)$. However, as L goes to infinity, the probability of containment goes to zero. Hence, the coefficient associated with the positive root (β_1) should be zero (Dixit & Pindyck, 1994, p. 218). As such, equation (32) simplifies to

$$W_a(L) = A_2 L^{\beta_2} + \frac{L}{(\rho - \alpha)} - \frac{\bar{L}}{\rho}. \tag{33}$$

7.2 Proof of proposition 2

To determine the social value of the contained bank, we make use of the same methodology as used in proposition 1, although this time, several of the assumptions made above have to be taken into account. These include the postulates that a contained bank is enabled to create exactly the amount of liquidity needed to cover its operational welfare costs ($\bar{L}$) and the fact that containment is upheld at the expense of a periodic cash flow in the form of liquidity support, namely b, which in itself hurts welfare. As such, the relevant Bellman equation takes the following form:

$$W_c(L) = -bdt + E[W_c(L + dL)e^{-\rho dt}]. \tag{34}$$

which differs only from (15) in the sense that the current contribution is –b instead of $L - \bar{L}$. Following the same techniques as above, one therefore finds a very similar non-homogeneous linear second order differential equation:

$$\frac{1}{2}\sigma^2 L^2 W_c''(L) + \alpha L W_c'(L) - \rho W_c(L) - b = 0, \tag{35}$$

with the same solution and accompanying expressions for the homogeneous equation

$$W_c(L) = B1 L^{\beta_1} + B_2 L^{\beta_2}. \tag{36}$$

For a particular solution, propose $W_c^p(L) = kL + m$ with $W_c^{p'}(L) = k$ and $W_c^{p''}(L) = 0$. Substituting this in (35) yields

$$0 + kLa - \rho(kL + m) - b = 0. \tag{37}$$

This is only true if:

- Terms related to L are 0:

$$\Leftrightarrow [k(\alpha - \rho)]L = 0, \tag{38}$$

$$\Leftrightarrow k = 0.$$

- Terms unrelated to L are 0:

$$-\rho m - b = 0, \tag{39}$$

$$\Leftrightarrow m = \frac{-b}{\rho}. \tag{40}$$

Hence, the particular solution to the non-homogeneous differential equation is:

$$W_c^p = \frac{-b}{\rho}. \tag{41}$$

The social value of the contained bank is then given by

$$W_c(L) = B_1 L^{\beta_1} + B_2 L^{\beta_2} - \frac{b}{\rho}. \tag{42}$$

Here, $\frac{b}{\rho}$ represents the present value of the liquidity support cost assuming the support lasts forever. $B_1 L^{\beta_1}$ represents the value of the option to reactivate the contained bank while $B_2 L^{\beta_2}$represents the value of the option to liquidate the bank. Unlike before, both roots are used in the expression as $L \in (L_l, L_r)$, which does not include infinity nor 0.

8 Appendix B

The problem at hand is to reduce the complexity of the six-equation system discussed above. In a first step, we split the system in two and only consider the first four equations, which are rewritten as follows:

$$(A_2 - B_2)L_c^{\beta_2} - B_1 L_c^{\beta_1} + \frac{L_c}{(\rho - \alpha)} + \frac{b - \bar{L}}{\rho} = 0 \tag{43}$$

$$(A_2 - B_2)\beta_2 L_c^{\beta_2 - 1} - B_1 \beta_1 L_c^{\beta_1 - 1} + \frac{1}{(\rho - \alpha)} = 0 \tag{44}$$

$$(A_2 - B_2)L_r^{\beta_2} - B_1 L_r^{\beta_1} + \frac{L_r}{(\rho - \alpha)} + \frac{b - \bar{L}}{\rho} - B = 0 \tag{45}$$

$$(A_2 - B_2)\beta_2 L_r^{\beta_2 - 1} - B_1 \beta_1 L_r^{\beta_1 - 1} + \frac{1}{(\rho - \alpha)} = 0 \tag{46}$$

Replacing $(A_2 - B_2)$ by D then results in a four equation system in four unknowns.

