European Commission

ISSN 1725-3187 (online)
ISSN 1016-8060 (print)

EUROPEAN ECONOMY

Economic Papers 548 | April 2015

Banking Stress Scenarios for Public Debt Projections

Peter Benczur, Katia Berti, Jessica Cariboni, Francesca Erica Di Girolamo, Sven Langedijk, Andrea Pagano, Marco Petracco Giudici

Economic and Financial Affairs

Economic Papers are written by the staff of the Directorate-General for Economic and Financial Affairs, or by experts working in association with them. The Papers are intended to increase awareness of the technical work being done by staff and to seek comments and suggestions for further analysis. The views expressed are the author's alone and do not necessarily correspond to those of the European Commission.

Comments and enquiries should be addressed to:

European Commission
Directorate-General for Economic and Financial Affairs
Unit Communication
B-1049 Brussels
Belgium
E-mail: ecfin-info@ec.europa.eu

LEGAL NOTICE

This paper exists in English only and can be downloaded from http://ec.europa.eu/economy_finance/publications/.

More information on the European Union is available on http://europa.eu.

Luxembourg: Publications Office of the European Union, 2015

KC-AI-15-548-EN-N (online)
ISBN 978-92-79-44818-8 (online)
doi:10.2765/734404 (online)

KC-AI-15-548-EN-C (print)
ISBN 978-92-79-44819-5 (print)
doi:10.2765/7150 (print)

European Commission

Directorate-General for Economic and Financial Affairs

Banking Stress Scenarios for Public Debt Projections

Peter Benczur, Katia Berti, Jessica Cariboni, Francesca Erica Di Girolamo, Sven Langedijk, Andrea Pagano, Marco Petracco Giudici

Abstract

The latest economic and financial crisis has shown how quickly vulnerabilities on the financial side of the economy can turn into a strong deterioration of public accounts, thus highlighting the importance to monitor fiscal risks arising outside the realm of public finances. This is particularly the case for the building up of risks in the banking sector, due to its central role in financial stability. In this spirit, this paper presents banking stress-test scenarios for public debt projections based on SYMBOL, a Monte Carlo micro-simulation model that allows obtaining losses from simulated bank defaults, using actual bank balance-sheet information. The estimated bank losses are used to assess the size of the potential impact on government deficit and gross public debt that feed into a debt projection model, allowing drawing conclusions in terms of projected public debt dynamics. The methodology for the stress tests proposed here has three major advantages. First, it allows distinguishing between simulated bank losses and bank recapitalisation needs (particularly relevant in that public funds used to cover the latter could be recouped later by selling the financial assets acquired). Secondly, through the use of bank-level balance-sheet data, country-specific features of national banking systems are accounted for, while remaining within a common conceptual framework. Thirdly, the approach allows reflecting in the designed stress tests the institutional changes (bail-in, elements of Basel III, the resolution fund) along the path leading to the full implementation of the banking union legislation. Results for a selected group of EU countries are presented in the paper based on end-2013 bank balance-sheet data.

JEL Classification: C15, E62, G01, G21, H63, H68.
Keywords: public debt, debt sustainability, contingent liabilities, banking crisis, microsimulation.

Corresponding authors: K. Berti is Team Leader – Economist in the Fiscal Policy Directorate of the European Commission's Directorate General for Economic and Financial Affairs; P. Benczur, J. Cariboni, F. E. Di Girolamo, S. Langedijk, A. Pagano and M. Petracco are researchers at the European Commission's Joint Research Centre.
Contacts: K. Berti, Katia.Berti@ec.europa.eu; P. Benczur, peter.benczur@jrc.ec.europa.eu.

Acknowledgements: We thank G. Cannas for her support; and M. Marchesi, M. Salto and S. Zedda for their contribution to the stream of work that has led to the development of this framework.

1. INTRODUCTION

The latest economic and financial crisis has shown how quickly vulnerabilities on the financial side of the economy can turn into a strong deterioration of public accounts. Ireland, having recorded an increase in gross public debt as a percentage of GDP by almost 100 percentage points between 2007 and 2013, is emblematic in this respect, as it is the case of Spain, with a debt ratio increase by more than 50 percentage points over the same time period.

The crisis has indeed highlighted the importance of monitoring fiscal risks arising outside the realm of public finances. This is particularly the case with regard to the building up of risks in the banking sector, due to its central role in financial stability. When such risks materialize, the ensuing increase in gross public debt can be sufficiently steep to endanger sustainability also in countries with an initially low public debt, as shown by the two country examples mentioned above.[1] It is therefore of utmost importance to assess possible vulnerabilities on the financial side that have the potential to quickly "destabilise" public finances. It is against this background that work has recently been conducted at the European Commission (Directorate General for Economic and Financial Affairs – DG ECFIN, with the support of the Commission's Joint Research Centre – DG JRC) to develop a new module for the analysis of governments' contingent liability risks from the banking sector, as part of the public debt sustainability analysis (DSA) conducted by the Commission services (DG ECFIN).[2]

DSA exercises run by international organizations like the European Commission and the IMF[3] are aimed at assessing public debt sustainability on the basis of debt projections relying on a set of macro-fiscal assumptions (on government primary balance, real GDP growth, inflation, interest rates, exchange rate, stock-flow adjustment). In this type of exercises, the impact of changes in macroeconomic assumptions on projection results is evaluated through sensitivity analysis around baseline debt projections. It has, moreover, become common to complement the latter with stochastic projection methods[4] to gauge, in a more extensive way, the impact of uncertainty in macroeconomic conditions on public debt dynamics.

Equipping the DSA's analytical toolkit with modules (including specific debt projection scenarios) aimed at assessing risks from governments' bank-related contingent liabilities is key in ensuring a sufficiently comprehensive DSA. In this respect, the Commission's DSA framework has already been broadened to include a "heat map" that captures banking sector vulnerabilities. Variables like the private sector credit flow, the bank loans-to-deposits ratio, the share and the change in the share of non-performing loans and the change in nominal house prices are all scrutinized in this heat map, which also includes an estimate of the theoretical probability of government contingent liabilities due to banking losses exceeding 3% of GDP.[5] As detailed in European Commission (2014a), for countries that would be deemed as "vulnerable" under this specific dimension, based on variables included in the heat map, a stress-test scenario for bank-related contingent liability risks should additionally be run to complement the country's DSA.

