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SYMBOL MODEL DATABASE and ANALYSES for PUBLIC FINANCE SUSTAINABILITY

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Abstract

In the present report, we describe the main steps we have taken in order to create a sound database for the European Union Member States banking system. The final goal is to use this database as source for input variables of SYMBOL (SYstemic Model of Banking Originated Losses) model, developed by the Join Research Centre of Ispra in cooperation with the European Commission Direcotrate General for Internal Market and Services and experts from academia, for monitoring financial crises.

SYMBOL simulates potential crises in the banking sector under various assumptions, and it allows assessing the cumulative effects of different regulatory measures (e.g. higher capital requirements, strengthened deposit insurance and introduction of resolution funds) and their most effective combinations. It uses items in bank's balance sheet to estimate the potential losses for a given banking system via a Monte Carlo analysis. The model is flexible and can be deployed either on a single country or on a set of financial institutions sharing common features.

The report also shows an application of SYMBOL for assessing the impact on public finance of a crisis in the baning sector and compares the current regulatory framework with a future scenario where the new capital requirements set in Basel III and an effective framework for bank resolution are in place.

Keywords: Data mining, missing data, imputation, distribution function

1. INTRODUCTION

In the present report, we describe the main steps we have taken in order to create a sound database for the European Union Member States (EU27) banking system. The final goal is to use this database as source for input variables of SYMBOL (SYstemic Model of Banking Originated Losses) model, developed by the Join Research Centre (JRC) of Ispra in cooperation with the European Commission Direcotrate General for Internal Market and Services and experts from academia, for monitoring financial crises.[1]

SYMBOL simulates potential crises in the banking sector under various assumptions, and it allows assessing the cumulative effects of different regulatory measures (e.g. higher capital requirements, strengthened deposit insurance and introduction of resolution funds) and their most effective combinations. It uses items in bank's balance sheet to estimate the potential losses for a given banking system via a Monte Carlo analysis. The model is flexible and can be deployed either on a single country or on a set of financial institutions sharing common features.

SYMBOL is a micro funded model working at single bank's level. For each bank, we first compute using several items in bank's balance sheet the Asset Probability to Defaults (AssetPD). Then according to bank's characteristics, SYMBOL simulates a number of random scenarios, large enough to guarantee stability of losses distributions. Finally losses are compared with capital hold by the bank.

Input variables needed for running SYMBOL are:

- Asset PD: estimated from balance sheet variables;
- Total Assets: taken from the balance sheet;
- Capital Requirements: taken either from the balance sheet or reconstructed;
- Customer Deposits: elaborated using data from balance sheet;
- Inter-bank exposure: elaborated using data from balance sheet.

The model may run also taking into consideration contagion between banks. Such effect is driven by inter-bank exposure.

The main source of information for our database is *Bankscope*, which is a commercial data base developed by Bureau van Dijk[2]. Hereafter we refer to data relative to 2010.

We start by describing some quantitative aspects of the dataset. For all EU Member States (MS), we select as many as 29 variables such as Total Assets, Regulatory Tier 1 Capital, Total Regulatory Capital, Common Equity , Tier 1 Regulatory Capital Ratio, Risk Weighted Assets, Total Customer Deposits, Loans and Advances to Banks, Deposits from Banks, Total Deposits[3].

Institutions are listed in Bankscope under various categories according to their main activities (see Table 1). In particular, the following table reports all categories present in Bankscope and the number of European Union (EU) institutions reported in each of them

[1] Details on SYMBOL can be found in De Lisa R.; Zedda S.; Vallascas F.; Campolongo F. & Marchesi M., *Modelling Deposit Insurance Scheme Losses in a Basel 2 Framework*, Journal of Financial Services Research, 2011, 40, 123-141, and in *Public Finance in Emu 2011* http://ec.europa.eu/economy_finance/publications/european_economy/2011/pdf/ee-2011-3_en.pdf

[2] See http://www.bvdinfo.com/

[3] Though *SYMBOL* needs only six variables, but in order to reconstruct missing (or possibly incorrect) values one should use a larger set of variables.

Table 1: Specialization of banks in the sample.

Specialization	
Bank Holding & Holding Companies	273
Central Bank	27
Clearing Institutions & Custody	40
Commercial Banks	2,501
Cooperative Bank	2,803
Finance Companies (Credit Card, Factoring & Leasing)	492
Group Finance Companies	39
Investment & Trust Corporations	155
Investment Banks	304
Islamic Banks	8
Micro-Financing Institutions	5
Multi-Lateral Government Banks	2
Other Non Banking Credit Institution	94
Private Banking & Asset Mgt Companies	233
Real Estate & Mortgage Bank	368
Savings Bank	1203
Securities Firm	186
Specialized Governmental Credit Institution	162
Total	**8,895**

Furthermore, institutions are also divided according to the accounting system they use, being either consolidated (C-type) or unconsolidated (U-type), as detailed in Table 2.

Table 2: Consolidation type.

U-type banks	**C-type banks**	**Total4**
7,310	1,570	8,880

The main goal we would like to pursue, by using such dataset, is simulating potential losses which may hit public finances in single EU27 MS. In general, we will be interested only in U-type banks (whose activities mostly refer to the domestic market). Moreover we usually focus on commercial banks, cooperative banks and saving banks.

For some specific countries, because of the peculiar nature of their banking system, we may include either a selection of C-type banks and/or banks whose activities are different from those we have mentioned. In Appendix A: effects of including C-type BANKS, we will discuss the effects of including these extra institutions.

[4] One should notice that the total number of banks in this table differs from the total number of banks reported in Table 1. This is due to the presence of financial institution listed as A-type which we are not going to consider.

2. COHERENCE CHECKS AND IMPUTATION OF MISSING VALUES

As for all databases some errors due either to missing information or to recording mistakes may be present. We have set a series of automatic checks to assure the internal coherence among variables. In particular we have checked:

1. Banks for which Tier1 capital is larger than total assets: one U-type bank among those of the three main categories, in total three banks;
2. Banks for which Total regulatory capital is larger than total assets (same subset of point 1.);
3. Banks for which Common equity is larger than total assets. In this case we have a larger group. In particular we found 14 financial institutions 3 of them being Commercial bank.

Due to the exiguous number of these anomalous records they have not been included in the final dataset.

A more severe problem is related to missing values (see Table 3). We first observe that for some variables, typically banks' *Total Asset* the only source of information is the balance sheet. Therefore we reduce our dataset according to data availability for this variable. Moreover in order to reconstruct missing values for Tier1 and Capital requirements, we need to have data for *Common equity* variable.

Table 3: Data availability for total assets and equity, all banks (U-,C-,A-types).

Total number of banks	8,895
Number of banks with total asset	4,821
Number of banks with common equity	4,786
Number of banks with both total asset and common equity[5]	4,786

Hence from now on we refer to a database containing 4,786 banks (U-type 3,905).