The second step, inspired by Martzoukos(2001), consists of writing D and B_1 in terms of L_c and L_r to further simplify the system. First note that the smooth pasting conditions (44) and (46) can be written as:

$$D\beta_2 L_c^{\beta_2} - B_1 \beta_1 L_c^{\beta_1} + \frac{L_c}{(\rho - \alpha)} = 0 \tag{47}$$

$$D\beta_2 L_r^{\beta_2} - B_1 \beta_1 L_r^{\beta_1} + \frac{L_r}{(\rho - \alpha)} = 0 \tag{48}$$

From these equations one can obtain that:

$$D = \frac{B_1 \beta_1 L_c^{\beta_1 - \beta_2} - \frac{L_c^{1-\beta_2}}{\rho - \alpha}}{\beta_2} \tag{49}$$

$$B_1 = \frac{D \beta_2 L_r^{\beta_2 - \beta_1} + \frac{L_r^{1-\beta_1}}{\rho - \alpha}}{\beta_1} \tag{50}$$

and via substitution in each other that:

$$D = \frac{L_r^{1-\beta_1} L_c^{\beta_1 - \beta_2} - L_c^{1-\beta_2}}{\beta_2 (\rho - \alpha)(1 - L_r^{\beta_2 - \beta_1} L_c^{\beta_1 - \beta_2})} \tag{51}$$

$$B_1 = \frac{\left[\frac{L_r^{1-\beta_1} L_c^{\beta_1-\beta_2} - L_c^{1-\beta_2}}{(\rho-\alpha)(1 - L_r^{\beta_2-\beta_1} L_c^{\beta_1-\beta_2})}\right] L_r^{\beta_2 - \beta_1} + \frac{L_r^{1-\beta_1}}{\rho - \alpha}}{\beta_1} \tag{52}$$

Putting these values in (43) and (45) then results in a two equation system in two unknowns (L_c and L_r) which a computer can easily solve. The last step then involves the determination of the previously ignored elements via the knowledge about the threshold values.

9 Appendix C

The first step in the creation of the liquidity creation measures is the classification of the bank's assets and liabilities as 'liquid', 'semi-liquid' and 'illiquid'. Tables 6-8 give an overview of all of the posts found on the consolidated balance sheet of Dexia, their 2008 value and their classification (based on the categorization scheme in the Berger & Bouwman article). In the next step, all posts within the same category are summed up. Finally, these sums are weighted and combined according to the scheme of Berger & Bouwman (2009, p. 3790-3791) in order to arrive at the two liquidity creation measures[21]. As such, one has that:

- Cat fat measure:

[21] A weight of 0 is given to each semi-liquid category. Illiquid assets and liquid liabilities receive a weight of +1/2 while liquid assets and illiquid liabilities receive a weight of -1/2

Liquidity creation $=\frac{1}{2}*$€ 317792 million $+0*$€ 258457 million $-\frac{1}{2}*$€ 74757 million $+\frac{1}{2}*$€ 272500 million $+0*$€ 155891million $-\frac{1}{2}*$€ 222615 million $+\frac{1}{2}*$€ 99991 million = € 196455.5 million

- Cat non-fat measure

Liquidity creation $=\frac{1}{2}*$€ 317792 million $+0*$€ 258457 million $-\frac{1}{2}*$€ 74757 million $+\frac{1}{2}*$€ 272500 million $+0*$€ 155891million $-\frac{1}{2}*$€ 222615 million = € 146459.5 million