The aim of this paper is to present this stress test on public debt projections. The test is based on the SYMBOL model (Systemic Model of Banking Originated Losses), developed by JRC, in cooperation with the European Commission's former Directorate General for Internal Market and Services and academics (see De Lisa et al, 2011). The model allows obtaining losses at banking system/country

---

1 Both Ireland and Spain entered the crisis with relatively low gross public debt (below 40% of GDP in Spain in 2008 and below 25% of GDP in Ireland in 2007, rising to 92% and 123% of GDP respectively in 2013). Note that the debt increase is not entirely attributable to the direct costs of the banking crisis. The crisis also exposed the fact that, in the run-up to it, the two countries relied excessively on temporary and unsustainable revenues to finance rapidly increasing expenditures.

2 See European Commission (2014a).

3 See European Commission (2014a) and European Commission (2012a) for a detailed description of the European Commission – DG ECFIN's DSA framework, and IMF (2013) for a description of their new DSA framework.

4 These are mostly based on the historical variance-covariance matrix approach (see, for instance, Berti, 2013) or the VAR methodology (see, for instance, Medeiros, 2012). The European Commission's DSA framework includes stochastic projections based on the historical variance-covariance matrix approach (see European Commission, 2014a and 2012; Berti, 2013).

5 In the heat map, values taken by these variables are reported in red, yellow or green depending on where values lie for the country concerned relative to some upper and lower (variable-specific) thresholds of risk (the so called "signals' approach" lies behind the determination of the thresholds – see European Commission, 2014a, for more details).

level derived from simulated bank defaults, using actual bank balance sheet information,[6] and taking into account potential banking safety net tools.[7] Estimated bank losses can be used to assess the size of the potential impact on government deficit and gross public debt. A stress test on public debt projections can then be designed by simply inserting the latter in a traditional debt projection model centered around the standard debt evolution equation, and analysing the way the debt path would be affected as a result.

The DSA template used in the context of the IMF's Art. IV surveillance[8] also includes a standard financial contingent liability shock scenario for "vulnerable" countries. This standard sensitivity test is, however, based only on the size of the banking system. Besides introducing the same type of exercise in the Commission's DSA framework, this paper proposes a new method by adding results from a bank-level micro-simulation model to a traditional debt projection model. This has two major advantages. First, by using bank-level balance sheet data, it becomes possible to account for country-specific features of national banking systems, while remaining within a common conceptual framework. Second, the approach proposed here further allows reflecting in the designed stress test the institutional changes along the path leading to the full implementation of the banking union legislation (with bail-in, elements of Basel III, and the resolution fund becoming available).

The paper is structured as follows. In Section 2 we present the SYMBOL model and explain how banking losses are simulated. We then explain the use of SYMBOL results in assessing the potential impact on public finances, including the underlying assumptions. Section 3 then presents the contingent liability stress-test scenario on public debt projections based on SYMBOL. We provide results for a number of EU countries. Section 4 concludes, while additional details are reported in the annexes.

2. SYMBOL

2.1. THE MODEL

SYMBOL is a Monte Carlo micro-simulation model that simulates the distribution of banking sector losses within a banking system (usually a country) by aggregating individual banks' losses.[9] The latter are generated via a Monte Carlo simulation using the Basel Foundation Internal Rating Based (FIRB) loss distribution function, based on the Vasicek model, which in broad terms extends the Merton model to a portfolio of borrowers.[10] [11] As will be further detailed in what follows, simulated losses are based on an "effective default probability" (*implied obligor probability of default, IOPD*) of the portfolio of assets of an individual bank, derived from the bank's minimum capital requirement and total assets.

---

6 Banks' balance sheet information is taken from Bankscope, a commercial database developed by Bureau van Dijk.

7 SYMBOL has already been used in the analysis of government contingent liability risks from the banking sector in the European Commission's Fiscal Sustainability Report 2012 (where estimated probabilities of public finances being hit by simulated bank losses were presented in Section 5.5.1 – see European Commission, 2012a) and in the 2011 Report on Public Finances in EMU (where results on the distribution of costs for public finances from simulated bank defaults were presented in Section 2, Part IV, together with the estimated probabilities of a hit on public finances - see European Commission, 2011).

8 See IMF (2013).

9 See De Lisa et al. (2011).

10 See Vasicek (2002) and Merton (1974) for more details.

11 The Basel Committee permits banks a choice between two broad methodologies for calculating their capital requirements for credit risk. One alternative, the Standardised Approach, measures credit risk in a standardised manner, supported by external credit assessments. The alternative is the Internal Rating-Based (IRB) approach, which allows institutions to use their own internal rating-based measures for key drivers of credit risk as primary inputs to the capital calculation. Institutions using the Foundation IRB (FIRB) approach are allowed to determine the borrowers' probabilities of default, while those using the Advanced IRB (AIRB) approach are permitted to rely on own estimates of all risk components related to their borrowers (e.g. loss given default and exposure at default). The Basel FIRB capital requirement formula specified by the Basel Committee for credit risk is the Vasicek model for credit portfolio losses. Default values for all parameters, except obligors' probabilities of default, are provided in the regulatory framework. On the Basel FIRB approach, see Basel Committee on Banking Supervision (2005, 2006, 2010 and 2011).

The modelling rests on the following assumptions:

i. SYMBOL approximates all banking risks as if they were credit risk, meaning that no other risk categories (e.g. market, liquidity or counterparty risks) are explicitly considered;
ii. SYMBOL implicitly assumes that the FIRB formula adequately represents (credit) risks banks are exposed to;
iii. Banks in the system are correlated to each other according to the same correlation factor[12] (either as a consequence of the banks' common exposure to the same borrower, or to the common influence of the business cycle);
iv. All default events happen at the same time, i.e. there is no sequencing in the simulated events.