Coming to the single country analysis, Table 4 reports the number of financial institutions (all specialization types) which are present in Bankscope (both total number and only those with common equity). It is worth noticing that for running SYMBOL we need capital requirements, and this variable is often missing in the balance sheets. We employ some robust regression techniques to reconstruct missing values. In Appendix E we describe in some details the statistical aspects of the procedure.

Table 4: Number of institutions in each country (all types).

Country	**Country code**	**# of institutions**	**# of institutions with common equity and TA data**
Belgium	BE	216	81
Bulgaria	BG	43	30
Czech Republic	CZ	73	38
Denmark	DK	220	153
Germany	DE	2,892	1,718
Estonia	EE	30	11
Ireland	IE	132	52
Greece	GR	67	36
Spain	ES	418	198
France	FR	992	458
Italy	IT	1,162	624
Cyprus	CY	50	18
Latvia	LV	52	38

5 Banks with common equity is a proper subset of banks with total asset.

Country	Country code	# of institutions	# of institutions with common equity and TA data
Lithuania	LT	26	18
Luxembourg	LU	218	85
Hungary	HU	81	32
Malta	MT	31	23
Netherland	NL	223	78
Austria	AT	432	257
Poland	PL	112	50
Portugal	PT	115	52
Romania	RO	60	29
Slovenia	SI	52	31
Slovakia	SK	46	23
Finland	FI	59	35
Sweden	SE	195	117
United Kingdom	UK	898	501
Total		**8,895**	**4,786**

2.1 MISSING VALUES IMPUTATION AND OUTLIERS DETECTIONS

To give an idea of the number of missing values we need to reconstruct, we only consider U-type Commercial, Cooperative and Savings banks. The other cases (different specializations, C-type banks) show similar figures. The following table reports, for each country, the number of banks with or without values for capital requirements (either Tier1 or Regulatory Capital).

Table 5: Number of institutions with data for capital.

Country	Regulatory Capital		Tier1	
	Yes	No	Yes	No
BE	0	31	0	31
BG	13	4	13	4
CZ	12	4	13	3
DK	84	12	84	12
DE	490	1007	256	1241
EE	2	2	2	2
IE	3	5	2	6
GR	10	7	9	8
ES	6	124	7	123
FR	5	164	5	164
IT	468	15	468	15
CY	4	1	4	1
LV	16	4	16	4
LT	9	1	9	1
LU	14	41	13	42
HU	3	8	1	10
MT	4	3	3	4
NL	3	21	4	20
AT	22	161	29	154
PL	5	24	4	25
PT	10	12	10	12
RO	10	5	10	5

Country	Regulatory Capital		Tier1	
	Yes	No	Yes	No
SI	9	6	11	4
SK	4	4	4	4
FI	7	2	7	2
SE	71	1	71	1
UK	40	67	39	68
Total	**1,324**	**1,736**	**1,094**	**1,966**

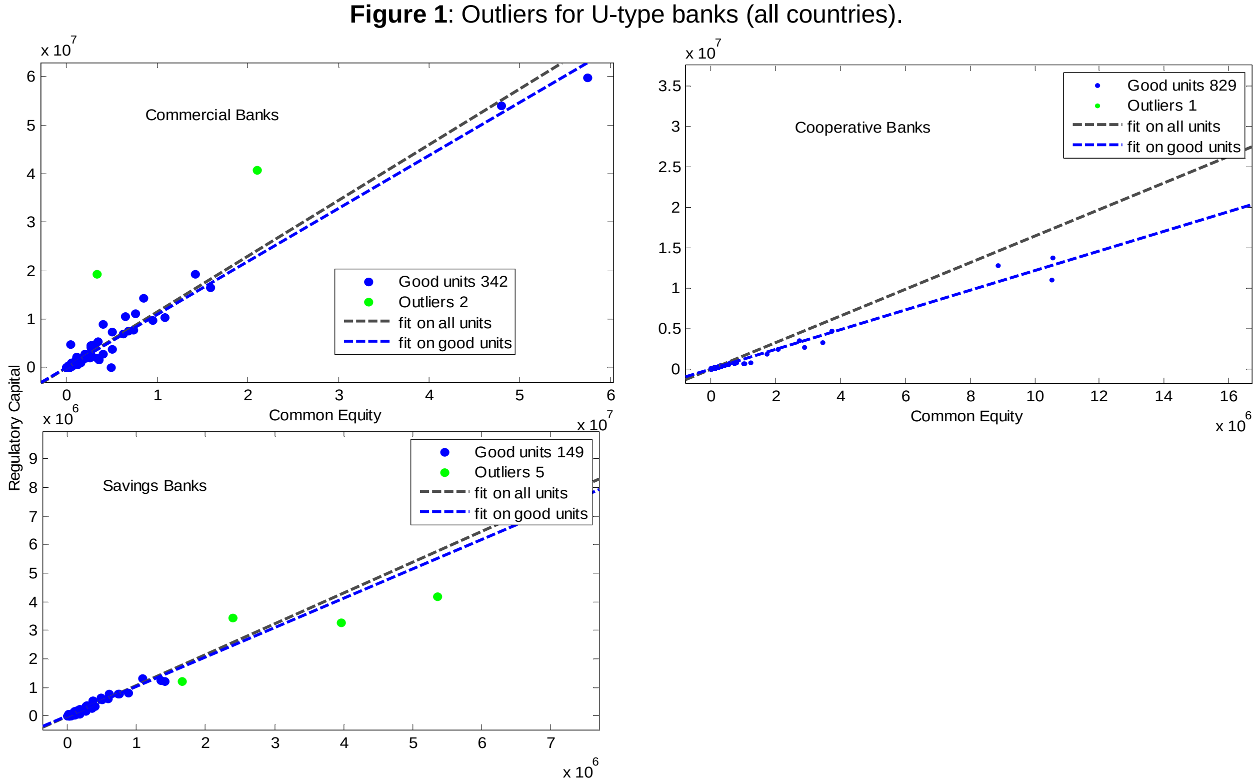
From Table 5, one can see that the number of records reporting values for capital requirement differs from country to country. On the other hand, whenever these variables are available, data show a strong correlation between capital requirement and common equity. Hence we use this fact to infer values for capital using common equity as explanatory variable.

In order to have reliable results, we employ a set of algorithms developed at JRC enforcing robust regression techniques (see also Annex E). Among other advantages, this approach allows us to find anomalous values which were not already detected by previous analyses. To reconstruct capital requirements values, we may use three different levels:

1) the whole database;
2) country level;
3) specialization types level.

Since for some country we have small number of records where both capital requirements and common equity are available (for Belgium we have none) and since using the whole database may lead to some inconsistencies, we have chosen to approach the problem at bank's specialization level. To give a glimpse of which kind of data we are using, we present in Figure 1 some plots, where correlation among data (actually strong collinearity) and outliers detection are evident.

Figure 1: Outliers for U-type banks (all countries).