Year	2008	Classification
Assets (in millions of euros)		
Cash and balances with central banks	2448	**Liquid**
Loans and advances due from banks	61864	**Semi-liquid**
Loans and advances to customers:		
Public	196409	**Semi-liquid**
Other	172426	**Illiquid**
Impaired (calculated: subtracted impaired losses)	10	**Illiquid**
Financial assets measured at fair value through profit or loss:		
For trading	10836	**Liquid**
Bonds issued by public bodies (by category division)	184	**Semi-liquid**
Loans ; other bonds and fixed- income instruments	5024	**Illiquid**
Financial investments:		
Public sector	53359	**Illiquid**
Banks	55876	**Illiquid**
Other	14842	**Illiquid**
Impaired	952	**Illiquid**
Derivatives (only on actual balance sheet)	55213	**Liquid**
Fair value revaluation of portfolio hedge	3938	**Illiquid**
Investments in associates (/carrying value)	682	**Illiquid**
Tangible fixed assets (net book value)	2353	**Illiquid**
Intangible assets and goodwill	2193	**Illiquid**
Tax assets	4139	**Illiquid**
Other assets	1998	**Illiquid**
Non-current assets held for sale	6260	**Liquid**
Liquid assets total	74757	
Semi-liquid assets total	258457	
Illiquid assets total	317792	
Total	651006	

Table 6: Classification of assets Dexia 2008

Year	2008	Classification
Liabilities (in millions of euros)		
Due to banks:		
On demand	13197	**Liquid**
Term	12393	**Semiliquid**
Repo	35331	**Semiliquid**
Central banks	120559	**Liquid**
Other borrowings	31712	**Semiliquid**
Customer borrowings and deposits:		
Demand deposits	30874	**Liquid**
Savings deposits	26072	**Liquid**
Term deposits	42587	**Semiliquid**
Other customer deposits	2807	**Illiquid**
Repo (borrowing)	9314	**Semiliquid**
Other borrowings	3074	**Semiliquid**
Financial liabilities measured at fair value through profit or loss:		
Financial liabilities held for trading	273	**Liquid**
Non subordinated liabilities	15135	**Illiquid**
Subordinated liabilities	347	**Illiquid**
Unit linked products	3197	**Illiquid**
Derivatives	75834	**Liquid**
Fair value revaluation of portfolio hedge	1543	**Illiquid**
Debt securities		
Certificates of deposits	16466	**Semiliquid**
Customer savings certificates	5011	**Semiliquid**
Convertible debt	3	**Semiliquid**
Non-convertible bonds	166640	**Illiquid**
Subordinated debts (includes hybrid debt)	4407	**Illiquid**
Technical provisions of insurance companies	16739	**Illiquid**
Provisions and other obligations (retirement, litigation, ...)	1487	**Illiquid**

Table 7: Classification of liabilities Dexia 2008

Year	2008	Classification
Liabilities (in millions of euros)		
Tax liabilities	302	**Illiquid**
Other liabilities	4393	**Illiquid**
Liabilities included in disposal groups held for sale	5691	**Liquid**
Liquid liabilities total	272500	
Semi-liquid liabilities total	155891	
Illiquid liabilities total	222615	
Total equity	5618	
Total	651006	
Off- balance sheet guarantees (in millions of euros)		
Regular way trade		
Loans to be delivered and purchases of assets	7129	**Illiquid**
Borrowings to be received and sales of assets	17707	**Illiquid**
Guarantees		
Guarantees given	17104	**Illiquid**
Guarantees received	110045	**Illiquid**
Loan commitments		
Unused lines granted	87163	**Illiquid**
Unused lines obtained ('revaluation' 2009)	9654	**Illiquid**
Other commitments		
Insurance activity- commitments given	-25	**Illiquid**
Banking activity: commitments given (different definition for 2006)	126026	**Illiquid**
Illiquid guarantees total	99991	

Table 8: Classification of liabilities (continued) and off-balance sheet guarantees Dexia 2008

10 Appendix D

Tables 9 and 10 contain the names of all the banks considered in the EU-15 sample per country (which are ranked alphabetically). For each bank it was checked on their annual report whether the total asset size was the same as given by bankscope in order to 'guarantee' the correctness of the data. Priority was given to size ; although specific activity and company structure (i.e. being part of a group) were also considered to avoid double counting and keep the sample as relevant as possible. Priority was also given to banks which had a clear relation with the country under scrutiny. In any case, within each country, the number before the name of the bank indicates its relative size compared to each other. A * sign indicates that the bank was either directly or indirectly (i.e. via its parent company) bailed out in the year 2008/beginning 2009. Information concerning the bailout, including its cost, was obtained from various newspapers and reports[22].

