Optimal Bail-out and Bail-in policy mix: Lessons from the Banco Espírito Santo (BES) failure

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by

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Abstract: This paper evaluates the optimal bail-out and bail-in mix in the case of bankruptcy of Banco Espírito Santo (BES), SA, the second largest Portuguese private bank. The solution after the crisis of the BES, was to partition the bank into a good bank (Novo Banco (New Bank)) and keep the toxic assets and problematic ones in a bad bank, the old BES bank, which would also receive those assets and bonds which were correlated with the ESFG (Espírito Santo Financial Group).

We show, in general, that the optimal policy mix parameter for the regulator’s bail-out and bail-in is contingent on the correlations between the shocks of residuals to the deposits and the shocks to the assets (equity and bonds).

We develop three cases: case A, regulation under perfect information and no shocks, a kind of benchmark; case B; with subcases B1 and B2, which reflect respectively perfect positive correlation between the deposit and assets shocks, and perfect negative correlation; and finally case C, which reflect a general correlation between the deposits and assets, between -1 and 1.

The conclusions, based upon simulations, tend to show that the optimal regulator problem in A was to intervene with optimal bail-out policy mix correspondence between deposit rates (r_d) and assets (r_a); while at B1 and B2 the optimal mix bail-out case is around 50% with deviation being derived from the correlation between deposits and assets’ residuals.

The main lesson that can be derived from the BES implosion, is that market value of the Novo Banco (New Bank) can be effectively assured if the market decouples for real the Novo Banco from BES, because if the correlation is a perfect fit (+1), new problems might arise in the near future.

Key-Words: Banco Espírito Santo(BES) , Bank of Portugal (BdP), Bankruptcy, Bail-in, Bail-out, ECB, Novo Banco, Optimal mix bail-out, Portuguese Banking sector, Regulators.

JEL codes: C15,E02,E44,E58,F36,G11,G18,G21,G28,G33;

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1. Introduction

This paper evaluates, from the point of view of the regulator, the Bank of Portugal (BdP), what is the optimal bail-out and bail-in mix in the case of bankruptcy of Banco Espírito Santo (BES), SA, the second largest Portuguese private bank. The solution after the crisis of the BES, was to partition the bank into a good bank (Novo Banco (“New Bank”)) and keep the toxic assets and problematic ones in a bad bank, the old BES bank which would receive all those toxic assets and bonds which were correlated with the ESFG (Espírito Santo Financial Group)- see Figure 1 in the annex (Merler, 2014).

We show, in general, that the optimal policy mix parameter for the regulator’s bail-out and bail-in is contingent on the correlations between the shocks of residuals to the deposits and the shocks to the assets (equity and bonds).

We develop three cases: case A, regulation under perfect information and no shocks, a kind of benchmark, for which we derive an optimal bail-out policy correspondence; case B; with subcases B1 and B2, which reflect respectively perfect positive correlation between the deposit and assets shocks, and perfect negative correlation; and finally case C, which reflect a general correlation between the deposits and assets, between -1 and 1.

The conclusions, based upon simulations, tend to show that the optimal regulator problem in A was to intervene with optimal mix correspondence contingent on the deposit remuneration \( r \) and assets \( r_a \); while at cases B1 and B2 the optimal mix bail-out case is around 50% with deviation above and below being derived from the correlation between deposits and assets’ residuals.

The main lesson that can be derived from the BES implosion, is that market value of the Novo Banco (New Bank) can be effectively assured if the market decouple for real the Novo Banco from BES, because if the correlation is a perfect fit (+1), new problems might arise.

Further extensions of this paper can be done, by integrating imperfect information, and the principal-agent model, namely by introducing a game theoretical framework, thus a reaction function from the new executive board of the Novo Banco facing the regulator, and comparing this with the previous executive board. Thus, it would be interesting to analyze optimal strategies and sustainable Nash equilibria in the long run.

So, the paper is structured in the following manner; in section 2 we define the optimal mix bail-out and bail-in from the regulator’s point of view, in section 3 we present the benchmark case with optimal policy bail-out correspondence (case A), the second case (case B, subdivided in B1 and B2), with perfect residuals correlation, and finally the general case (case C) with general correlation between deposits and assets (equity and bonds) residuals. On section 4, we compare the optimal mix results for this one shot
game of the regulator, that is for the three cases (A,B,C), on section 5 we simulate the optimal mix general result for the regulator’s problem (case C), and we present the simulations results. On section 6, we present the conclusions after discussing the results, the hypothesis the model is contingent on, and look forward to further extensions, and, also finally, we present some political economic implications for these kind of regulation; besides section 7 presents the tables, figures and annexes, section 8 list the acknowledgements and 9 the references.