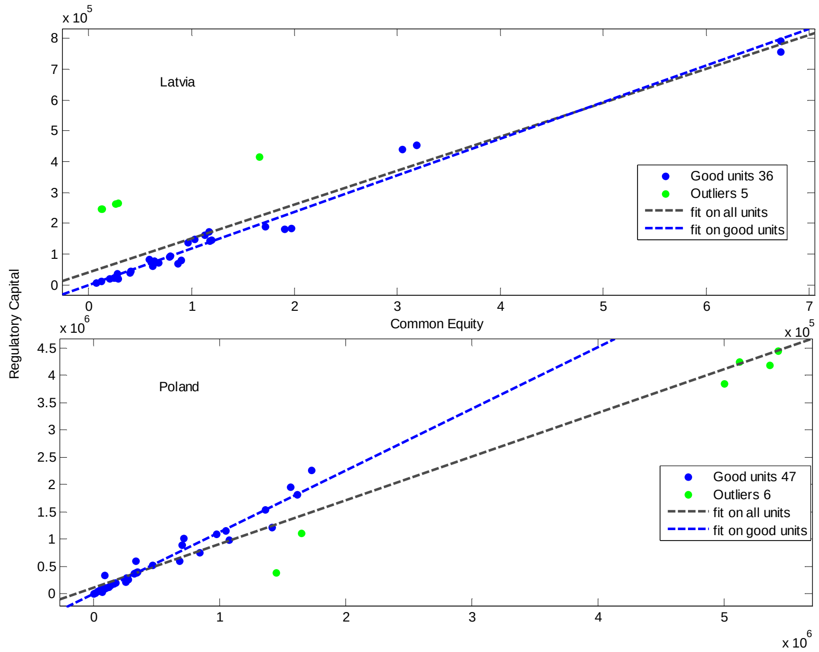


If we look at country level, outliers are mostly concentrated in few countries (see Table 6). In particular for Latvia and Poland the situation is presented in Figure 2.

Table 6: Outliers in the sample at country level.

Country	AT	GR	HU	IE	LV	MT	NL	PL	RO	SI
U-type	1	0	1	1	0	0	1	3	1	0
C-Type	0	1	0	2	5	2	0	3	4	1

Figure 2: Outliers for U-type banks in Latvia dna Poland.



We repeat this exercise for all specialization categories and we use only those values not detected as outliers to regress capital requirements (both Tier1 and Regulatory Capital) versus Common equity. We now have a database where all records contain complete information about capital requirements (as well as total assets and common equity).

As we have already mentioned, for some small countries we add to our dataset C-type banks and also banks whose specialization is different from Commercial, Cooperative and Savings. In particular we add: Bank Holding & Holding Companies, Finance Companies (Credit Card, Factoring & Leasing), Investment Banks, Real Estate & Mortgage Bank and Specialized Governmental Credit Institution (see Table 6 below for countries for which we have enlarged the dataset). Since U-type and C-type banks follow different accounting rules, throughout the entire process of outlier detection and the associate use of robust regression for imputation of missing values, we have kept clear the distinction between these two families.

We should remark that the results of automatized search for outliers are followed by a direct analysis of the bank and the country involved. Then we may decide whether or not to keep the possible outliers on the basis of bank and country specific situation or if other sources of information were available to correct the data. For example we have not ruled out one bank in Netherland although it was detected as outlier by the automatized procedure.

Moving from this, we proceed with the imputation of other two variables which are likely to be absent:
1) Capital ratios: we have imputed missing values by using the country averages as reported by European Central Bank (ECB). Hence the database is now complete as capital variables are concerned.

2) Risk Weighted Asset (RWA). RWA is imputed as the ratio between capital and capital ratio, and the capital requirement variable is then calculated as the 8% of RWA (Basel II framework).

In order to include in our analysis the impact of the new requirements set by Basel II, we have modified the values of capital requirements and RWA according to European Banking Authority (EBA) Quantitative Impact Study results[6]. Finally we restrict our data set to those banks for which Customer Deposit variable exists.

3. SYMBOL DATABASE

Once we have put in place all checks and imputation procedures as discussed in previous sections, we have a complete 2010 database for all 27 European Union MS. Table 7 shows the number of banks we have extracted from each country (last column refers to banks whose specialization according to Bankscope is different from commercial, cooperative or savings).

Table 6: SYMBOL database.

Country	Banks	G1Banks	C-type	Other specialization
BE	28	3	0	0
BG	21	0	1	2
CZ	21	0	4	2
DK	91	3	0	0
DE	1469	7	0	0
EE	5	0	1	0
IE	20	9	2	8
GR	20	6	1	2
ES	126	6	0	0
FR	160	10	0	0
IT	480	7	0	0
CY	11	0	4	3
LV	21	0	3	0
LT	9	0	0	0
LU	52	1	0	0
HU	18	2	5	4
MT	12	0	0	5
NL	20	3	0	0
AT	171	0	0	0
PL	35	0	6	1
PT	28	7	6	4
RO	22	0	7	1
SI	16	0	0	1
SK	13	0	3	4
FI	12	4	1	3
SE	63	3	0	0
UK	86	10	0	0

Because including C-type banks may give rise to several questions we refer to Appendix A, where we will discuss the differences between SYMBOL results obtained by including or not C-type banks. Apart from this issue, there are several aspects one should keep in mind, while analyzing (and using) SYMBOL results.

[6] See http://www.eba.europa.eu/Publications/Quantitative-Impact-Study.aspx

3.1 SAMPLE DIMENSION

From our extraction, and after all steps we have taken in order to have a reliable dataset, we have only a sample of banks, not the entire country population. Since our task is to estimate the impact of financial crisis on public finance, we need to rescale potential losses coming from SYMBOL simulations to the country banking system population. In order to have a reliable estimate of each country financial system population, we refer to data from the ECB, and we compare the sum of total assets in our sample to the ECB aggregate values. We should observe that ECB reports aggregate statistics of consolidated data, while we mainly consider unconsolidated data. Hence, to have a more credible ground for comparison we need to depurate ECB figures from foreign branches. Once we have these data we may compute the ratio sample/population for each country, see Table 8.