[22] For more information, consult the electronic appendix via https://www.uantwerpen.be/nl/personeel/glen-vermeulen/mijn-website/

Austria	**Belgium**
1)UniCredit Bank Austria AG-Bank Austria	1)Dexia*
2)Erste Group Bank AG*	2)BNP Paribas Fortis SA/ NV (=Fortis 2008)*
3)Raiffeisen Zentralbank Oesterreich AG – RZB*	3)KBC Groep NV/ KBC Groupe SA-KBC Group*
4)Volksbanken Verbund*	4)Argenta Spaarbank-ASPA
5)Hypo Alpe-Adria Bank International AG*	5)AXA Bank Europe SA/NV
Denmark	**Finland**
1)Danske Bank A/S	1)Nordea Bank Finland Plc
2)Nykredit Realkredit A/S	2)OP-Pohjola Group
3)Nordea Bank Danmark Group-Nordea Bank	3)Municipality Finance Plc-Kuntarahoitus Oyj
4)Jyske Bank A/S	4)Aktia Bank Plc
5)BRF Kredit A/S	5)Alandsbanken Abp-Bank of Aland Plc
France	**Germany**
1)BNP Paribas*	1)Deutsche Bank AG
2)Crédit Agricole-Crédit Agricole Group*	2)Sparkassen-Finanzgruppen
3)Société Générale*	3)Commerzbank AG*
4)Groupe Caisse d'Epargne*	4)UniCredit Bank AG (= Hypovereinsbank)
5)Crédit Mutuel*	5)Landesbank Baden-Wuerttemberg*
Greece	**Ireland**
1)Eurobank Ergasias SA*	1)Depfa Bank Plc*
2)Alpha Bank AE*	2)Bank of Ireland*
3)Piraeus Bank SA*	3)Allied Irish Banks plc*
4)Emporiki Bank of Greece SA*	4)Permanent TSB Plc
5)Agricultural Bank of Greece*	5)Ulster Bank Ireland Limited*
Italy	**Luxembourg**
1)UniCredit SpA	1)Banque Internationale à Luxembourg SA*
2)Intesa Sanpaolo	2)Deutsche Bank Luxembourg SA
3)Cassa Depositi e Prestiti	3)BGL BNP Paribas*
4)Banca Monte dei Paschi di Siena SpA	4)Société Générale Bank & Trust*
5)Unione di Banche Italiane Scpa (=UBI Banca)	5)Banque et Caisse d'Epargne de l'Etat Luxembourg

Table 9: list of banks in EU-15 sample per country

Portugal	**Spain**
1)Caixa Geral de Depositos	1)Banco Santander SA
2)Banco Comercial Português SA-Millennium bcp	2)Banco Bilbao Vizcaya Argentaria SA
3)Banco Espirito Santo SA	3)Caja de Ahorros y Pensiones de Barc.(La Caixa)
4)Banco BPI SA	4)Banco Popular Espanol SA
5)Banco Santander Totta SA	5)Banco de Sabadell SA
Sweden	**The Netherlands**
1)Skandinaviska Enskilda Banken AB	1)ING Groep NV*
2)Svenska Handelsbanken	2)RBS Holdings NV (=ABN Amro 2008)**
3)Swedbank AB*	3)Rabobank Nederland
4)Nordea Bank AB	4)Fortis Bank (Nederland) N.V.*
5)SBAB Bank AB	5)SNS Reaal NV*
United Kingdom	
1)HSBC Holdings Plc	
2)Royal Bank of Scotland Group Plc*	
3)Barclays Bank Plc	
4)Bank of Scotland Plc*	
5)HBOS Plc*	

Table 10: list of banks in EU-15 sample per country (continued)