2. Defining the optimal regulator’s mix: Step One

We define the optimal regulator’s problem as maximising the market value of the Bank (with intervention) $V(\alpha)$, as a function of a parameter ($\alpha$) of assurance and cover of deposits ($D_t$) and assets ($A_t$).

So, the problem is:

$$\max_{\alpha \in [0,1]} V(\alpha) = \alpha D_t + (1 - \alpha) A_t \quad \text{(1) [obj fct]}$$

s.t.

$$D_t + A_t = (1 + r).D_{t-1} + (1 + r_a).A_{t-1} \quad \text{(2) [Total bank value]}$$

$$D_t = (1 + r).D_{t-1} + \varepsilon_t \quad \text{(3) [Deposits]}$$

$$A_t = (1 + r_a).A_{t-1} + \eta_t \quad \text{(4) [Assets]}$$

Equation (1) is the objective function, the regulator aims to maximize bank’s market value, in order to minimize losses, guaranteeing covering of deposits, thus choosing $\alpha$, as an optimal target that maximizes market value of deposits. This is, thus the optimal degree of the bail-out of the bank, in order to avoid bank runs. But also, at the same time, defines $(1 - \alpha)$, as the degree that the regulator accepts as bail-in for the bank, being thus $\alpha D_t$ the loss shareholders acknowledge for their foregone investment assets.

Equation (2) depicts the total market value of the bank over time. Equation (3) depicts capitalization of deposits at rate $r$ subject to stochastic disturbance ($\varepsilon$), the same goes to assets capitalization (4) at rate ($r_a$) subject to disturbance ($\eta$).

We assume $\varepsilon$ and $\eta$ regular i.i.d.~$\sim N(0, \sigma^2)$ for the time being.

So the central bank (CB), Bank of Portugal (BdP), in this case with supervision of ECB, should define optimal $\alpha^*$ contingent on the stochastic shocks both to deposits and assets.
We first define the benchmark, CASE A, assuming a risk-neutral central bank, thus maximizing \( E[V(\alpha)] = E[\alpha. D_t + (1 - \alpha). A_t] = \alpha.E[D_t] + (1 - \alpha).E[A_t] \) subject to the constraints.

By recursivity, it can be shown (see the annex) substituting equation (3) and (4) on the objective function and deriving in order to \( \alpha \):

\[
\max_{\alpha \in [0, 1]} E[V(\alpha)] = \alpha.E[D_t] + (1 - \alpha).E[A_t] \tag{5}
\]

Equivalent to

\[
\max_{\alpha \in [0, 1]} E[V(\alpha)] = \frac{\alpha}{r} + \frac{(1 - \alpha)}{r_a} \tag{6}
\]

Which thus yields the following f.o.c. solution:

\[
\alpha^* = \alpha(r, r_a) \tag{7}
\]

Graphically this can be depicted as the correspondence graph between \( \alpha^* \) and \( (1 - \alpha^*) \), contingent on the \( r \) and \( r_a \) interest rates [see Figure 0- CASE A], but the solution would be indeterminate for some values.

But we can show also that as the deposit participation guarantee is bounded between \([0, 1]\), we have:

\[
\alpha^* = \alpha(r, r_a) = \begin{cases} 
\alpha^* = 1; \text{ iff } r < r_a \\
\alpha^* = \text{ any } [0, 1]; \text{ iff } r = r_a \\
\alpha^* = 0; \text{ iff } r > r_a 
\end{cases} \tag{8}
\]

### 3. Three cases of optimal mix bail-out: Step Two

Now we extend to other cases.

#### CASE A: BENCHMARK

As depicted before, problem (1) s.t. to (2)-(4) with i.i.d. \( \sim N(0, \sigma^2) \) and both equivalent, uncorrelated and independent.

Solution to case A as in equation (8):

\[
\alpha^* = \alpha(r, r_a) = \begin{cases} 
\alpha^* = 1; \text{ iff } r < r_a \\
\alpha^* = \text{ any } [0, 1]; \text{ iff } r = r_a \\
\alpha^* = 0; \text{ iff } r > r_a 
\end{cases}
\]

#### CASE B: PERFECT CORRELATION

which splits between case B1 and B2

CASE B1: we assume perfect positive correlation between \( \varepsilon \) and \( \eta \), thus \( \rho_{\varepsilon, \eta} = +1 \).