Table 7: Ratio sample/population

	Total Assets (m€)		
Country	**ECB no Branches**	**Bankscope**	**Ratio**
BE	1,041,052	803,991	77%
BG	38,485	32,377	84%
CZ	156,387	142,031	91%
DK	1,096,635	565,751	52%
DE	8,100,761	5,300,778	65%
EE	14,856	24,433	164%
IE	1,406,903	1,034,940	74%
GR	478,123	427,774	89%
ES	3,261,638	2,591,630	79%
FR	7,693,831	6,223,479	81%
IT	3,543,323	2,287,518	65%
CY	127,185	113,805	89%
LV	26,654	21,887	82%
LT	21,063	19,078	91%
LU	939,871	486,863	52%
HU	117,328	91,620	78%
MT	50,200	19,735	39%
NL	2,184,189	1,717,377	79%
AT	967,692	288,440	30%
PL	297,124	172,478	58%
PT	519,758	537,574	103%
RO	85,574	53,015	62%
SI	52,478	45,012	86%
SK	54,361	29,769	55%
FI	457,185	393,546	86%
SE	984,365	513,176	52%
UK	5,921,563	5,964,820	101%
Total	**39,638,584**	**29,902,897**	**75%**

We see that for some countries (e.g. Austria) the ratio population sample is quite low. Even though SYMBOL simulation results will be normalized using these ratios, a low value of sample dimension may indicate that some large banks are not considered, which may lead to underestimating the resulting losses. If necessary, different source of information may be used to enlarge the data set.

We may also notice that for some countries the ratio is larger than 100%. This is due to the presence of C-type banks. It is still questionable if C-type banks should be included or not (see Appendix A).

3.2 INTER-BANK EXPOSURE

A second set of problems is related to different definitions banks use for the same variables. A typical case is the inter-bank exposure, which may or may not include debt certificates. We may consider running SYMBOL under two different hypotheses:

1) Leave the Inter-bank market as Bankscope's data (see Appendix B);
2) Rescaled the inter-bank market according to ECB data (see Section

4.1. SCENARIO 1).

The ratios used to rescale the Inter-bank exposure have been computed by the following rule:

$$\frac{IB}{IB + DebtCert} \qquad \text{Equation 1}$$

where *DebtCert* is the amount of Debt certificates including bonds (all values have been rescaled according to total assets of domestic market, i.e. foreign branches have been excluded). In particular, for year 2010 inter-bank exposures are rescaled according to Table 9.

Table 8: Inter-bank ratios.

Country	Inter-bank market ratios
BE	0.56%
BG	0.80%
CZ	0.44%
DK	0.23%
DE	0.53%
EE	0.97%
IE	0.72%
GR	0.77%
ES	0.47%
FR	0.54%
IT	0.43%
CY	0.99%
LV	0.62%
LT	0.35%
LU	0.72%
HU	0.61%
MT	0.99%
NL	0.19%
AT	0.52%
PL	0.59%
PT	0.52%
RO	0.80%
SI	0.77%
SK	0.56%
FI	0.22%
SE	1.00%
UK	0.30%

3.3 COVERED DEPOSITS

Covered deposits[7] are used when SYMBOL results are post processed to study the impact of some tools which can be introduced in order to protect the public finance. In particular they are used to compute the size of Deposit Guarantee Schemes (DGS) funds needed to minimize the cost of systemic banking crises (see Section 4). To estimate covered deposits, we use the Bankscope variable “Customer Deposits”, which does not account for the amount of eligible and protected deposits[8].

JRC run a survey throughout the European network of natioanal DGSs asking, among other information, the percentages of eligible and covered deposits. For those countries with missing information we use the Eurostat database, where similar information can be extracted. In particular we have used Eurostat data to reconstruct the ratio for eligible deposit while for the covered deposit we have used estimates based on previous survey run by JRC[9]. The ratios used are reported in Table 10.

Table 9: Covered deposit ratios.

Country	Covered deposit ratios	Source
BE	66%	Eurostat+JRC
BG	63%	Survey
CZ	61%	Eurostat+JRC
DK	52%	Eurostat+JRC
DE	54%	Eurostat+JRC
EE	50%	Survey
IE	59%	Eurostat+JRC
GR	33%	Survey
ES	65%	Eurostat+JRC
FR	67%	Survey
IT	62%	Eurostat+JRC
CY	33%	Survey
LV	39%	Eurostat+JRC
LT	69%	Eurostat+JRC
LU	66%	Eurostat+JRC
HU	51%	Survey
MT	76%	Eurostat+JRC
NL	71%	Eurostat+JRC
AT	53%	Survey
PL	32%	Survey
PT	37%	Survey
RO	37%	Survey
SI	73%	Survey
SK	51%	Survey
FI	62%	Survey
SE	54%	Eurostat+JRC
UK	59%	Eurostat+JRC

7 Covered deposits are those deposits which in case of bank default are protected from the deposit guarantee scheme.

8 Eligible deposits are deposits repayable by the guarantee scheme under your national law, before the level of coverage is applied while Covered deposits are those obtained from eligible deposits when applying the level of coverage provided for in your national legislation.

9 http://ec.europa.eu/internal_market/bank/guarantee/index_en.htm

4. SYMBOL SIMULATIONS

Once the database has been created and all ancillary parameters have been computed, SYMBOL simulations are run. Regarding SYMBOL we need to explain the settings we use.

As already mention SYMBOL is used to simulate, via Monte Carlo experiments, potential losses in the banking system. Each run pretends to simulate one year. In the present setting we have fixed to 100,000 the number of runs with at least one bank's default. Because of the different sizes of countries' banking systems the actual runs needed to reach 100,000 defaults varies from country to country. The final result will be the country's aggregated excess losses (losses minus capital) for each simulated year. We then may decide to consider either the distribution conditioned to bank's defaults (whose length is 100,000) or the unconditional distribution whose length varies depending on country.

Currently, we have run two different sets of simulations, representing two different regulatory scenarios to manage a banking crisis[10]:

1) Scenario 1: This scenario represent the current situation where banks have started to improve the quality of their capital in compliance with the new Basel III rules and satisfy a minimum capital requirement of 8% of the risk weighted assets (see Section 4.1). The resolution framework in place is assumed not to be capable to stop contagion effects.
2) Scenario 2: The second scenario represents a future situation where Basel III is fully implemented, banks' capital requirements are at least equal to 10.5% of RWA (i.e. the basel III capital conservation buffer is implemented). Contagion is stopped by an effective resolution framework which includes: (i) ex-ante funds for bank resolution at 1% of the amount og covered deposits, (ii) bail-in regime is implemented to guarantee a total loss absorbing Capacity at 10% of total liabilities (see Section 4.2). This scenario represent the full implementation of Basel III and the introduction of an effective EU resolution framework.

We should notice that for numerical stability reasons for some countries (e.g. the three Baltic States), we have also run simulations where they have been considered together as a unique country[11]. The results are very similar in the case contagion does not take place and they differ whenever contagion has been considered. Results of this particular analysis would be found in

[10] One can find arguments for these choices in http://ec.europa.eu/internal_market/bank/crisis_management/index_en.htm

[11] This will imply the assumption that Inter-bank market across these countries show similar features as the genuine internal market.

Appendix B: the case of BALTIC STATES.

In the following, we will present the results of SYMBOL simulations regarding the national aggregate at selected percentile for the unconditional distribution of excess losses (losses minus capital). Moreover we have also computed, this time on the conditional distributions, the percentiles where the excess losses are larger than 0.1% and 1% of country's GDP.

Finally we have also calculated at which percentile excess losses are larger that S2.