Estimating the distribution of losses in excess of banks' capital for a given country involves the following steps (see also Annex 1 for a more technical explanation of the mechanics of the model).

STEP 1: Estimation of the Implied Obligors' Probability of Default (IOPD) of the portfolio of each individual bank

The model estimates the IOPD of the portfolio of each individual bank by numerical inversion of the Basel FIRB formula for credit risk.[13] The credit risk model adopted by the regulator is indeed public, as are all the relevant parameters used for its computation, the only exception being the default probabilities of banks' obligors assessed by the banks themselves and validated by the regulators. Using publicly available data on capital requirements,[14] total assets, and the regulatory values for the other parameters of the credit risk model,[15] the underlying average default probability of individual banks' obligors is obtained, reflecting the assessments done by the banks (see Annex 1 for more technical details on IOPD estimation). The average probability of default of the credit portfolio of each bank is therefore estimated consistently with minimum regulatory capital requirements for credit risk.

STEP 2: Simulation of correlated losses for the banks in the system

Given the estimated average IOPD, SYMBOL assumes that correlated banks' losses can be simulated via Monte Carlo using the same FIRB formula and imposing a certain correlation structure among banks (with a correlation coefficient ρ set at 0.5 in the baseline scenario). This correlation exists either as a consequence of the banks' common exposure to the same borrower or, more generally, to a particular common influence of the business cycle.[16]

In each simulation run $j=1,2,\ldots,M$, losses $L_{i,j}$ for bank $i=1,2,\ldots,N$ are simulated as:

$$L_{i,j} = LGD \cdot N\left[\sqrt{\frac{1}{1-R_i}}N^{-1}(IOPD_i) + \sqrt{\frac{R_i}{1-R_i}}N^{-1}(\alpha_{i,j})\right]$$

$$R_i = 0.12\frac{1-e^{-50IOPD_i}}{1-e^{-50}} + 0.24(1-\frac{1-e^{-50IOPD_i}}{1-e^{-50}})$$

with $\alpha_{i,j} \sim N(0,1) \;\; \forall\, i,j$ and $cov(\alpha_{i,j}, \alpha_{l,j}) = \rho \;\; \forall\, i \neq l$

---

12 As the outcome of ongoing work, SYMBOL can now incorporate a richer correlation structure among banks (see Benczur et al, 2015). This will be incorporated into the Commission DSA later on.

13 The Basel Accord imposes that each bank satisfies regulatory capital requirements to guard against risks the bank may face. As the Basel FIRB formula to calculate capital requirements is related to the bank's default probability, the latter can be estimated by inverting the Basel formula.

14 Banks must comply with capital requirements not only for their lending activity and credit risk component, but also in relation to other types of risks (market risk, counterparty risk, operational risk, etc.). As already indicated, the assumption behind SYMBOL is that all risks can be approximated as credit risk.

15 These are the loss given default, the correlation between banks' assets, maturity and other correction parameters.

16 The choice of the 0.5 correlation for the baseline scenario is based on Sironi and Zazzara (2004). A discussion and a sensitivity check on this assumption can be found in De Lisa et al. (2011).

where *LGD* is the Loss Given Default, set to 45% as in the Basel regulation; *N()* is the normal distribution function; R_i is the coefficient of correlation among different obligors of bank i; and $IOPD_i$ is the average implied obligors' probability of default estimated for bank i in Step 1. The random numbers $\{N^{-1}(\alpha_{i,j})\}_{i=1\ldots N, j=1\ldots M}$ are drawn from a correlated normal distribution, with the correlation coefficient among banks (ρ) being 50%.

STEP 3: Determination of the bank insolvency event

Given the matrix of correlated losses, SYMBOL determines which banks is insolvent ("fails"). As illustrated in Graph 1, a bank fails when simulated portfolio losses exceed the sum of expected losses (*EL*) and total actual capital (*K*), the latter being the sum of its minimum capital requirement and the excess capital, if any: [17]

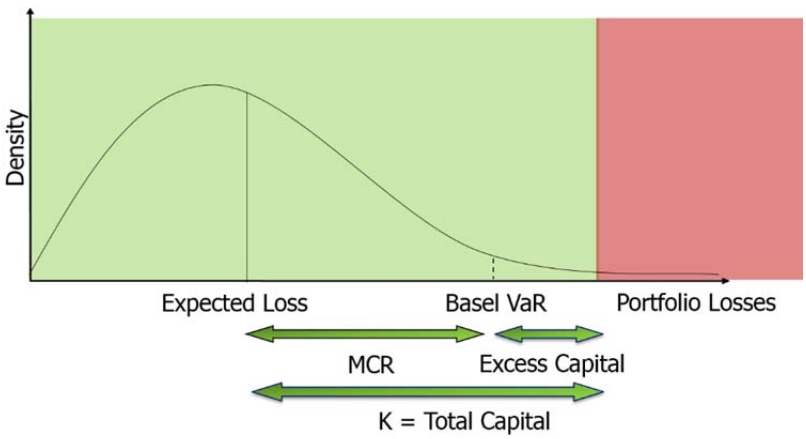
$$L_{i,j} \geq EL_i + K_i$$

The light-shaded (green) area in Graph 1 represents the region where losses are covered by provisions and total capital, while the dark-shaded (red) area corresponds to bank failure under the definition above. It should be noted that the probability density function of losses for an individual bank is skewed to the right, i.e. there is a very small probability of extremely large losses and a high probability of losses that are closer to the average/expected loss. The Basel Value at Risk (VaR) corresponds to a confidence level of 0.1%, meaning that the minimum capital requirement (MCR) covers losses from the obligors' portfolio with probability 99.9%. This percentile falls in the light-shaded (green) area, as banks generally hold an excess capital buffer on top of the minimum capital requirement.

The data needed for determining the failure event for each bank is its level of total capital.

