Simulation for the stability and DEA risk analysis of Greek banks within a prolonged duration of the debt crisis.

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Abstract

In the current paper, we study the stability and the survival probabilities of enterprises and banks within a prolonged duration of the debt-crisis (after 2007, and beyond 2011), with simulation. We utilize historical data from banks and enterprises within the debt-crisis to define crisis-variability and crisis-average values of input parameters of the simulation. We also compute Data Envelopment Analysis (DEA), with relevant to simulation inputs and outputs, so as to have a mutual relative efficiency of the Banks, and some enterprises.

Keywords: Simulation; Banking risk; Debt-crisis; Data Envelopment Analysis.
1. Introduction

Non-parametric simulation and Monte Carlo simulation become particularly powerful in cases, where the final random variables, are derived from the other known input variables with complicated, combinatorial and non-linear equations. The use of the computers in such cases, is very effective, and the accuracy of the results rather impressive. In a previous paper we derived the probabilities of bankruptcy of various types of enterprises, within continuing economic crises, through the technique and geometric combinatorial indicator of Maximum Draw-down of Equities. (See Kyritsis 2013). We had to code a special simulator, to compute the maximum Draw-down of equities. Other techniques in the bibliography, (e.g. see Samih Antoine 2012) use in a rather arbitrary way classes of functional formulas for the probability, which try to simulate. We consider our method, more realistic. On the other hand the methodology in the paper Virginiaclark, 2010 and Bruner R., 1992 is closer to our approach. The results of simulation are reviewed and presented in short in the paper from the previous (Kyritsis K, 2013) so as to compare and enhance them with the methodology of DEA, which has more than 3000 publications in various sciences. We estimate the relative efficiency of these banks (and selected other industrial enterprises) with Data Envelopment Analysis. We give also a short review of the methodology of DEA. The results of the simulation are discouraging negative for the banks but the results of DEA are re-assuring in to that almost all banks are best performing compared among them. For the details of the simulation the reader is directed to the paper Kyritsis K. 2013. Further analysis of the risk of enterprises based on the concept of business cycles in Kyritsis C. et al 2007. Here we present only the tables of the results, comments of the historic data used, and their interpretation but not the details of how they were derived.

2. The historic data

The historical data of enterprises are used to compute the average value $r_0$ of the annual rate of change of the assets and the standard deviation $s_0$ of the annual percentage changes of the assets. They are used also to define the critical value of the equities maximum draw-down, above which the enterprise is lead to bankruptcy. We utilized, 50 non-bank Greek enterprises that are listed in the Athens Stock Exchange market,(FTSE/ASE 20, FTSE/ASE 40 & FTSE/ASE 80), with higher capitalization compared to the rest. We calculated the $r_0$, and $s_0$, within the debt-crises, that is from 2008 till 2011. We also utilized all of the 14 Greek banks. We calculated the $r_0$, and $s_0$, within the debt-crises, that is from 2008 till 2010. We may raise here the issue that the enterprises may overstate their achievements in their financial statements (see e.g. in the references the papers Kramer S. et al 2011 and Petrova E. 2012, and Hytis E et al 2011). This is often unavoidable. In our case also some banks did not publish at all financial statements for 2011, that is why we used data from 2008 to 2010. We do not consider here this issue and we assume that the financial statements are fair enough.

3. Simulation analysis and the survival probabilities of non-bank enterprises within a prolonged duration of the debt crisis.

Here we calculate with the simulator the survival probabilities for 5 years and for 11 years of continuing debt-crisis, for the average profile of 50 enterprises. The choice of the horizon is relevant to the 11 year business cycle (see Kyritsis C. et al 2007). The result is that they do not seem to be really in danger as a whole. But we also calculate 3 particular indicative cases that give lower probabilities of survival. The main positive feature of these companies is their rather high percentage of equities in the assets, or low capital structure leverage. If an enterprise has negative momentum, in the assets changes (decreasing assets), it is of higher risk. The same happens if it has low rate of increase of assets, but very high standard deviation of this rate.
Here we calculate with the simulator the survival probabilities for 5 years and for 11 years of continuing debt-crisis, for the average profile of 14 banks, and for each bank separately. The result is that they do have significant risk and survival probabilities close to 60%, as a whole. Some banks are safe, with 100% probability of survival, but some cases give low survival probabilities. The banks as a whole have at least double the risk of bankruptcy, compared to the non-bank enterprises. The main risk factor here is the fractional reserve rule 1 to 10 or more, that gives very low percentage of the equities in the assets, or high capital structure leverage.