4.1. SCENARIO 1

In this case we have capital requirement set at 8% of the RWA and contagion is considered. Because of the contagion effects, the role of the inter-bank market is essential. To quantify this aspect we have also run SYMBOL using the same data set but with no reduction for inter-bank. Results may be found in Appendix C. If inter-bank exposures are rescaled by using data as in Table 8, we obtain results in Table 11, where we report selected percentiles of the unconditional distribution of excess losses, i.e. losses not covered by banks' capital and funds available in the safety net.

Table 10: Distribution of losses in m€ for scenario 1 (no capital conservation buffer and no effective resolution framework.

	95	**99**	**99.5**	**99.9**	**99.95**	**99.99**	**99.999**
BE	0	0	35	9,505	15,535	33,825	55,546
BG	0	0	0	42	93	289	767
CZ	0	0	0	130	379	1,346	3,204
DK	0	0	18	644	3,261	10,790	30,722
DE	21	430	1,544	21,105	41,666	161,914	282,877
EE	0	0	0	0	0	1,430	2,074
IE	0	62,520	77,946	92,229	98,319	114,048	141,752
GR	0	17	145	2,752	5,969	25,013	35,854
ES	0	117	714	7,769	14,353	37,011	75,313
FR	128	1,895	4,905	59,693	185,512	292,692	399,813
IT	54	690	1,567	6,889	11,294	30,698	69,602
CY	0	1	2	109	608	3,076	7,413
LV	0	0	1	67	118	313	805
LT	0	0	0	30	75	243	635
LU	0	0	47	53,009	61,192	77,319	95,440
HU	0	0	0	119	345	1,183	3,478
MT	0	0	0	100	252	722	1,785
NL	0	0	20	1,019	3,632	20,112	56,218
AT	0	77	311	3,092	6,164	20,569	40,569
PL	0	0	44	370	691	2,016	6,199
PT	0	291	1,655	7,433	13,483	22,026	32,440
RO	0	0	0	89	220	663	1,846
SI	0	25	674	1,561	2,007	3,165	4,866
SK	0	0	0	99	233	715	1,601
FI	0	13	68	504	6,515	12,998	25,260
SE	0	0	0	4,274	13,975	41,598	68,413
UK	0	91	774	18,494	31,233	71,161	147,745

In order to compare, across European MS, the amount of potential losses hitting each country's banking system we compute the percentiles for which losses are larger than two thresholds based on country's economy: namely we have set these two thresholds to be equal to 0.1% and 1% of country GDP. Table 12 shows both these percentiles and the ratios losses/GDP at selected percentiles.

Table 11: Distribution of losses over GDP for scenario 1 (no capital conservation buffer and no effective resolution framework

	Percentiles							Thresholds	
	95	**99**	**99.5**	**99.9**	**99.95**	**99.99**	**99.999**	**0.1%GDP**	**1%GDP**
BE	0%	0%	0%	3%	4%	10%	16%	77%	80%
BG	0%	0%	0%	0%	0%	1%	2%	62%	98%
CZ	0%	0%	0%	0%	0%	1%	2%	76%	98%
DK	0%	0%	0%	0%	1%	5%	13%	85%	93%
DE	0%	0%	0%	1%	2%	6%	11%	98%	100%
EE	0%	0%	0%	0%	0%	10%	14%	35%	44%
IE	0%	41%	51%	60%	64%	74%	92%	4%	25%
GR	0%	0%	0%	1%	3%	11%	16%	66%	91%
ES	0%	0%	0%	1%	1%	3%	7%	79%	96%
FR	0%	0%	0%	3%	9%	14%	19%	88%	97%
IT	0%	0%	0%	0%	1%	2%	4%	96%	100%
CY	0%	0%	0%	1%	3%	18%	42%	99%	99%
LV	0%	0%	0%	0%	1%	2%	4%	49%	95%
LT	0%	0%	0%	0%	0%	1%	2%	51%	96%
LU	0%	0%	0%	127%	147%	186%	229%	24%	54%
HU	0%	0%	0%	0%	0%	1%	4%	39%	92%
MT	0%	0%	0%	2%	4%	12%	29%	23%	60%
NL	0%	0%	0%	0%	1%	3%	10%	79%	94%
AT	0%	0%	0%	1%	2%	7%	14%	81%	96%
PL	0%	0%	0%	0%	0%	1%	2%	89%	100%
PT	0%	0%	1%	4%	8%	13%	19%	60%	83%
RO	0%	0%	0%	0%	0%	1%	2%	66%	99%
SI	0%	0%	1%	2%	3%	5%	7%	49%	68%
SK	0%	0%	0%	0%	1%	2%	4%	30%	87%
FI	0%	0%	0%	0%	4%	7%	14%	82%	94%
SE	0%	0%	0%	1%	4%	12%	20%	78%	78%
UK	0%	0%	0%	1%	2%	4%	9%	95%	99%

4.2. SCENARIO 2

In this case we consider SYMBOL results based on the same dataset as in Scenario 1, with capital requirements as set by Basel III (10.5% of RWA) . We do not consider contagion effects. In the post processing phase, we introduce two instruments whose intervention is aimed to minimize the impact of systemic crises on public finances:

(i) part of losses would be covered by both DGS/RF funds set at the value corresponding to 1% of covered deposits;

(ii) part of losses would be absorbed by bail-in instruments. The amount of bail-in bonds for each bank is such that the total Loss Absorbing Capacity (LAC) of the bank (capital + bail-in instruments) equals 0% of the total liabilities.

Since contagion is not considered there is not difference in rescaling or not the inter-banks values.

For such scenario results are reported in Table 13 and 14. Regarding the levels of potential losses they are significantly lower than those in the previous scenario.

Table 13: Distribution of losses in m€ for scenario 2 (Basel III fully implemented and effective resolution framework in place with ex-ante funds and bail-in instruments).

	95	99	99.5	99.9	99.95	99.99	99.999
BE	0	0	0	0	0	0	4,781
BG	0	0	0	0	0	36	341
CZ	0	0	0	0	0	52	1,640
DK	0	0	0	0	0	0	3,061
DE	0	0	0	0	0	0	1,279
EE	0	0	0	0	0	70	682
IE	0	0	0	0	0	1,541	8,440
GR	0	0	0	0	0	922	5,627
ES	0	0	0	0	0	3,253	30,622
FR	0	0	0	0	0	0	27,504
IT	0	0	0	0	0	0	10,453
CY	0	0	0	0	0	344	2,624
LV	0	0	0	0	0	92	324
LT	0	0	0	0	0	67	361
LU	0	0	0	0	0	0	6,088
HU	0	0	0	0	0	278	1,373
MT	0	0	0	0	0	104	640
NL	0	0	0	0	0	4,176	40,126
AT	0	0	0	0	0	0	4,422
PL	0	0	0	0	0	607	2,333
PT	0	0	0	0	0	1,544	6,067
RO	0	0	0	0	0	209	977
SI	0	0	0	0	0	257	1,072
SK	0	0	0	0	0	213	1,012
FI	0	0	0	0	0	174	1,735
SE	0	0	0	0	0	56	10,587
UK	0	0	0	0	0	0	27,824

Table 12: Losses over GDP for scenario 2 (Basel III fully implemented and effective resolution framework in place with ex-ante funds and bail-in instruments).