For the purpose of the exercise conducted in this paper, each SYMBOL simulation ends when 100,000 runs with at least one bank failure are obtained. The large number of runs ensures a sufficient degree of stability in the estimated tail of the loss distributions. Because of the different sizes of national banking systems, the actual number of runs needed to reach at least 100,000 failures varies from country to country. For this reason, the model typically runs for a few millions of iterations for small countries and hundreds of thousands iterations for medium and large countries.

Graph 1**: Individual bank loss probability density function**



[17] Banks are expected to cover their expected losses on an ongoing basis, e.g. by provisions and write-offs. Unexpected losses, on the contrary, relate to potentially large losses that occur seldom. According to this concept, capital would only be needed for absorbing unexpected losses.

STEP 4: Obtaining the aggregate distribution of losses for the whole banking system and the estimate of bank losses hitting public finances

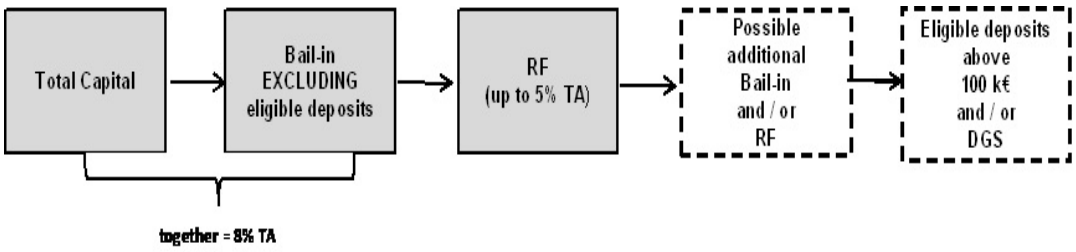
Aggregate losses and recapitalisation needs ($XLRecap_j$) are obtained by summing losses in excess of capital and the recapitalisation needs of all distressed banks in the system (both failed and undercapitalised banks) in each simulation run j, as from the equation below:

$$XLRecap_j = \sum_i \left(L_{i,j} - EL_{i,j} - K_i + Recap_{i,j}\right) \quad (1)$$

We consider two separate scenarios in terms of bank recapitalisations: 4.5% and 8% of each bank's risk-weighted assets.[18] The 8% level is justified on two grounds, as being the level of minimum capitalisation at which a bank is considered viable under Basel rules and the minimum level to which banks were recapitalised by public interventions in the last economic and financial crisis. The alternative recapitalisation assumption of 4.5% can be viewed as a lower bound on bank recapitalisation needs falling on public finances. A lower level in general reflects the fact that banks can raise part of their necessary capital by issuing equity on the markets, cutting dividend earnings, and also that the European Stability Mechanism (ESM) will be allowed to provide financial assistance for the recapitalisation of financial institutions. The choice of 4.5% is motivated by the fact that a bank needs to be recapitalized at least up to this level before the ESM can step in.[19]

When estimating the impact of bank losses on public finances, in addition to banks' capital, SYMBOL can take into account the existence of a safety net for bank recovery and resolution, with tools (like deposit guarantee schemes - DGS, resolution fund – RF, and bail-in) intervening to partly cover banks' losses and recapitalisation needs before public finances. Reflecting the position agreed in 2014 by the European Parliament, the Council and the European Commission,[20] the order of intervention of the banking safety net tools would be as sketched in Graph 2. Under bail-in arrangements, a minimum amount of losses corresponding to 8% of total liabilities plus own funds (here measured by the bank's total assets, TA) needs to be covered by shareholders and unsecured creditors before other tools can intervene. Then, only in exceptional circumstances, national RFs can contribute to the resolution, up to 5% of the total assets of the failing bank, in order to exclude (totally or partially) an eligible liability or class of eligible liabilities from absorbing losses. After this, the order of intervention of the remaining tools is subject to the discretion of the resolution authority. For instance, the additional bail-in tool could be used (i.e. all other unsecured creditors, if any, could be written down) and/or the remaining RF could be called to cover losses above 5% of total liabilities (including own funds), after all unsecured non-preferred liabilities (other than eligible deposits) have been written down or converted in full. Eligible deposits (above 100.000 euros) and/or the DGS could also intervene absorbing losses as the last tools (though the DGS cannot be used for recapitalising banks).

Graph 2: **The banking safety net tools: order of intervention**



Simulations presented in the main text of the paper will be based on the assumption that all simulated bank losses and recapitalisation needs that are not covered by bank capital fall on public finances. Banking safety net tools like DGS, RF and bail-in will therefore be considered as not available to cushion the impact on public finances at the time at which the banking contingent liability shock is assumed to take place (the first projection year, which is 2015 at the time of writing the paper).

[18] Under the Basel II regulation, risk-weighted assets are defined implicitly, being 1/0.08=12.5 times the required regulatory capital.

[19] See, for example, page 3 of European Financial Stability Facility and European Stability Mechanism (2013).

[20] See European Parliament and Council (2014).

Simulation results under "theoretical" scenarios already including the aforementioned safety net tools as of 2015 are nonetheless presented in Annex 3 to give some indication on how results could be expected to change following the introduction of such tools. Future stress tests will incorporate some of these elements.

The reason for excluding the aforementioned safety net tools from the simulations presented in the main text of the paper is that our stress-test scenario is meant to reflect the stage of implementation of the banking union legislation at the time of the simulated banking shock. To be able to timely gauge the possible impact of short-term risks on public finances, the stress test on public debt projections should allow an assessment of risks related to the materialisation of a bank contingent liability shock in the very immediate future. For this reason, the banking shock is assumed to take place in the first projection year (currently 2015) and the scenario needs to reflect the institutional setting in place in that year. Based on this logic, given that the bail-in tool will *generally* enter into force starting from 2016 [21] and the RF has been given a target level of 1% of covered deposits to be collected over a period of 8 years starting from 2015, both tools are considered as not yet available to the purpose of the simulations presented in this paper.