The next picture is the histogram of cumulative survival probabilities of the average profile of a bank. The probability in the y-axis e.g. 50.54% as in the above table, for a value e.g. 6% in the x-axis, and it gives the probability (of the maximum draw-down of assets) for a horizon of 5 years of debt crisis, to be 6% or less (not losing all the equities).
We conclude here that the banks are far more in danger, compared to the other enterprises, in a prolonged duration of the debt crisis. The survival probability of the average profile of a bank is about 60%. Of course the above results assume that the debt crisis will continue with a momentum neither worse nor better, for a horizon of 5 or 11 years. In addition that the financial management policy is the usual common sense, most probable decision making. Radical changes of the banks like merging, splitting, recapitalization etc are not included in the above simulation. More radical extraordinary financial management, as above, would improve the survival probabilities. The above analysis may be also considered a sophisticated fundamental analysis with simulation that can select less risky enterprises from the stock exchange market for a safer investment portfolio.

4. A short description of the concepts of DEA.

The methodology of Data Envelopment Analysis (DEA) allows for a calculation of the mutually relative efficiency from 0% to 100% of a number of Decision Making Units (DMA’s). (See e.g. D. Sherman and J. Zhu, 2006 chpt 2) This gives not only a relative ordering of the units but also it permits the estimation of what has to happen to units that are not 100% efficient so as to become 100% efficient. The calculation is based on data of inputs and outputs, for each unit. Millions of dollars can be saved in this ways and there are real life examples in various and different industries. There are more than 3000 publications of papers utilizing the DEA methodology in various sciences and disciplines. This does not mean that DEA is an infallible methodology as it has both advantages and disadvantages that will be discussed below.

One of the basic advantages of the DEA is that the input and output values of the units can be of radically different nature and units of measurement. They can be of technological, human or economic nature. DEA is based on the following logically working axioms. (see e.g. S. Sigaroudi 2009 chapter 2)
Production Possibility Set
In productivity analysis, or efficiency measurement in general, when the DMUs consume different inputs to produce m different outputs, the production possibility set (PPS) is the collection of all feasible DMUs that are capable of producing output $y = (y_1, y_2, ..., y_m)$ consuming input $x = (x_1, x_2, ..., x_s)$. The PPS is defined as the set:

$$\Psi = \{ (x, y) \in \mathbb{R}^{m+s} / x \text{ can produce } y \}$$

(1)

Disposability axiom: A fundamental assumption to form the PPS out of the available data is 'disposability'. If $x$ can produce $y$ so does any $x_i - x$ and if $y$ could be produced by $x$ so could be any $y_j - y$. Formally each observed data $X = (x_1, ..., x_m)$, $Y = (y_1, ..., y_s)$ brings along part of the unobserved piece of the PPS which is defined as

$$\{X_i, Y_i \in \mathbb{R}^{m+s} / X_i \geq X \text{ and } Y_i \leq Y\}$$

(2)

This is like saying if DMUi could be realized then any DMU that is doing worse is feasible, too. This assumption leads to the Free Disposal Hull (FDH) model, which shares its PPS with most of the other models.

Convexity: Any convex linear combination of realized DMUs is feasible. In other words if two DMUs are in the PPS so does the line connecting these two ones (any linear combination of them). This assumption leads to the BCC model, a variable return to scale model.

Ray Unboundedness: Scaling up or down of any realized DMU generates a new feasible DMU. This assumption added to the convexity assumption is the basis of CCR, a constant returns to scale model.

A fractional formulation for the case of $s$ outputs, $m$ inputs, and $n$ DMUs where the $y$ terms represent output levels, the $x$ terms represent input levels, and the $u$ and $v$ terms represent the weights associated with outputs and inputs respectively, is shown below as Formulation 1

Formulation 1

Maximize

$$\frac{\sum_{i=1}^{s} u_i y_i r_1}{\sum_{i=1}^{m} v_i x_i r_2}$$

subject to

$$\frac{\sum_{i=1}^{s} u_i y_j}{m} \leq 1 \text{ for } j=1,...,n, \text{ and } u, v_i \geq 0, \text{ for } r=1,...,s \text{ and } \text{ for } r=1,...,m$$

(4)

The formulation is not linear. Charnes and Cooper (1978) demonstrate that this particular type of non-linear problem can be converted to linearity. Thus the DEA can be solved using linear methods. A linear version of the above formulation is shown below as Formulation 2.