CASE B2: we assume perfect negative correlation between \( \varepsilon \) and \( \eta \), thus \( \rho_{\varepsilon, \eta} = -1 \).
CASE B1: PERFECT POSITIVE CORRELATION

Doing all the recursive approach, using time lag operator (L), and the properties of $\epsilon$ and $\eta$, thus $\rho_{\epsilon,\eta} = +1$.

\[
\max_{\alpha \in [0,1]} E[V(\alpha)] = \frac{\alpha}{r} + \frac{(1-\alpha)}{r_a} + \frac{\alpha(1-\alpha)}{(1-r^2)} \left( \frac{1}{r_a^2} \right) (\sigma^2)^2.
\] (9)

Deriving and obtaining the f.o.c. and solving in order to $\alpha$, we obtain:

\[
\alpha^*(B_1) = \frac{1}{2} + \left( \frac{1}{2} \right) \left[ \frac{(r_a-r)(1-r^2)(1-r_a^2)}{r_a^3} \right] (\sigma^2)^2.
\] (10)

CASE B2: PERFECT NEGATIVE CORRELATION

Doing all the recursive approach, using time lag operator (L), and the properties of $\epsilon$ and $\eta$, thus $\rho_{\epsilon,\eta} = -1$.

\[
\max_{\alpha \in [0,1]} E[V(\alpha)] = \frac{\alpha}{r} + \frac{(1-\alpha)}{r_a} + \frac{\alpha(1-\alpha)}{(1-r^2)} (-1) \left( \frac{1}{r_a^2} \right) (\sigma^2)^2.
\] (11)

Deriving and obtaining the f.o.c and solving in order to $\alpha$, we obtain:

\[
\alpha^*(B_2) = \frac{1}{2} + \left( \frac{1}{2} \right) \left[ \frac{(r-r_a)(1-r^2)(1-r_a^2)}{r^3} \right] (\sigma^2)^2.
\] (12)

CASE C: GENERAL CASE CORRELATION

General correlation between $\epsilon$ and $\eta$, thus $-1 < \rho_{\epsilon,\eta} < 1$.

It is quite alike B, but with general correlation, assuming constant variance but correlated residuals:

\[
\max_{\alpha \in [0,1]} E[V(\alpha)] = \frac{\alpha}{r} + \frac{(1-\alpha)}{r_a} + \frac{\alpha(1-\alpha)}{(1-r_a^2)} \left( \frac{1}{r_a^2} \right) (\sigma_{\epsilon,\eta})^2.
\] (13)

Thus, deriving with respect to $\alpha$ and obtaining the f.o.c for the general problem:
\[ \alpha^*(C) = \frac{1}{2} + \left( \frac{1}{2} \right) \cdot \frac{(r_a-r)(1-r^2)(1-r_a^2)(\sigma_e^2 \cdot \sigma_\eta^2)}{r^3r_a^3 (\sigma_{e,\eta})} \] (14)

4. Comparing the optimal bail-out mix \( \alpha^* \) results

Table 2, in the annex, sums up all the possible bail-out policy functions contingent on the three cases.

We can check, that equation (14) [CASE C] is the general case and that cases B1 and B2 can be derived from (C) with setting some definite parameter cases. Thus, respectively, if we have the same variance \( \sigma_e^2 = \sigma_\eta^2 = \sigma^2 \), and \( \sigma_{e,\eta} = 1 \), departing from (CASE C) we end up with case B1. However, if we depart from, again the same variance \( \sigma_e^2 = \sigma_\eta^2 = \sigma^2 \), but a perfect negative covariance, \( \sigma_{e,\eta} = -1 \), we end up with case B2.

Figures 2 to 9 describe the simulations of optimal \( \alpha^* \), for the referred cases from B1, B2 and C, regarding specific parameter values. We have chosen, \( r \) and \( r_a \) as reasonable values, this is starting from around 0% till 5%, and defined thus this bivariate grid, from which we simulated the optimal 3D surface for optimal \( \alpha^* \).