DGSs and the bail-in of eligible deposits above 100.000 euros are also excluded from the simulations. Our reason for this is that there is a high degree of regulatory uncertainty on the use of such tools, and their use could also raise financial stability concerns. On the other hand, one may argue that, until provisions of the Bank Recovery and Resolution Directive[22] are implemented by the Member States, there could be a case for a call being made on the DGS to cover losses. However, these funds would effectively prevent a hit on public finances only if they were completely pre-paid. As this is not the case for many Member States, we chose not to consider a sheltering role for the DGS either.

Finally, with regard to the Capital Requirement Directive IV (CRD IV),[23] the impact of its introduction is taken into account in the simulations presented in the paper. This is done by correcting total capital and risk-weighted assets from banks' balance sheets using results of the end-2013 European Banking Authority (EBA) Quantitative Impact Study (QIS),[24] which determines the average impact of introducing CRD-IV rules (see more in the following section). By applying these corrections the level of total capital decreases and the risk-weighted assets from banks' balance sheets increase.

2.2. THE INPUT DATASET

The main data source for SYMBOL simulations is Bankscope, a commercial database of banks' balance sheets produced by Bureau van Dijk. The dataset covers a quite large sample of banks in 28 EU countries (about 2,380 banks). We focus on commercial, cooperative and savings banks only. The data used in the simulations are as of end 2013 (end-2012 data are only used for comparative purposes in Annex 4). Bankscope data have been integrated with public information on banks' financial statements released by supervisory authorities and/or central banks, when needed and possible. Furthermore, ECB data on aggregated banks' total assets per country are used as the statistical population, in order to calculate the sample coverage ratio. To maximize the sample size, robust imputation procedures have been applied in order to input missing data for capital variables.[25]

---

21 Bail-in will *generally* enter into force as of 2016, while it *could* be applied before 1 January 2016 in order to allow for effective resolution outcomes, as explicitly indicated in the Bank Recovery and Resolution Directive.

22 Directive 2014/59/EU (European Parliament and of the Council, 2014) establishing a framework for the recovery and resolution of credit institutions and investment firms and amending Council Directive 82/891/EEC, and Directives 2001/24/EC, 2002/47/EC, 2004/25/EC, 2005/56/EC, 2007/36/EC, 2011/35/EU, 2012/30/EU and 2013/36/EU, and Regulations (EU) No 1093/2010 and (EU) No 648/2012, of the European Parliament and of the Council, L 173/190.

23 Directive 2013/36/EU (European Parliament and of the Council, 2013) of 26 June 2013 on access to the activity of credit institutions and the prudential supervision of credit institutions and investment firms, amending Directive 2002/87/EC and repealing Directives 2006/48/EC and 2006/49/EC, 2013, Official Journal of the European Union, L 176/338. This legislation increases the quality and quantity of minimum capital requirements that banks should set aside.

24 See European Banking Authority (2013).

25 Overall, we use the following Bankscope variables: total assets; regulatory tier 1 capital; total regulatory capital; tier 1 regulatory capital ratio; total regulatory capital ratio; risk-weighted assets; loans and advances to banks; deposits from banks; customer deposits; common equity. For full details of the SYMBOL database, see Pagano et al (2012).

Aggregate sample amounts of selected SYMBOL input variables are reported in Table 1 (see Annex 2 for a description of the sample at Member State level). It should nonetheless be noted that, as indicated in the previous section and further detailed below, capital levels and risk-weighted assets used in the simulations are modified relative to current balance sheet data, and therefore differ from values presented in Table 1.

The last two columns of the table compare the total assets in the sample with total assets from the population of banks based on ECB data. Our sample covers roughly 72% of all EU banking assets as reported by the ECB. At Member State level, whenever the sample ratio is low (i.e. the country-level aggregates are based on banks which represent less than 15% of the country's banking sector - see Annex 2 for the information by Member State), or the number of banks is extremely small (less than 6), simulation results are deemed not to be reliable, since a minor change to any bank's data or the addition of a new bank could have large effects on results. For countries for which this is the case based on latest (end-2013) data (Estonia and Ireland have too few banks, Malta has a low sample ratio, and Cyprus has both), SYMBOL simulation results are not provided. For the same reason, there is an additional set of countries for which we have obtained simulation results based on 2013 data, but they should be interpreted with caution (Austria, Greece, Hungary and Lithuania).[26]

Table 1: **Sample used in SYMBOL simulations: selected variables (data as of December 2013)**

	SYMBOL sample							
	Banks	**G1 banks***	**Total assets (bn €)**	**RWA (bn €)**	**Customer deposits (bn €)**	**Capital (bn €)**	**Sample ratio**	**ECB total assets (bn €)**
Total EU-27	2,387	71	27,479	10,725	11,035	1,420	72%	38,197

Source: Bankscope, ECB and Commission services (DG JRC estimations).
Notes:
* G1 banks are those with Tier 1 capital larger than 3 bn euros.

To properly account for the effects of introducing Basel III rules (thus the Capital Requirement Directive IV), we make use of the results of the Basel III monitoring exercise run by EBA.[27] The aim of the EBA exercises (started in 2009 and since then regularly updated)[28] is indeed to assess and monitor the impact of the new Basel III capital standards on a specific sample of EU banks. In particular, we use the average reduction in the capital ratio and average increase in risk-weighted assets from the monitoring exercise, as reported in Table 2 for G1 and G2 banks.[29] These adjustments reflect the more stringent definition of capital, as well as the new risk-weighted-asset rules,[30] under Basel III. Based on Table 2, a G1 bank with capital and risk-weighted assets in 2013 given by K (2013) and RWA (2013) respectively has its capital and risk-weighted assets under Basel III rules, $K^{adj}(2013)$ and $RWA^{adj}(2013)$, calculated as:

$$K^{adj}(2013) = K(2013) \cdot 0.80$$

$$RWA^{adj}(2013) = RWA(2013) \cdot 1.10$$

The equations above reflect the fact that, given a certain amount of bank capital, the amount deemed to be of "good quality" (i.e. capable of absorbing losses) under Basel III is lower than under Basel II. In the same way, risk-weighted assets under Basel II were not adequately reflecting some risks faced by the banks. Adjustments based on the EBA study, referred to as QIS^{RWA} and QIS^{K} respectively in what follows (see Table 2), are therefore applied.