Formulation 2.
Maximize
\[
\sum_{r=1}^{s} u_r y_{r1} - \sum_{i=1}^{m} v_i x_{i1}
\]  
(5)

Subject to
\[
-\sum_{i=1}^{m} v_i x_{i1} \leq -1, \quad \sum_{r=1}^{s} u_r y_{r1} - \sum_{i=1}^{m} v_i x_{ij} \leq 0 \quad \text{for } j=1,\ldots,n \quad \text{and}
\]
\[
u_r, v_i \geq 0, \quad \text{for } r=1,\ldots,s \quad \text{and } i=1,\ldots,m
\]  
(6)

DEA gives advantage to each branch or service unit (see e.g. D. Sherman and J. Zhu, 2006 page 66) when calculating the efficiency value. All DMUs should have the same set of inputs and the same set of outputs.

The two basic DEA models are named after the respective researchers to first introduce them: the Charnes Cooper Rhodes (CCR) and the Banker Charnes Cooper (BCC) models. (See e.g. Kassim, et al. 2010) The two models are a constant-return-to-scale (CRS) or variable return-to-scale (VRS) represented in the CCR and the BCC models, respectively. An organization is said to exhibit CRS if an increase in inputs will result in a proportional increase in its outputs. The CRS frontier surface (see e.g. S. Sigaroudi 2009 chapter 2 and 3) is represented by a straight line that starts at the origin and passes through the first organisation that it meets as it approaches the observed population.

However, it is possible and sometimes beneficial to treat each DMU-time period combination as a distinct DMU in a single DEA. For more on this technique, called window analysis, the interested reader is directed to Charnes, Clark, and Cooper (1985).

The models orientation is either input or output orientation. (see e.g. S. Sigaroudi 2009 page 12) Input orientation is implying that an inefficient organization may be made efficient by reducing the proportions of its inputs but keeping the output proportions constant; Output orientation is implying that an inefficient organization may be made efficient by increasing the proportions of its outputs while keeping the input proportions constant.

DMUs are represented by their inputs and outputs in the frontier diagram. Efficiency scores depend on how far the DMU is located from the frontier. Depending on the problem, DMUs can reduce their inputs or increase their outputs or target improvement in inputs and outputs simultaneously in order to move to a point on the frontier. The CCR and BCC models are either focused on minimizing input (input oriented) or maximizing output (output oriented). An additive model by definition is the one that focus on decreasing input and increasing output simultaneously and therefore has no orientation. Additive model shares the same PPS with BCC model.

In the next we set some definitions between different concepts of efficiency. (See e.g. R. S. Sale, M.L. Sale 2003)

In DEA, the efficiency is relative, in the sense, that we compare the DMU between them. But if all of them of equal efficiency this would be a 100%. While in reality we do no know if the best of the DMU could be further improved by some internal technical management innovation or re-design.

**Full Absolute Efficiency**: Full absolute efficiency is attained by any DMU, in an isolated analysis, if and only if none of its inputs or outputs can be improved without worsening some of its other inputs or outputs irrespectively of the other comparing units. This is also called absolute Pareto optimality. (See e.g. R. S. Sale, M.L. Sale 2003)

**Full Relative or Technical efficiency**: Full technical efficiency is attained by any DMU if and only if, compared to other observed DMUs, none of its inputs or outputs can be improved without
worsening some of its other inputs or outputs. This is also called relative Pareto optimality.

**Relative efficiency** of the unit when compared to its peer groups is the amount of input that could be eliminated or the amount of output increased without worsening any other input or output. The peer groups might change over time or as the result of managerial decisions, because of changing the production technology or merging with other entities.

**Scale efficiency:** Is the difference between the “variable returns to scale” model, BCC, and the “constant return to scale” model, CCR, as a production scale effect. Scale efficiency represents the failure in achieving the most productive scale size and the score difference between CCR and BCC models reflects that. It is computed as the CCR efficiency score divided by the BCC efficiency score.

One rule of thumb is that there should be at least twice as many DMUs as there are inputs and outputs combined. (see e.g. S. Sigaroudi 2009 chapt. 4 p.26 and R. S. Sale, M.L. Sale 2003) and If this is not the case then the likelihood of most or all DMUs receiving efficiency scores at or near 1.0 is great. Again, this limits the interpretive power of the DEA.