We depict unconstrained optimal \( \alpha^* \) in the surface, but we know that the optimal \( \alpha^* \), should be in the closed interval [0,1]. This is a working hypothesis, because we are assuming that the Central Bank (CB), in this case the Bank of Portugal, is not willing to pay, no more than the 100% value of the deposits itself, and at most to leave them at 0% coverage. So, for real \( \alpha^* \) belongs to the closed interval [0,1].

Regarding another hypothesis, in our model, that in equation (1) the Bank of Portugal is only choosing \( \alpha \), and simultaneously \( 1-\alpha \) which arises by definiton, and thus the model reflects a new trade-off between covering deposits and allowing foregone investment losses: \[ \max_{\alpha \in [0,1]} V(\alpha) = \alpha.D_t + (1-\alpha).A_t. \] This is what happened for real, and for the first time in the Banco Espírito Santo case (BES).

We could, eventually, resume another cases of bank failure in which the trade-off was not present, and for instance allow, a decision between two covering parameters, both simultaneously, as it happened in the Banco Português de Negócios (BPN) or in Banco Privado Português (BPP), in which there was a total bail-out, with decision parameters in the following problem:

\[ \max_{\alpha,\beta \in [0,1]} V(\alpha) = \alpha.D_t + \beta.A_t. \] (15)

And in this case, for real, could simultaneously happen \( \alpha_{BPN}^* = 1 \); and \( \beta_{BPN}^* = 1 \).
We opted for the equation (1) bail-out type of model, because this (our new model) was the type of bail-out and bail-in mix, which is quite new in the framework of banking regulation in Portugal, and also in the framework of the ECB, and thus Banking Union (BU). This, immediately reflects a change in policy and intervention regulation by the Bank of Portugal and also the ECB.

So, all this type of considerations, such as relations between optimality among Bank of Portugal, ECB and the bank itself will be further explored in next sections, but further developments by means of using reaction functions from the ECB and the bankrupt bank facing the policy decision from the Bank of Portugal (BdP) can be done.

Do notice that framework (15) was the general rule before BES failure, and can eventually still be used for analysis, not just, as referred to BPN, but also to other contexts such as Northern Rock in Northern Ireland, and eventually other frameworks across Europe and the world. The advantage of equation (1) is that reflects the new stance of Bank of Portugal in the framework of Banking Union and, in the aftermath of BES implosion, the possible new stance also by the ECB towards Banking Union.

5. Sensitivity to shocks: simulations results

Now we shall take a closer look at the optimality simulated solutions for cases B1, B2 and especially case C (the general case). Again, table 2 on the annex list the all possible cases.

Figure 2 and 3 show, respectively the optimal intervention degree ($\alpha^*$) surface contingent on $r$ and $r_a$, for variance $\sigma^2 = \sigma^2 = \sigma^2 = 0.0025$, and covariance ($\sigma_{e,\eta} = \pm 1$), between deposits and assets.

In figure 2, we can check that optimal degree of intervention attains full coverage of deposits ($\alpha^* = 1$) in a spike around with $r$ near 1% to 1.5% and $r_a$ from 0.5% to 1%. We have a negative value (from the unbounded problem) around between $r$ at 0.5% to 1% and $r_a$ from 0% to 0.5%, this would naturally be censored at $\alpha^* = 0$.

In figure 3, we have a quite alike behaviour, except that, as we have a negative correlation, the optimality trade-off between $r$ and $r_a$ is more pronounced, attaining nevertheless the same quite alike spike around the same $r$ and $r_a$ values.

In figures 4 and 5 we depict the case with different variances (respectively,) $\sigma^2 = 0.009$; $\sigma^2 = 0.0049$, and covariance ($\sigma_{e,\eta} = \pm 0.7$). Again the same optimal surface criteria emerges, nevertheless again the optimal “spike” appears around, as in figures 2 and 3, for 0.5% to 1% for $r$ and 0% to 0.5% for $r_a$. Again, figure 4 presents a negative value that must be censored (thus, $\alpha^* = 0$) for the blue surface. As for figure 5 presents relative to figure 4, alike as figure 3 relative to figure 2, a more pronounced decline of optimal $\alpha^*$
surface. One important aspect of figures 4 and 5 is that the “ceiling” for the optimal surface does not yield an optimal $\alpha^*=1$, its peak never exceeds 89% for the calibrated simulation. Thus, revealing for those interest rates the full coverage of deposits ($\alpha^*=1$) would not maximize bank’s market value at 100% coverage, but only at $\alpha^*=89\%$.