	Percentiles							Thresholds	
	95	**99**	**99.5**	**99.9**	**99.95**	**99.99**	**99.999**	**0.1%GDP**	**1%GDP**
BE	0%	0%	0%	0%	0%	0%	1%	97%	99%
BG	0%	0%	0%	0%	0%	0%	1%	96%	100%
CZ	0%	0%	0%	0%	0%	0%	1%	97%	100%
DK	0%	0%	0%	0%	0%	0%	1%	99%	100%
DE	0%	0%	0%	0%	0%	0%	0%	100%	Never
EE	0%	0%	0%	0%	0%	0%	5%	58%	76%
IE	0%	0%	0%	0%	0%	1%	5%	94%	98%
GR	0%	0%	0%	0%	0%	0%	2%	96%	99%
ES	0%	0%	0%	0%	0%	0%	3%	99%	100%
FR	0%	0%	0%	0%	0%	0%	1%	100%	100%
IT	0%	0%	0%	0%	0%	0%	1%	100%	100%
CY	0%	0%	0%	0%	0%	2%	15%	100%	100%
LV	0%	0%	0%	0%	0%	1%	2%	92%	99%
LT	0%	0%	0%	0%	0%	0%	1%	90%	99%
LU	0%	0%	0%	0%	0%	0%	15%	99%	99%
HU	0%	0%	0%	0%	0%	0%	1%	88%	99%
MT	0%	0%	0%	0%	0%	2%	10%	87%	90%
NL	0%	0%	0%	0%	0%	1%	7%	98%	98%
AT	0%	0%	0%	0%	0%	0%	2%	100%	100%
PL	0%	0%	0%	0%	0%	0%	1%	98%	100%
PT	0%	0%	0%	0%	0%	1%	4%	95%	99%
RO	0%	0%	0%	0%	0%	0%	1%	93%	100%
SI	0%	0%	0%	0%	0%	0%	2%	94%	99%
SK	0%	0%	0%	0%	0%	1%	3%	88%	96%
FI	0%	0%	0%	0%	0%	0%	1%	99%	100%
SE	0%	0%	0%	0%	0%	0%	3%	98%	99%
UK	0%	0%	0%	0%	0%	0%	2%	100%	100%

APPENDIX A: EFFECTS OF INCLUDING C-TYPE BANKS

Here, we discuss the differences one obtains by including or not C-type banks in the dataset. As already observed this occurrence happens only for some countries: the main reason being use larger data set in order to minimize possible numerical instability in SYMBOL simulations. In particular we included C-type banks for the following MS: Bulgaria, Cyprus, Czech Republic, Estonia, Finland, Greece, Hungary, Ireland, Latvia, Poland, Portugal, Romania and Slovakia.

We first show the differences when computing sample/population ratios we get by including or not C-type banks, see Table 15.

Table 13: Effect of including C-type banks in the sample for selected MS.

	Sample/population original database	Sample/population no C-type banks
Bulgaria	84%	79%
Cyprus	89%	12%
Czech Republic	91%	87%
Estonia	164%	30%
Finland	86%	84%
Greece	89%	71%
Hungary	78%	48%
Ireland	74%	65%
Latvia	82%	70%
Netherland	79%	57%
Poland	58%	34%
Portugal	103%	78%
Romania	62%	52%
Slovakia	55%	36%

There are countries for which the including C-type institutions would not change significantly the ratios sample/population (Bulgaria, Czech Republic, Finland). For others the variations are still acceptable (Greece, Ireland, Latvia, Romania) while for the remaining the differences are quite dramatic.

For all these countries, we have a run a SYMBOL simulation test in order to assess the impact of having included C-type banks. To properly compare results we have computed the relative differences between simulations with C-type banks (R_C) and simulations without them (R_{nC}), and in particular we have used the following formula:

$$\frac{R_C - R_{nC}}{\frac{R_C + R_{nC}}{2}} \qquad \text{Equation 2}$$

We show in Table 16 the results in the case of Scenario 1 and only for selected percentiles.

Table 14: Effects of including C-type banks on the distribution of losses for selected contries (see Equation 2).

	95	**99**	**99.5**	**99.9**	**99.95**	**99.99**	**99.999**
Bulgaria				-2%	-1%	1%	0%
Cyprus	38%	37%	37%	-9%	-29%	31%	19%
Czech Republic				0%	1%	2%	2%
Estonia						-50%	-6%
Finland		0%	0%	0%	0%	1%	1%
Greece		-2%	-1%	9%	19%	8%	6%
Hungary				-50%	-25%	8%	7%
Ireland		-44%	-3%	-3%	-3%	-3%	-3%
Latvia			-50%	6%	7%	6%	5%
Poland			-50%	-2%	1%	14%	10%
Portugal		-19%	7%	8%	5%	4%	3%
Romania				-44%	-23%	-1%	14%
Slovakia				-29%	-11%	-10%	-8%

One can see that there are significant differences in many cases. It is also worth noticing that for the tail of the distribution, there are countries for which the difference is of the order of few points of percentage. Typically this happens for countries for which C-type banks would not change the ratios sample/population. What happens in all other cases should be better analyzed on the basis of country's characteristics. One possible approach may be to use ECB Total Assets without excluding foreign branches for those countries with C-type banks.

APPENDIX B: THE CASE OF BALTIC STATES

Baltic States Estonia (5 banks), Lithuania (9 banks) and Latvia (21 banks) are quite peculiar. First they have a relative small financial sector (in particular Estonia) and they seem sharing some cross country financial institutions. For these reasons we have considered a different approach: we have put them all together and we have use SYMBOL to simulate the potential losses of their aggregated financial sector. Losses were then split based on banks' contry of origin. As expected when contagion is off (Scenario 2) results considering them separately or as whole are very similar (see Table 17). When contagion works results show some losses variations: which need to be discussed. One can see that potential losses for the two smaller countries (Estonia and Lithuania) are generally smaller when they are considered as part of a larger financial sector while they are larger for (Latvia).

Table 15: Baltic States comparison (Scenario 2).