[26] For the same reason, simulation results based on 2012 data (used for comparative purposes in Annex 4) are not reliable and cannot be used for Cyprus, Estonia, Greece, Ireland and Malta; while caution is needed for Austria, Hungary and Lithuania.

[27] See European Banking Authority (2013). Unfortunately, the correction coefficients are not publicly available at the country level.

[28] The last published update makes use of bank data as of end 2013 (see European Banking Authority, 2013).

[29] G1 banks have Tier 1 capital above 3 billion € and G2 banks are all the others.

[30] From the change in the capital ratio and the change in the risk-weighted assets one can estimate the change in capital.

Table 2: **Adjustments in EU average capital and risk-weighted assets (RWA) by banking group due to the implementation of Capital Requirement Directive IV**

	G1 banks	G2 banks	Large G2 banks	Small G2 banks
$QIS^{RWA}(2013)$	1.10	1.11	1.12	1.05
$QIS^{K}(2013)$	0.80	0.86	0.85	0.87

Source: EBA (Basel III monitoring exercise, 2013) and Commission services (DG JRC estimations).
Notes: G1 banks are those with Tier 1 capital larger than 3 bn euros; G2 banks are all those with Tier 1 capital lower than 3 bn €; Large G2 banks are those with Tier 1 capital higher than 1.5 bn €; Small G2 banks are those with Tier 1 capital lower than 1.5 bn €.

2.3. SIMULATION RESULTS

SYMBOL simulations presented in this section provide an estimate of the banking losses and recapitalisation needs that would be faced in case of a financial crisis similar to the one started in 2008. Bank losses and recapitalisation needs triggered by the last crisis are proxied by data on state aid provided to the banking sector over 2008-12 (around 590 bn euros).[31] For the EU as a whole, a loss of similar amount would correspond to the 99.95th percentile of the distribution of aggregate losses including recapitalisation needs ($XLRecap_j$ of equation (1)) over the same time period.[32] In this exercise, we therefore focus on the 99.95th percentile of the aggregate loss distribution obtained from SYMBOL to estimate the banking loss and recapitalisation needs that each country would be expected to face in case of a future financial crisis of the same magnitude of the last one.[33]

It is important to note that being at the 99.95th percentile does not mean that the event happens with a probability of at most 0.05 percent. It is more appropriate to think about the SYMBOL (and also the Basel) probabilities as "theoretical probabilities". The Basel II criteria are such that an institution is expected to suffer losses that exceed its capital on average once in a thousand years (a confidence level of 99.9%). The regulation acknowledges that “the high confidence level was also chosen to protect against estimation errors, that might inevitably occur from banks’ internal PD, LGD and EAD[34] estimation, as well as other model uncertainties” (See Basel Committee on Banking Supervision, 2005). Laeven and Valencia (2013) identifies 17 systemic banking crisis episodes in the period 2008-2011 worldwide, and 147 episodes since 1970. Based on this, it is safe to say that the Basel models tend to underpredict the actual frequency of bank defaults, which then carries over to model estimates. Theoretical probabilities cannot be thus taken literally as frequencies. Their relative magnitudes, however, can inform us whether one bank or one country is at higher risk than another.

As indicated in Section 2.1, SYMBOL simulations can distinguish between bank losses in excess of capital and bank recapitalisation needs[35] related to the fulfillment of the minimum capital requirement

[31] Using numbers from the State Aid Scoreboard 2014 of the European Commission's Directorate General for Competition, the total amount of recapitalisation measures in the period 2008-12 is 428 bn euros. A total of 179 bn euros was also provided to the financial sector via asset relief during the same period (European Commission, 2014b).

[32] Due to computational constraints, simulations are run on a country by country basis. The EU-level percentile value is defined as the sum of all country level percentiles. Benczur et al (2015) already features an improved methodology, running SYMBOL on the entire sample with distinction between correlations within and between countries. Future DSA exercises are intended to incorporate this new methodology.

[33] One could consider that the hardest hit countries had a more severe crisis than the average EU crisis reflected by the 99.95th percentile of the loss distribution. The framework presented in this paper allows testing the impact of more severe stress on debt dynamics by moving to a higher percentile of the loss distribution.

[34] These three factors correspond to the risk parameters upon which the Basel II IRB approach is built. PD denotes the probability of default, which gives the average percentage of obligors that default in the course of one year. EAD is exposure at default, giving an estimate of the amount outstanding in case the borrower defaults. LGD is loss given default, which gives the percentage of exposure the bank might lose in case the borrower defaults. The Expected Loss is then the product of these three terms (Basel Committee on Banking Supervision, 2005).

[35] Note that one has to define the correct notion of the 99.95th percentile of these variables: the extremity of the event is determined by the value of aggregate excess losses and recapitalization needs. The simulation runs are thus first ranked according to *XLRecap*. We then sort all the other aggregated distributions according to the same ranking. As the outcome of the step above may not be monotonically increasing, we approximate the loss distributions via a Hodrick-Prescott filter to eliminate the noise from the ranking. This method has proven to be quite reliable and robust in general. An alternative approach is explored in Cariboni et al. (2015).

imposed by regulation. This allows us to make reasonable assumptions on how public funds are injected in the banking sector to cover the two types of funding needs, and based on such assumptions treat the two differently in terms of their impact on public finances. Bank losses in excess of capital would be covered by liquidity injections (subsidies) in the banking sector, affecting the public deficit, and gross and net debt equally. On the contrary, recapitalisation needs to provide the bank with capital in accordance with the minimum capital requirements reflect shareholder value and can be considered recoverable as the government receives shares in the bank in exchange. Given that the provided capital is transformed into (partial) government ownership of the bank, it is recorded as a financial transaction, thus affecting only gross debt through the stock-flow adjustment, and not the deficit, nor net debt. Funding provided for bank recapitalisation could be recouped, thus "reintegrating" public finances at a later stage.