11 Appendix E

In tables 11-13, one can find the normalized cat fat measure of liquidity creation as well as the threshold values for each considered bank in the sample. In case a bailout was observed, the cat fat score was compared to the reactivation threshold (L_r) and deemed optimal if cat fat $> L_r$. In the absence of a bailout, the cat fat was compared with the containment threshold (L_c) and deemed optimal if cat fat $> L_c$. Nationalization, according to this model is interpreted as a situation where both L_l and L_r do not exist, i.e. a situation of eternal containment where the bank continues to operate with the help of government funding. Banks are listed alphabetically. In case no bailout was observed, B was set to the standardized average bailout amount for calculation purposes.

Bank Name	**Cat fat score**	$\mathbf{L}_c$	$\mathbf{L}_r$	$\mathbf{L}_l$	**Bailout?**	**Correct?**
Agricultural Bank of Greece	31.98	0.8737	1.4987	/	YES	YES
Aktia Bank Plc	89.79	0.8060	2.1753	/	NO	YES
Alandsbanken Abp	35.55	0.8060	2.1753	/	NO	YES
Allied Irish Banks plc	41.03	0.8481	1.6452	/	YES	YES
Alpha Bank AE	34.82	0.9211	1.3170	/	YES	YES
Argenta Spaarbank	**-284.61**	**0.8060**	**2.1753**	**/**	**NO**	**NO**
AXA Bank Europe SA/NV	54.24	0.8060	2.1753	/	NO	YES
Banca Monte dei Paschi di Siena	32.09	0.8060	2.1753	/	NO	YES
Banco Bilbao Vizcaya Argentaria	23.63	0.8060	2.1753	/	NO	YES
Banco BPI SA	27.51	0.8060	2.1753	/	NO	YES
Banco de Sabadell SA	40.38	0.8060	2.1753	/	NO	YES
Banco Espirito Santo SA	27.98	0.8060	2.1753	/	NO	YES
Banco Popular Espanol SA	51.24	0.8060	2.1753	/	NO	YES
Banco Santander SA	28.41	0.8060	2.1753	/	NO	YES
Banco Santander Totta SA	38.21	0.8060	2.1753	/	NO	YES
Bank of Ireland	40.28	0.8419	1.6915	/	YES	YES
Bank of Scotland Plc	136.77	0.7977	2.4414	/	YES	YES
Banque et Caisse d'Epargne Lux.	31.09	0.8060	2.1753	/	NO	YES
Banque Internationale à Lux.	315.71	0.9905	1.0880	/	YES	YES
Barclays Bank Plc	**-0.83**	**0.8060**	**2.1753**	**/**	**NO**	**NO**
BGL BNP Paribas	29.23	0.7994	2.3750	/	YES	YES
BNP Paribas	**-3.90**	**0.9991**	**1.0253**	**/**	**YES**	**NO**
BNP Paribas Fortis SA/ NV	26.81	0.9324	1.2818	/	YES	YES
BRF Kredit A/S	119.30	0.8060	2.1753	/	NO	YES
Caixa Geral de Depositos	26.74	0.8060	2.1753	/	NO	YES
Cassa Depositi e Prestiti	32.25	0.8060	2.1753	/	NO	YES
Commerzbank AG	28.54	0.8056	2.1851	/	YES	YES
Crédit Agricole	13.22	0.9987	1.0299	/	YES	YES
Crédit Mutuel	27.85	0.9982	1.0368	/	YES	YES