Nevertheless, if we again calibrate the model with the same variances as in figure 4 and 5, but with smaller co-variances, respectively, $\sigma_\varepsilon^2 = 0,009$; $\sigma_\eta^2 = 0,0049$, and covariance ($\sigma_{\varepsilon,\eta} = \pm 0,3$) for figures 6 and 7, we again repeat the relative surface scenarios of figures 2 and 3. Thus, having to censor ($\alpha^*=0$) for the blue surface in figure 6, and yielding this turn a sensitive spike around the same $r$ and $r_a$ domain values, keeping the sensitivity of the ceiling in green exceeding 1; so having to censor ($\alpha^*=1$) for the green surface in both figures 6 and 7.

To end up, and extend our sensitivity measures, we can see figure 8, with very reduced variances ($\sigma_\varepsilon^2 = \sigma_\eta^2 = \sigma^2 = 0,000000009$) and positive covariance, which leads to optimal ($\alpha^*=0,5$) for the orange surface, thus indicating if deposits and assets are less volatile, the optimal burden should be widespread evenly between deposits and assets ($\alpha^*=50\%$).

If we change the magnitude of variances: In figure 9, we can check that if deposits are more volatile than assets, with a perfect negative covariance, $\sigma_\varepsilon^2 = 0,0049$; $\sigma_\eta^2 = 0,0009$, and covariance ($\sigma_{\varepsilon,\eta} = -1$) it still makes sense to diversify. This is because they are negatively correlated, but the optimal surface again never reaches the ($\alpha^*=1$) ceiling but only 89% for the calibrated model.

This last result, even though unlikely in reality (because this different kind of higher volatilities in deposits versus lower volatility risky assets is uncommon), is a positive check for the model, because if we have an higher volatile deposit and lower volatile asset, both perfectly negatively correlated, in order to maximize expect return, we will still diversify the portfolio by sharing between the two investments. Thus, this might assures us of the validity of the model, contingent on the parameter calibration, for proper policy uses.

6. Conclusions, policy implications and further extensions

When analyzing the intrinsic nature of the implications of a regulatory policy practice, both political as economic and social implications of regulating a failed bank must be taken into account. These might be highly controversial, because they raise issues not just of efficiency, but also of equity. The Portuguese media revealed recently a political
stress and grievance towards the optimal share burden of assuring the cost of recap of the failed BES, a private bank which would, allegedly be saved, by public funds. Namely, by comparison of what happened in the recent past, with situations alike in the Banco Português de Negócios (BPN) and Banco Privado Português (BPP) there was media grievance towards similar solutions.

The BdP of Portugal was cunning and we prove that might have been over-protective, but nevertheless, there are always other considerations to take into account. Our simulations show that given certain conditions, $r$ and $r_a$ around certain given values (between 0% and 5%), the optimal degree of deposit coverage should be inferior to 100%, thus raising a new avenue of research in trying to establish and trying to define the optimal degree of deposit coverage. So, we conclude that the BdP might have been over-protective, in the decision to assume the 100% coverage on deposits, and we should not have taken for granted that in order to maximize the failed bank market’s value one should comply by that rule.

This paper, as far to my knowledge, is yet the first to evaluate with the simplest framework, see section 2 and 3, the optimal degree of deposit coverage assurance for a failed bank, from the point of view of the regulator (Bank of Portugal, BdP), after the Banco Espírito Santo (BES) imploded on the 3rd of August (see Merler, 2014). This is yet the first attempt to evaluate the intervention of the BdP on the BES, and its market valuation from a theoretical optimal perspective.

Some preliminary conclusions based on our simulations, $\alpha^*$ surface optimality is contingent on the return of the deposits and assets ($r$ and $r_a$). The real solution in the case of $\alpha^{BES}=1$, was decided by the Bank of Portugal in accordance with the ECB and the BES bank (new management team). For our model we only attain this situations in a given proper framework as we saw in the discussion of the simulations for low returns around 1% for $r$ to 1,5% of assets - see figures 2 to 9 in the annex. This might reveal that the BdP might eventually have covered too much in terms of efficiency to maximize global market value of the failed bank. Nevertheless, we know that our model is contingent on our hypothesis, and so if we extend our model our conclusions might and should be sensitive to it.

Some hypothesis our model is contingent on: we are working with a risk neutral Bank of Portugal (BdP), our model is quite alike the risk burden share of Harry Markowitz (1952, 1968) in portfolio selection (yet simpler).