Simulation results for a selected group of EU countries are reported in Table 3, distinguishing along these lines between bank (excess) losses (impacting on the government budget balance) and bank recapitalisation needs (impacting only on gross debt). Both scenarios of recapitalisation up to 4.5% and 8% of risk-weighted assets (RWA) are considered, based on the logic detailed in Section 2.1.

SYMBOL results *based on end-2013 data* (see Annex 4 for a comparison with results based on 2012 data) show a particularly strong hit of a simulated banking crisis on public finances in Portugal (in the absence, as already indicated, of banking safety tools that will be set in place with the implementation of the banking union legislation). Simulated bank losses in excess of bank capital would trigger a worsening of almost 1.5% of GDP in the government balance in the year of the banking shock. Simulated recapitalisation needs for Portuguese banks due to the shock would amount to 2.5% of GDP (in case of recapitalisations up to 4.5% of RWA), leading to an increase of the same size in gross public debt over GDP. In the more pessimistic scenario of bank recapitalisation up to 8% of RWA, the simulated increase in the Portuguese gross public debt would get as high as 6% of GDP.

Spain and the Netherlands are other two countries for which the simulations point to a relatively strong hit on public finances, with simulated increases in gross public debt of more than 4% and more than 3.5% of GDP under the more pessimistic scenario of recapitalisation up to 8% of RWA (the simulated increase in public debt of the two countries would be in the range of 1.5-2% of GDP under the more optimistic scenario of recapitalisations up to 4.5% of RWA). France follows the aforementioned countries in the ranking of the strongest simulated impact on public finances. A more muted effect is obtained, on the contrary, for other countries with high public debt like Italy and Belgium, with the impact on the government balance remaining at or below 0.2% of GDP and the impact on gross public debt due to recapitalisations remaining safely below 1% of GDP for both countries, also under the more pessimistic scenario.

When looking into the specific features of the banking systems of the aforementioned countries (see the last three columns of Table A2.1 in Annex 2), one can find explanations for why the simulated banking shock is large or small for a given country (which also allows fully realising the capabilities of a micro-simulation tool like SYMBOL). Based on end-2013 data, Portugal, for example, has a very high aggregate ratio of risk weighted assets to total assets *and* the lowest capital to risk weighted asset ratio, which means a relatively low capitalization. France has the second highest leverage (total assets to capital) and the second lowest level of capitalization. For Spain and the Netherlands, the aggregates are in fact not informative, all ratios being in the mid-range of the sample. Looking into the bank level (end-2013) data reveals that both countries have some very large banks with higher levels of risk-weighted assets, lower capitalization or both. Finally, on the other side of the spectrum, Belgium has a very low level of risk-weighted assets, while Italy has a high degree of capitalization.

The impact on public finances would be significantly smaller if banking safety net tools like bail-in and resolution funds were already available at the time of the simulated bank shock, as evident from simulation results in Annex 3. In future perspective, the stress-test scenario on public debt projections based on SYMBOL described in the next section can therefore be expected to yield more positive results than what reported in this paper based on the current institutional setting.

Table 3: **Simulated bank losses in excess of bank capital and simulated bank recapitalisation needs up to 4.5% and 8% of risk-weighted assets (RWA) for selected EU countries (based on end-2013 bank balance-sheet data)**

Country	Simulated bank (excess) losses impacting on gov't balance, % GDP	Simulated bank recap. (up to 4.5% RWA) impacting only gross public debt, % GDP	Simulated bank recap. (up to 8% RWA) impacting only gross public debt, % GDP
BE	0.20%	0.23%	0.76%
CZ	0.26%	0.51%	1.07%
DE	0.53%	0.71%	1.73%
DK	0.25%	0.88%	2.22%
ES	0.54%	1.83%	4.28%
FI	0.09%	0.42%	0.92%
FR	0.68%	1.11%	2.78%
HR	0.09%	0.21%	0.59%
HU	0.05%	0.07%	0.18%
IT	0.18%	0.31%	0.89%
LT	0.11%	0.18%	0.52%
NL	0.82%	1.60%	3.72%
PL	0.23%	0.60%	1.45%
PT	1.42%	2.48%	5.96%
RO	0.10%	0.17%	0.33%
SE	0.05%	0.66%	1.57%
SK	0.13%	0.34%	0.78%
UK	0.47%	0.79%	1.66%

Source: Commission services (DG JRC estimations, based on Bankscope data).

3. A STRESS TEST ON PUBLIC DEBT PROJECTIONS FOR BANK-RELATED CONTINGENT LIABILITY RISKS

3.1. DESIGNING A STRESS-TEST SCENARIO BASED ON SYMBOL FOR THE EUROPEAN COMMISSION'S DEBT SUSTAINABILITY ANALYSIS FRAMEWORK

As indicated in the introduction to the paper, the objective of this work is to design a stress-test scenario for public debt projections allowing to capture potential bank-related contingent liability risks over the short-term horizon. One of the lessons taught by the latest economic and financial crisis is that economic policy surveillance needs to take an encompassing view, ensuring that interconnections between the private and the public, the financial and the real sectors of the economy are properly monitored, so as to better identify risks early on and support the design of timely corrective actions. This has clearly been the spirit driving some of the most important reforms in the EU's economic governance framework, like the introduction of the Macroeconomic Imbalances Procedure with the so called *Six-pack*.[36] It is also the spirit that has shaped the design of some of the new analytical tools that are now part of the European Commission's fiscal sustainability assessment framework, like the S0 indicator of short-term risk of fiscal stress, designed to capture fiscal risks arising from both the

[36] See Regulation (EU) No 1176/2011 (European Parliament and Council, 2011a) of 16 November 2011 on the prevention and correction of macroeconomic imbalances and Regulation (EU) No 1174/2011 (European Parliament and Council, 2011b) on enforcement measures to correct excessive macroeconomic imbalances in the Euro Area.

financial and the real sides, the private and public sectors of the economy.[37] It is again the drive towards a comprehensive monitoring of fiscal risks possibly arising from outside the realm of public finances that has led to the inclusion of a stress-test on public debt projections for bank-related contingent liability risks as an important new element for the European Commission's Debt Sustainability Analysis (DSA) framework.[38] This new element allows for a sufficiently comprehensive debt sustainability analysis, which is rather important in the light of the very significant impact "banking troubles" have had on public finances in countries like Ireland and Spain in the context of the last financial crisis.