More precisely the general rule for DEA models requires \( n \geq \max \{3(m + s), m \times s\} \). (3)

We give the next definitions. (See e.g. S. Sigaroudi 2009 page 11)

**Input Slack factor:** Identifies the minimum value \( x \) for input \( m \) without changing other inputs or output \( y \) when \((x, y)\) belongs to the PPS

**Input substitution factor:** Identifies the smallest value \( x \) for input \( m \) that is possible for any \( x \) such that \((x, y)\) belongs to the PPS

**Output Slack factor:** Identifies the maximum value \( y \) for output \( s \) without changing other outputs or inputs when \((x, y)\) belongs to the PPS

**Output substitution factor:** Identifies the largest value \( y \) for output \( s \) that is possible for any \( y \) such that \((x, y)\) belongs to the PPS

5. The inputs and outputs and the Data Envelopment Analysis results.

As it was remarked before all the inputs must be chose so that the less their value the better the performance and the output so that the higher their values the better the performance. Because we have already used some magnitudes for risk analysis and simulation in the previous study, we shall keep on utilizing the standard deviation which is a risk measure also in DEA, which will therefore be also a risk efficiency analysis. The data are averages over the 5 years 2005-2011. Negative values are substituted with zeros. In the previous study we had by simulation only 13 banks, here in the DEA analysis, we have added a 14th bank the Cyprus-Marfin, for better comparisons.

So the inputs are

**Input1**= taxes/assets

**Input2**= Standard deviation of the assets annual percentage change

And the outputs are

**Output1**= Percentage of equities in the assets

**Output2**= Percentage of profits in assets (ROA)
Table 3. Input data

|               | taxes/assets | Standard deviation of the ASSEST ANNUAL PERCENTAGE CHANGE INPUT | Percentage of equities in the assets OUTPUT | Percentage of profits in assets (ROA) OUTPUT |
|---------------|--------------|---------------------------------------------------------------|--------------------------------------------|--------------------------------------------|
| ETHNIKI       | 0.000873     | 0.03                                                          | 0.09                                       | 0.011233                                   |
| ALPHA         | 0.000112     | 0.12                                                          | 0.08                                       | 0.008151                                   |
| AGROTIKI      | 0.001662     | 0.12                                                          | 0.03                                       | 0                                           |
| EUROBANK      | 0            | 0.10                                                          | 0.07                                       | 0.006567                                   |
| CYPRUS        | 0.00172      | 0.03                                                          | 0.06                                       | 0.01011                                    |
| MARFIN        | 0.00209      | 0.23                                                          | 0.05                                       | 0.00273                                    |
| CYPRUS-MARFIN | 0            | 0.13                                                          | 0.00                                       | 0.007803                                   |
| PIREOS        | 0.001647     | 0.10                                                          | 0.06                                       | 0.007016                                   |
| TT            | 0.001761     | 0.15                                                          | 0.05                                       | 0.003419                                   |
| GENIKI        | 0.001097     | 0.13                                                          | 0.05                                       | 0                                           |
| PROTON        | 0.003683     | 0.36                                                          | 0.10                                       | 0.077474                                   |
| ATTICA        | 0.001069     | 0.15                                                          | 0.10                                       | 0                                           |
| EMPORIKI      | 0.000998     | 0.09                                                          | 0.03                                       | 0                                           |
| T-BANK        | 0            | 0.13                                                          | 0.04                                       | 0                                           |

Table 4. Output data

|               | Taxes/total assets | Standard deviation of the previous (INPUT) | Percentage of equities in the assets (OUTPUT) | Percentage of profits in assets (ROA) OUTPUT |
|---------------|--------------------|---------------------------------------------|-----------------------------------------------|---------------------------------------------|
| BIOXK         | 0.005135           | 0.078152                                     | 0.539039                                      | 0.005594                                   |
| DEH           | 0.005483           | 0.050516                                     | 0.392906                                      | 0.010857                                   |
| EEEK          | 0.016869           | 0.097163                                     | 0.399675                                      | 0.054186                                   |
| ELLAKO        | 0.014469           | 0.119083                                     | 0.300421                                      | 0.031005                                   |
| ELPE          | 0.01614            | 0.077924                                     | 0.409164                                      | 0.042191                                   |
| MOH           | 0.030118           | 0.277522                                     | 0.213665                                      | 0.077271                                   |
| MIELA         | 0.052452           | 0.084713                                     | 0.587609                                      | 0.13463                                    |
| MYTIL         | 0.020313           | 0.127933                                     | 0.387824                                      | 0.079661                                   |
| OPAP          | 0.215506           | 0.27299                                      | 0.551938                                      | 0.481682                                   |
The next table 5 shows the relative efficiency of the 14 banks of the sample, in an input oriented variable returns DEA model. Half of the banks are relatively efficient.