We are working just with two types of investment allocations: deposits and assets. This model, tends to reflect the nature of the trade-off between assuring deposit coverage and asset coverage for foregone investment losses in equation (1), which yields the new policy stance for the Bank of Portugal.
In the framework of the Banking Union (BU)\(^3\), one still needs to assess the theoretical game between the optimality of \(\alpha^*\) from the Bank of Portugal, with those from the ECB and the failed bank \((\alpha^*_{\text{ECB}} \text{ and } \alpha^*_{\text{BES}})\). Naturally, one would expect that a Nash equilibria might arise in pure strategies, such as Cournot-Nash Game, which would have a second phase, in which both the players ECB and BES play in reply to BdP. Some preliminary results yield that a Cournot-Nash equilibria would be \((\alpha^* = \alpha^*_{\text{ECB}} = \alpha^*_{\text{BES}})\) in pure strategies, being the game played in quantities \((\alpha^*, \alpha^*_{\text{BES}}, \alpha^*_{\text{ECB}})\) and being the reaction function based upon the value of the bank. This is an avenue of research, quite interesting as it reflects the new stance of ECB, BdP and the banks in troubles, but which still be more proficuous with more data from other case countries from EU and BU.

One should nevertheless stress, that the model as yet simple, is not confined to the Portuguese case, as it reflects the new nature of the Euro-system and specially the nature of the Banking Union, and the inter-relation between Central Banks (CBs), the ECB and the banks in distress.

The main lesson that can be derived from the BES implosion, is that market value of the Novo Banco (New Bank) can be effectively assured if the market decouple for real the Novo Banco from BES, because if the correlation is a perfect fit (+1), new problems might arise. This is important and naturally arises by the optimal partition between the failed bank BES and Novo Banco, if the assets’ correlation and deposits are decoupled, then quite naturally the Novo Banco will face a new promising future. If not, there might surge new problems, and as perspectives to sell the Novo Banco in the market raise, a sensitivity analysis like this one is, yet very useful, for it allows to understand the tying correlations between the two assets: deposits (Novo Banco) and old toxic assets (BES).

We have developed three cases: case A, regulation under perfect information and no shocks, a kind of benchmark; case B; with subcases B1 and B2, which reflect respectively perfect positive correlation between the deposit and assets shocks, and perfect negative correlation; and finally case C, which reflect a general correlation between the deposits and assets, between -1 and 1.

The conclusions, based upon simulations, tend to show that the optimal regulator problem in A was to intervene with optimal bail-out policy mix correspondence between deposit rates \((r_d)\) and assets \((r_a)\); while at B1 and B2 the optimal mix bail-out case is around 50% with deviation being derived from the correlation between deposits and assets’ residuals.

We have shown, in general, that the optimal policy mix parameter for the regulator’s bail-out and bail-in is contingent on the correlations between the shocks of residuals to the deposits and the shocks to the assets (equity and bonds) using this new framework of intervention of the BES case by the Bank of Portugal. Yet, as the framework of our

\(^3\) See e.g., for one of the many discussions of Banking Union (BU), de Sousa and Caetano (2013).
theoretical model shows, for given calibrations, one cannot take for granted that optimal deposit coverage should always be at 100% - Recall figures 2 to 9.

Further extensions of this paper can be done, by integrating imperfect information, and the principal-agent model, namely by introducing a game theoretical framework, thus a reaction function from the new executive board of the *Novo Banco* facing the regulator, and comparing this with the previous executive board. Thus, it would be interesting to analyze optimal strategies and sustainable Nash equilibria in the long run.

Other interesting extensions of our model that might arise would be to link the value of optimal coverage insurance to: i) partial information in the players; ii) to the inverse probability of bank runs as the degree of coverage increases, as in the bank runs of Diamond and Dybvig (1983) model. These are naturally worthy lines of sustainable research which we are keen on.
7. Annex: Figures and Tables

FIGURE 1: BES and ESFG structure

Banco Espirito Santo Group Structure

Source: Merler (2014)
CASE A: BENCHMARK

\[ \max_{\alpha \in [0,1]} E[V(\alpha)] = \frac{\alpha}{r} + \frac{(1-\alpha)}{r_a} \] solution:

\[ \alpha^* = 1; \text{ iff } r < r_a \]
\[ \alpha^* = \text{any } [0,1]; \text{ iff } r = r_a \neq 0 \]
\[ \alpha^* = 0; \text{ iff } r > r_a \]