	Estonia		**Lithuania**		**Latvia**	
	Alone	Together	Alone	Together	Alone	Together
90	0	0	0	0	0	0
95	0	0	0	0	0	0
97	0	0	0	0	0	0
99	0	0	0	0	0	0
99.25	0	0	0	0	0	0
99.5	0	0	0	0	0	0
99.75	0	0	0	0	0	0
99.9	0	0	0	0	0	0
99.925	0	0	0	0	0	0
99.95	0	0	0	0	0	0
99.975	0	0	0	0	28,438	28,835
99.99	70,127	71,617	66,917	67,790	91,831	92,299
99.995	243,181	252,326	141,656	140,800	153,570	152,731
99.999	682,231	659,694	360,746	355,544	324,050	332,471

Table 16: Baltic States differences (Scenario 1)

	Estonia			**Lithuania**			**Latvia**		
	Alone	**Together**	**Relative differences**[12]	**Alone**	**Together**	**Relative differences**	**Alone**	**Together**	**Relative differences**
90	0	0	0	0	0	0	0	0	0
95	0	0	0	0	0	0	0	0	0
97	0	0	0	0	0	0	0	0	0
99	0	0	0	0	0	0	0	0	0
99.25	0	0	0	0	0	0	0	0	0
99.5	0	0	0	0	0	0	1,040	1,535	-10%
99.75	0	0	0	0	0	0	20,404	21,084	-1%
99.9	0	0	0	29,797	25,241	4%	66,654	68,339	-1%
99.925	0	0	0	46,851	40,023	4%	85,886	89,999	-1%
99.95	0	0	0	75,416	64,456	4%	118,438	131,240	-3%
99.975	1,596	5,260	-27%	139,660	113,320	5%	187,352	240,919	-6%
99.99	1,429,753	755,889	15%	242,690	192,358	6%	312,640	416,352	-7%
99.995	1,628,389	956,683	13%	339,597	267,382	6%	433,832	619,896	-9%
99.999	2,073,845	1,392,177	10%	634,672	495,586	6%	805,204	1,196,505	-10%

12 Relative differences are computed as in Equation 2.

APPENDIX C: NO REDUCTION FOR THE INTER-BANK EXPOSURE

Here we present the same SYMBOL results we had in Scenario 1, with the only difference lying in having used the Inter-bank exposure as coming from Bankscope (i.e. it has not been rescaled according to ECB data). As expected larger values for the Inter-bank would give rise to stronger effects for the contagion.

According to the expected stronger impact of the contagion these values are smaller than those presented in Section 4.1. Table 19 shows the relative differences between SYMBOL results obtained under the hypothesis that Interbank has been rescaled and SYMBOL results with no rescaling.

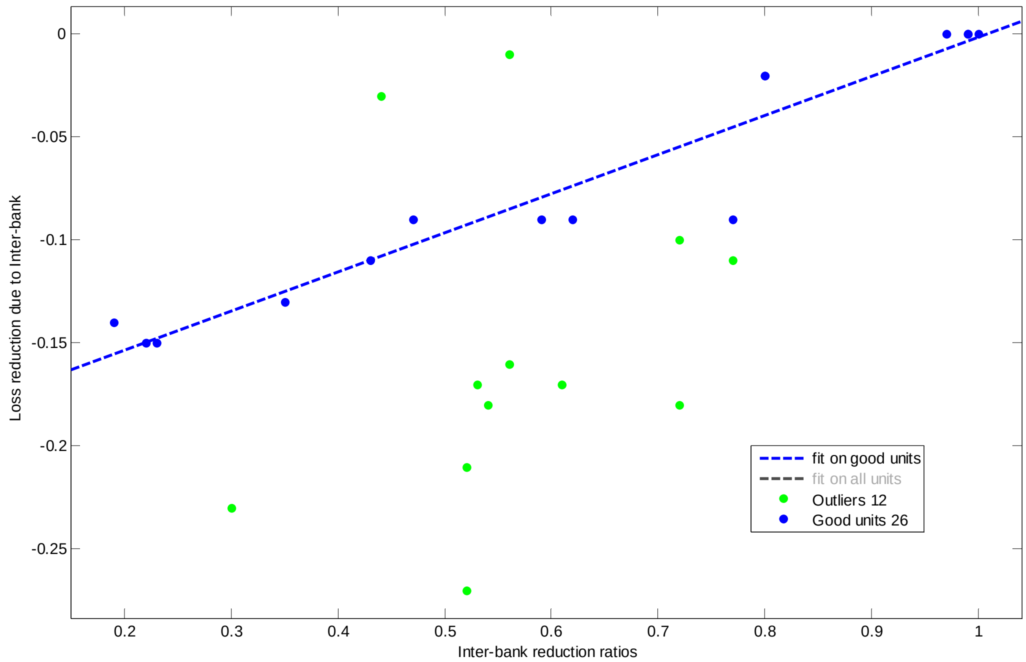
Table 17: Inter-bank impact on distribution of losses for Scenairo 1.

	95	**99**	**99.5**	**99.9**	**99.95**	**99.99**	**99.999**	**Average**
Belgium	0%	0%	0%	-35%	-29%	-17%	-11%	-19%
Bulgaria	0%	0%	0%	-1%	-1%	-2%	-4%	-2%
Czech Republic	0%	0%	0%	-1%	-6%	-4%	-3%	-4%
Denmark	0%	0%	0%	-4%	-26%	-36%	-24%	-18%
Germany	0%	-1%	-2%	-43%	-39%	-22%	-17%	-18%
Estonia	0%	0%	0%	0%	0%	-1%	0%	-1%
Ireland	0%	-16%	-12%	-10%	-9%	-8%	-7%	-10%
Greece	0%	0%	-2%	-15%	-25%	-10%	-7%	-10%
Spain	0%	-1%	-3%	-9%	-11%	-15%	-16%	-9%
France	0%	-2%	-13%	-40%	-25%	-18%	-15%	-16%
Italy	0%	-3%	-7%	-8%	-11%	-29%	-25%	-12%
Cyprus	0%	0%	0%	0%	0%	0%	0%	0%
Latvia	0%	0%	-1%	-8%	-10%	-11%	-14%	-9%
Lithuania	0%	0%	0%	-2%	-7%	-19%	-23%	-13%
Luxembourg	0%	0%	-1%	-20%	-18%	-14%	-12%	-13%
Hungary	0%	0%	0%	-12%	-23%	-16%	-15%	-17%
Malta	0%	0%	0%	0%	0%	0%	0%	0%
Netherland	0%	0%	-1%	-5%	-20%	-22%	-19%	-13%
Austria	0%	-1%	-20%	-44%	-40%	-28%	-19%	-25%
Poland	0%	0%	-1%	-4%	-7%	-17%	-18%	-9%
Portugal	0%	-9%	-18%	-33%	-24%	-17%	-13%	-19%
Romania	0%	0%	0%	-1%	-1%	-2%	-5%	-2%
Slovenia	0%	-3%	-8%	-8%	-8%	-7%	-6%	-7%
Slovakia	0%	0%	0%	-2%	-1%	-1%	-1%	-1%
Finland	0%	-1%	0%	-4%	-32%	-23%	-16%	-13%
Sweden	0%	0%	0%	0%	0%	0%	0%	0%
United Kingdom	0%	-2%	-6%	-42%	-40%	-33%	-25%	-21%

We use the average of loss differences (last column), to see if any relation can be found between Iiter-bank impact and the size of reduction we have used.