Table 5. Efficiency of banks.

| DMU No. | DMU Name | Efficiency  |
|---------|----------|-------------|
| 1       | ETHNIKI  | 1.00000     |
| 2       | ALPHA    | 1.00000     |
| 3       | AGROTIKI | 0.39514     |
| 4       | EUROBANK | 1.00000     |
| 5       | CYPRUS   | 1.00000     |
| 6       | MARFIN   | 0.25371     |
| 7       | CYPRUS-MARFIN | 1.00000 |
| 8       | PIREOS   | 0.44154     |
| 9       | TT       | 0.35184     |
| 10      | GENIKI   | 0.45700     |
| 11      | PROTON   | 1.00000     |
| 12      | ATTICA   | 1.00000     |
| 13      | EMPORIKI | 0.59714     |
| 14      | T-BANK   | 0.78757     |

The next table 6 shows the relative efficiency of the 12 industrial enterprises of the sample, in an input oriented variable returns DEA model. We notice that most of the industries are 100% efficient.

Table 6. Efficiency of industries.

| DMU No. | DMU Name | Efficiency  |
|---------|----------|-------------|
| 1       | BIOXK    | 1.00000     |
| 2       | DEH      | 1.00000     |
| 3       | EEEK     | 0.95398     |
| 4       | ELLAKO   | 0.67907     |
| 5       | ELPE     | 0.92346     |
| 6       | MOH      | 0.65736     |
6. Final instructions of the DEA analysis to the enterprises and conclusions.

In table 7 we see summarized the managerial instructions for the 14 banks so as to achieve 100% relative efficiency. The resulted values of outputs at 100% efficiency are tabulated also. As it was calculated an input oriented model, it is tabulated the decreased value of the inputs and the resulting increased values of outputs so as to have 100% efficiency.

Table 7. Managerial recommendations for the banks.

| DMU No. | DMU Name | Efficient Input Target | Efficient Output Target |
|---------|----------|------------------------|------------------------|
| 7       | MIILEA   | 1.0000                 |                        |
| 8       | MYTIL    | 1.0000                 |                        |
| 9       | OPAP     | 1.0000                 |                        |
| 10      | OTE      | 1.0000                 |                        |
| 11      | TITK     | 1.0000                 |                        |
| 12      | ABAX     | 0.74068                |                        |

In the table 8 we see summarized the managerial instructions for the 12 industrial enterprises so as to achieve 100% relative efficiency. The resulted values of outputs at 100% efficiency are tabulated also.

Table 8. Managerial recommendations for the industries.
The DEA analysis shows that the industrial enterprises are doing better than the banks, which agrees with the results of the simulation analysis. This is natural as the banks have by far higher leverage, thus risk, compared to the industrial enterprises. A second remark is that half of the banks are 100% relatively efficient. Somehow the results of DEA do not contradict the results of the Simulation. We conclude that the branch of banks required serious managerial and administrative interventions (like merging) and this is exactly what happened historically after the previous analysis.

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| DMU No. | DMU Name | Standard deviation of the previous (INPUT2) | Percentage of equities in the assets (OUTPUT1) | Percentage of profits in assets (ROA) OUTPUT2 |
|---------|----------|-------------------------------------------|--------------------------------------------|------------------------------------------|
| 1       | BIOXK    | 0.00513                                   | 0.53904                                    | 0.00559                                  |
| 2       | DEH      | 0.00548                                   | 0.39291                                    | 0.01086                                  |
| 3       | EEEK     | 0.01609                                   | 0.40247                                    | 0.05419                                  |
| 4       | ELLAKO   | 0.00983                                   | 0.39142                                    | 0.03100                                  |
| 5       | ELPE     | 0.01490                                   | 0.41739                                    | 0.04219                                  |
| 6       | MOH      | 0.01980                                   | 0.38800                                    | 0.07727                                  |
| 7       | MIELA    | 0.05245                                   | 0.58761                                    | 0.13463                                  |
| 8       | MYTIL    | 0.02031                                   | 0.38782                                    | 0.07966                                  |
| 9       | OPAP     | 0.21551                                   | 0.55194                                    | 0.48168                                  |
| 10      | OTE      | 0.02159                                   | 0.18483                                    | 0.02837                                  |
| 11      | TITK     | 0.02161                                   | 0.50214                                    | 0.07217                                  |
| 12      | ABAX     | 0.00719                                   | 0.39232                                    | 0.01876                                  |
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