Table 1: CASE A- Optimal bail-out mix correspondence

<table>
<thead>
<tr>
<th>(\alpha^*(r, r_a))</th>
<th>r</th>
<th>r</th>
<th>r</th>
<th>r</th>
<th>r</th>
<th>r</th>
<th>r</th>
<th>R</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>CASE A</td>
<td>0%</td>
<td>1,0%</td>
<td>1,5%</td>
<td>2,0%</td>
<td>2,5%</td>
<td>3,0%</td>
<td>3,5%</td>
<td>4,0%</td>
<td>4,5%</td>
</tr>
<tr>
<td>Ra 0,0%</td>
<td>Indet</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Ra 1,0%</td>
<td>1</td>
<td>(\alpha^*)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Ra 1,5%</td>
<td>1</td>
<td>1</td>
<td>(\alpha^*)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Ra 2,0%</td>
<td>1</td>
<td>1</td>
<td>1</td>
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<td>(\alpha^*)</td>
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<td>1</td>
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Source: Author's model for case A.
**TABLE 2: Optimal Bail-Out policy mix compared among three typical cases**

<table>
<thead>
<tr>
<th>Case</th>
<th>Problem</th>
<th>Solution</th>
</tr>
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<tr>
<td><strong>CASE A</strong></td>
<td><strong>Benchmark</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Problem</strong> [\alpha \in [0,1]] (E[V(\alpha)] = \frac{\alpha}{r} + \frac{(1 - \alpha)}{r_a})</td>
<td><strong>Solution</strong> (\alpha^* = \alpha(r, r_a) = \begin{cases} \alpha^* = 1; \text{iff } r &lt; r_a \ \alpha^* = \text{any } [0,1]; \text{iff } r = r_a \neq 0 \ \alpha^* = 0; \text{iff } r &gt; r_a \end{cases} )</td>
</tr>
<tr>
<td><strong>CASE B1</strong></td>
<td><strong>Perfect +</strong> (\rho_{\varepsilon, \eta} = +1) (E[V(\alpha)] = \frac{\alpha}{r} + \frac{(1 - \alpha) + 1}{r_a} \left( \frac{1}{r^2} - 1 \right) \left( \frac{1}{r_a^2} - 1 \right) \left( \sigma^2 \right)^4 )</td>
<td>(\alpha^*(B_1) = \frac{1}{2} + \frac{1}{2} \cdot \left( \frac{r_a - r}{r - r_a} \right) \left( \frac{1 - r^2}{1 - r_a^2} \right) \left( \sigma^2 \right)^4 )</td>
</tr>
<tr>
<td><strong>CASE B2</strong></td>
<td><strong>Perfect -</strong> (\rho_{\varepsilon, \eta} = -1) (E[V(\alpha)] = \frac{\alpha}{r} + \frac{(1 - \alpha) - 1}{r_a} \left( \frac{1}{r^2} - 1 \right) \left( \frac{1}{r_a^2} - 1 \right) \left( \sigma^2 \right)^4 )</td>
<td>(\alpha^*(B_2) = \frac{1}{2} + \frac{1}{2} \cdot \left( \frac{r - r_a}{r - r_a} \right) \left( \frac{1 - r^2}{1 - r_a^2} \right) \left( \sigma^2 \right)^4 )</td>
</tr>
<tr>
<td><strong>CASE C</strong></td>
<td><strong>Imperfect Correlation</strong> (-1 &lt; \rho_{\varepsilon, \eta} &lt; 1) (E[V(\alpha)] = \frac{\alpha}{r} + \frac{(1 - \alpha)}{r_a} \left( \frac{1}{r^2} - 1 \right) \left( \frac{1}{r_a^2} - 1 \right) \left( \sigma_{\varepsilon, \eta}^2 \right)^2 )</td>
<td>(\alpha^*(C) = \frac{1}{2} + \frac{1}{2} \cdot \left( \frac{r_a - r}{r - r_a} \right) \left( \frac{1 - r^2}{1 - r_a^2} \right) \left( \sigma_{\varepsilon, \eta}^2 \right)^2 \left( \sigma_{\varepsilon}^2 \right)^2 )</td>
</tr>
</tbody>
</table>