We consider the ratios we used for reducing the inter-bank (see Table 8***:*** *Inter-bank ratios*) as explanatory variable for the last column in Table 17***:*** *Inter-bank impact*. We try to see if there exists at least a subset of countries for which the inter-bank ratios may explain the reduction in potential losses. By using the same robust technique procedure we have used for imputation of capital's variables (see Section 2.1 and Appendix E) we obtain results presented in Figure 3.

Figure 2: Intebank outliers



In particular the outliers are the following countries: Austria, Belgium, Czech Republic, Germany, France, United Kingdom, Greece, Hungary, Ireland, Luxembourg, Portugal and Slovakia. This would imply that in many cases the role of the Inter-bank does not only depend on its size, but other aspects would come into the picture.

APPENDIX D: THE SUSTAINABILITY INDICATOR S2

The S2 indicator is part of the family of sustainability gap indicators. It shows (in % of GDP) the permanent adjustment necessary for the structural primary balance to achieve debt stabilization in the long term[13].

In the current analysis the impact on S2 of a banking crisis has been estimated by considering potential losses from banking crises as a stochastic additional component of current debt burden. This led to the construction of possible end-of-year debt levels including banking sector loss spillovers under each scenario. Based on these distributions and on the current level of S2, it is possible to calculate the probability that an unsustainable debt burden will be reached by the end of the year due to a banking crisis. This procedure makes use of two main assumptions: the first is that all losses generated in the banking sector and absorbed by public finances will be covered with new debt emissions (leading to overestimation); the second is that assumptions on the cost of debt will not vary with respect to the conditions assumed in the standard S2 analysis (leading to an underestimation).

Results base on SYMBOL simulations are at the moment not very instructive, but for sake of completeness we report them in the Table 20.

Table 18: Estimated S2 indicators.

	S2	Scenario 1	Scenario 2	Scenario 1 No IB Reduction
Belgium	100%	NaN	NaN	NaN
Bulgaria	19%	NaN	NaN	NaN
Czech Republic	44%	NaN	NaN	NaN
Denmark	45%	NaN	NaN	100%
Germany	80%	NaN	NaN	NaN
Estonia	6%	45%	98%	45%
Ireland	121%	100%	NaN	100%
Greece	199%	NaN	NaN	NaN
Spain	78%	NaN	NaN	NaN
France	92%	NaN	NaN	NaN
Italy	119%	NaN	NaN	NaN
Cyprus	71%	NaN	NaN	NaN
Latvia	47%	NaN	NaN	NaN
Lithuania	39%	NaN	NaN	NaN
Luxembourg	20%	73%	100%	63%
Hungary	77%	NaN	NaN	NaN
Malta	72%	100%	NaN	100%
Netherland	66%	NaN	NaN	NaN
Austria	74%	NaN	NaN	NaN
Poland	58%	NaN	NaN	NaN
Portugal	112%	NaN	NaN	NaN
Romania	36%	NaN	NaN	NaN
Slovenia	55%	NaN	NaN	NaN
Slovakia	51%	NaN	NaN	NaN
Finland	54%	NaN	NaN	NaN
Sweden	32%	100%	NaN	100%
United Kingdom	86%	NaN	NaN	NaN

[13] The indicator has two components: an "initial budgetary position" component (representing the adjustment necessary to stabilise debt under current structural deficit) and the required additional adjustment due to long-term changes in government expenditure (e.g. related to ageing

APPENDIX E: ROBUST REGRESSION FOR OUTLIERS DETECTION AND IMPUTATION OF MISSING VALUES

The goal of robust statistics is to build estimators independent from model assumption deviations and identify outliers, i.e. observations which are distant from the bulk of the observed data and can hardly comply with model assumptions.

The discipline has grown considerably in the last two decades and many robust methods are available in the literature (the book of Maronna, R. A.; Martin, D. R. & Yohai, V. J. *Robust Statistics: Theory and Methods* Wiley , 2006 is an excellent introduction to the field).

Among such methods, the Forward Search of Atkinson and Riani (*Robust Diagnostic Regression Analysis* Springer--Verlag , 2000) has shown superior properties in terms of size and power For a regression problem with p explanatory variables, the Forward Search (FS) builds subsets of increasing size *m*, starting from $m_{o} = p$, until all observations are included. The subsets are built using simple ordering criteria: at step *m*, the traditional least squares is used for fitting the *m* observations in the current subset and the next subset is built with the *m+1* units with smaller residuals of the fitted model.
During the process, as *m* goes from *p* to *n*, we can monitor the evolution of model estimates, the residuals of the fitted model, or other test regression statistics.

In absence of outliers we expect that during the search process all these statistics remain rather constant or show smooth increases.

On the contrary the entry of outliers, which by construction will happen in the last subsets, will be revealed by appreciable changes of the monitored statistics.

For an important statistic, the minimum deletion residual among observations not in the subset, distributional results and confidence bands can be used to identify precisely the outliers.

The Forward Search offers a very natural way to keep into account the potential presence of perfect fit cases, by monitoring the value of the coefficient of determination (R^2) during the search.

A value of R^2 that during the progression of the search stays constantly close to 1 is an indication of almost perfect fit.

In such case, we disregard outlier signals based on the standard diagnostic regression statistics, such as the minimum deletion residual, and we increase the confidence level to declare observations as anomalous.

This approach has been implemented using routines contained in the FSDA toolbox for Matlab, developed jointly by the University of Parma and the Joint Research Centre of the European Commission (Riani, M.; Perrotta, D. & Torti, F. *FSDA: A MATLAB toolbox for robust analysis and interactive data exploration*, Chemometrics and Intelligent Laboratory Systems, 2012) which is freely available for non-commercial use from http://www.riani.it/MATLAB or http://fsda.jrc.ec.europa.eu.

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Abstract

In the present report, we describe the main steps we have taken in order to create a sound database for the European Union Member States banking system. The final goal is to use this database as source for input variables of SYMBOL (SYstemic Model of Banking Originated Losses) model, developed by the Join Research Centre of Ispra in cooperation with the European Commission Direcotrate General for Internal Market and Services and experts from academia, for monitoring financial crises. SYMBOL simulates potential crises in the banking sector under various assumptions, and it allows assessing the cumulative effects of different regulatory measures (e.g. higher capital requirements, strengthened deposit insurance and introduction of resolution funds) and their most effective combinations. It uses items in bank's balance sheet to estimate the potential losses for a given banking system via a Monte Carlo analysis. The model is flexible and can be deployed either on a single country or on a set of financial institutions sharing common features. The report also shows an application of SYMBOL for assessing the impact on public finance of a crisis in the banking sector and compares the current regulatory framework with a future scenario where the new capital requirements set in Basel III and an effective framework for bank resolution are in place.

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