Table 11: Liquidity creation and bailout evaluation for EU-15 sample

Bank Name	**Cat fat score**	**L_c**	**L_r**	**L_l**	**Bailout?**	**Correct?**
Danske Bank A/S	51.11	0.8060	2.1753	/	NO	YES
Depfa Bank Plc	339.31	0.7815	8.7483	/	YES	YES
Deutsche Bank AG	**-32.07**	**0.8060**	**2.1753**	**/**	**NO**	**NO**
Deutsche Bank Luxembourg	686.67	0.8060	2.1753	/	NO	YES
Dexia	58.40	0.8403	1.7040	/	YES	YES
Emporiki Bank of Greece SA	24.95	0.7977	2.4418	/	YES	YES
Erste Group Bank AG	28.81	0.9970	1.0478	/	YES	YES
Eurobank Ergasias SA	16.71	0.9645	1.1838	/	YES	YES
Fortis Bank (Nederland)	52.30	0.8271	1.8301	/	YES	YES
Groupe Caisse d'Epargne	24.38	0.9991	1.0260	/	YES	YES
HBOS Plc	47.59	0.8171	1.9603	/	YES	YES
HSBC Holdings Plc	19.08	0.8060	2.1753	/	NO	YES
Hypo Alpe-Adria Bank International	37.97	0.8457	1.6627	/	YES	YES
ING Groep NV	24.09	0.9594	1.1997	/	YES	YES
Intesa Sanpaolo	24.32	0.8060	2.1753	/	NO	YES
Jyske Bank A/S	21.78	0.8060	2.1753	/	NO	YES
KBC Groep NV/ KBC Groupe SA	13.85	0.8628	1.5545	/	YES	YES
Kuntarahoitus Oyj	766.45	0.8060	2.1753	/	NO	YES
La Caixa	34.88	0.8060	2.1753	/	NO	YES
Landesbank Baden-Wuerttemberg	54.47	0.8129	2.0305	/	YES	YES
Millennium bcp	32.72	0.8060	2.1753	/	NO	YES
Nordea Bank AB	41.07	0.8060	2.1753	/	NO	YES
Nordea Bank Danmark Group	66.02	0.8060	2.1753	/	NO	YES
Nordea Bank Finland Plc	35.34	0.8060	2.1753	/	NO	YES
Nykredit Realkredit	79.21	0.8060	2.1753	/	NO	YES
OP-Pohjola Group	29.86	0.8060	2.1753	/	NO	YES
Permanent TSB Plc	29.41	0.8060	2.1753	/	NO	YES
Piraeus Bank SA	30.86	0.9877	1.1010	/	YES	YES
Rabobank Nederland	38.51	0.8060	2.1753	/	NO	YES

Table 12: Liquidity creation and bailout evaluation for EU-15 sample (continued)

Bank Name	**Cat fat score**	$\mathbf{L}_c$	$\mathbf{L}_r$	$\mathbf{L}_l$	**Bailout?**	**Correct?**
Raiffeisen Zentralbank Oesterreich AG	20.97	0.9716	1.1610	/	YES	YES
RBS Holdings NV (ABN Amro)	**5.89**	**0.8078**	**2.1333**	**/**	**Bought**	**NO**
Royal Bank of Scotland	23.05	0.8759	1.4882	/	YES	YES
SBAB Bank AB	219.32	0.8060	2.1753	/	NO	YES
Skandinaviska Enskilda Banken AB	46.66	0.8060	2.1753	/	NO	YES
SNS Reaal NV	31.91	0.9606	1.1960	/	YES	YES
Société Générale	8.49	0.9994	1.0210	/	YES	YES
Société Générale Bank & Trust	17.72	0.7995	2.3708	/	YES	YES
Sparkassen-Finanzgruppen	25.62	0.8060	2.1753	/	NO	YES
Svenska Handelsbanken	82.08	0.8060	2.1753	/	NO	YES
Swedbank AB	49.55	0.8060	2.1753	/	YES	YES
UBI Banca	26.96	0.8060	2.1753	/	NO	YES
Ulster Bank Ireland	70.97	0.7817	7.0536	/	YES	YES
UniCredit Bank AG	15.94	0.8060	2.1753	/	NO	YES
UniCredit Bank Austria AG	26.35	0.8060	2.1753	/	NO	YES
UniCredit SpA	21.74	0.8060	2.1753	/	NO	YES
Volksbanken Verbund	31.57	0.9099	1.3542	/	YES	YES

Table 13: Liquidity creation and bailout evaluation for EU-15 sample (continued)