Source: Author’s calculations.
CASE B1: PERFECT +1 CORRELATION

\[
\max_{\alpha \in [0, 1]} E[V(\alpha)] = \frac{\alpha}{r} + \frac{(1 - \alpha)}{r_a} + \frac{\alpha(1 - \alpha) \cdot (1)}{(1 - \frac{1}{r^2} - 1)} \cdot (\sigma^2)^4
\]

With solution: \(\alpha^*(B_1) = \frac{1}{2} + \left(\frac{1}{2}\right) \cdot \frac{(r_a-r)(1-r^2)(1-r_a^2)}{r^3 r_a^3} \cdot (\sigma^2)^4\)

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<td>0,07</td>
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**TABLE 3** Optimal alpha solution for bail-out

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<th>0,015</th>
<th>0,020</th>
<th>0,025</th>
<th>0,030</th>
<th>0,035</th>
<th>0,040</th>
<th>0,045</th>
<th>0,050</th>
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<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>(r)</td>
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<td>0,010</td>
<td>0,015</td>
<td>0,020</td>
<td>0,025</td>
<td>0,030</td>
<td>0,035</td>
<td>0,040</td>
<td>0,045</td>
<td>0,050</td>
</tr>
<tr>
<td>(r)</td>
<td>indet</td>
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<td>-6,3306</td>
<td>-3,8218</td>
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<td>-1,1115</td>
<td>-0,7590</td>
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<td>0,5112</td>
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</table>

Source: Author's model
CASE B2: PERFECT -1 CORRELATION

\[
\max_{\alpha \in [0,1]} E[V(\alpha)] = \frac{\alpha}{r} + \frac{(1 - \alpha)}{r_a} + \frac{\alpha(1 - \alpha) \cdot (-1)}{(\frac{1}{r^2} - 1) \left( \frac{1}{r_a^2} - 1 \right) \cdot (\sigma^2)^4}
\]

With solution: \( \alpha^*(B_2) = \frac{1}{2} \cdot \left( \frac{1}{2} \right) + \left( \frac{r - r_a}{r \cdot r_a^3} \right) \cdot \left( 1 - r^2 \right) \cdot (\sigma^2)^4 \)

\[ \text{Sigma} \quad 0.07 \]
\[ \text{Sigma sqd} \quad 0.00490 \]

TABLE 4 Optimal alpha solution for bail-out

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<thead>
<tr>
<th>( \alpha^*(r, r_a) )</th>
<th>R</th>
<th>r</th>
<th>r</th>
<th>r</th>
<th>r</th>
<th>r</th>
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Source: Author's model
CASE C: GENERAL CORRELATION

\[
\max_{\alpha \in [0,1]} E[V(\alpha)] = \frac{\alpha}{r} + \frac{(1 - \alpha)}{r_a} + \alpha(1 - \alpha) \cdot \left(\frac{1}{r^2} - 1\right) \left(\frac{1}{r_a^2} - 1\right) \cdot (\sigma_\varepsilon^2 \cdot \sigma_\eta^2)^2
\]

With solution: \( \alpha^*(C) = \frac{1}{2} + \left(\frac{1}{2}\right) \cdot \left[\frac{(r_a - r)(1 - r^2)(1 - r_a^2)(\sigma_\varepsilon^2 \cdot \sigma_\eta^2)^2}{r^3 \cdot r_a^3 \cdot (\sigma_\varepsilon \cdot \sigma_\eta)}\right] \)

\[Epsilon\] \[Eta\] \[Sigma\] \[0,07\] \[0,07\] \[0,0049\] \[0,0049\] \[COV (epsilon,eta)\] \[0,5\] \[\sigma_\varepsilon^2\] \[\sigma_\eta^2\] \[\sigma_\varepsilon \cdot \sigma_\eta\]

TABLE 5  Optimal alpha solution for bail-out

<table>
<thead>
<tr>
<th>(\alpha^*(r, r_a))</th>
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<th>0,010</th>
<th>0,015</th>
<th>0,020</th>
<th>0,025</th>
<th>0,030</th>
<th>0,035</th>
<th>0,040</th>
<th>0,045</th>
<th>0,050</th>
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<td>-13,1613</td>
<td>-8,1435</td>
<td>-5,3993</td>
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<td>-2,7229</td>
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Source: Author's model
8. Acknowledgements

*de Sousa* thanks POCTI/FEDER, FCT 2013 and NICPRI-UE for granting him research funds to conduct the subsequent research undergone. The author thanks an anonymous CEFAGE referee for suggestions and the usual caveat applies.

9. References