As indicated in European Commission (2014a), in the Commission's DSA framework a specific country's DSA would be integrated with the stress-test scenario described in this section, whenever the country is identified as "vulnerable" from the point of view of bank-related contingent liability risks. This is deemed to be the case when: i) *at least one* of the three variables (included in a heat map to the purpose of the DSA) indirectly capturing banking contingent liability risks (private sector credit flow in percentage of GDP; bank loan-to-deposit ratio; change in the share of non-performing loans) is above the respective critical threshold; and/or ii) the theoretical probability of government's contingent liabilities linked to bank losses exceeding 3% of GDP in the country under examination is estimated to be greater than the upper threshold under *at least one* of the two bank recapitalisation assumptions (4.5% and 8% of RWA). When at least one of these two conditions is met, the stress-test scenario for bank-related contingent liability risks, designed as described below, would be added to the country's DSA.

The stress-test scenario makes use of SYMBOL simulations presented in Section 2.3. Using a microsimulation model like SYMBOL to run the stress test has the important advantage of allowing to incorporate features of the national banking systems, while remaining within a unified conceptual framework. In particular, the stress scenarios take into account the size (total assets), asset quality (risk-weighted assets), and capitalization (regulatory and total capital) of a given country's banking sector. Moreover, they depend also on the distribution of these variables, as opposed to simple country-level aggregates. As shown by Table 3, these elements can lead to important cross-country differences in the size of fiscal risks originating from the banking sector.

At the same time, the use of a common modelling approach allows some standardisation in the way the stress-test scenario is conceived and run across EU countries. This is clearly an advantage relative to a design that would directly translate country-specific expertise in a more ad-hoc way into a particular risk assessment, stating that the impact of banking problems on public finances would be a certain increase in the debt-to-GDP ratio.

Another distinctive advantage of the modelling framework provided by SYMBOL is the possibility to distinguish between estimated bank losses and recapitalisation needs, as explained in Sections 2.1 and 2.3. This allows us to distinguish *in a finer way* between the impact of a banking crisis on the government balance and on gross public debt alone (through the stock-flow adjustment), based on some assumptions on the way public funding would intervene to support the banking sector (see Section 2.3). This distinction is particularly important in light of the fact that financial assets bought by the government to support the banking sector are sold at a later stage, so that part of the increase in the debt-to-GDP ratio (the part related to the coverage of bank recapitalisation needs) is reabsorbed (partly or fully) at a later stage. This feature of the model is exploited in the design of the stress-test scenario presented below.

Finally, as explained in Sections 2.1 and 2.3, SYMBOL allows considering in a rather straightforward way the intervention of banking safety net tools (bail-in, RF) and also the introduction of Basel III capital definitions and requirements, as introduced by the banking union legislation, therefore accounting for their sheltering effect on public finances. As already discussed, these tools are assumed not to be in place yet for the stress-test results presented in this section, simply because the banking shock is currently assumed to take place in 2015 (the first projection year at the time of writing the paper), and the aforementioned tools are not yet available for this year in general. On the other hand, as this additional stress test for banking contingent liability risks is supposed to become an integral

[37] For more details, see Berti, Salto and Lequien (2012).

[38] See European Commission (2014a) for a detailed description of the European Commission – DG ECFIN's DSA framework.

part of the Commission's DSA, it is important that in future perspective the model allows accounting for changes in the institutional setting.

The stress test on public debt projections based on SYMBOL is conducted as follows.

1. We assume that a severe banking crisis unfolds in the first projection year (currently 2015).
2. The estimated country-specific bank losses in excess of bank capital are assumed to lead to a reduction in the forecasted (by the Commission services)[39] government balance in the year of the banking shock (due to subsidies to the banking sector).
3. The estimated country-specific bank recapitalisation needs are assumed to lead to an increase in the forecasted (by the Commission services) gross public debt through the stock-flow adjustment in the year of the banking shock (due to the acquisition of banks' financial assets).
4. The public funding used for banks' recapitalisations is assumed to be recovered in full[40] (through the sale by the government of the acquired financial assets), gradually within a time span of 5 years following the year of the banking shock,[41] thus leading to a reduction in the gross public debt (through a decrease in the projected stock-flow adjustment) over those years.
5. Changes in GDP growth, inflation, and interest rates, relative to baseline values, can be brought about by the banking shock, according to estimates relying on country-specific expertise. This is nonetheless not done for the debt projection results presented in this paper, which can therefore be interpreted as being more on the optimistic side.
6. The government balance and stock-flow adjustment, adjusted for the impact of the banking shock as indicated above (and in case the adjusted growth rate, inflation rate and interest rates), are inserted in the standard debt evolution equation used in the public debt projection model (as explained in more details below) and the ensuing path of the debt-to-GDP ratio over a 10-year projection horizon is derived.
7. The path of the debt ratio obtained for this stress-test scenario is plotted alongside the path obtained under the baseline scenario to highlight the potential impact of a banking contingent liability shock.

Public debt projections under this stress-test scenario are derived using a standard debt projection model, centered on the debt evolution equation:

$$d_t = \alpha^n d_{t-1} \frac{1+i_t}{1+g_t} + \alpha^f d_{t-1} \frac{1+i_t}{1+g_t} \frac{e_t}{e_{t-1}} - b_t + c_t + f_t \qquad (2)$$

where d_t is the debt-to-GDP ratio in year t, α^n is the share of public debt denominated in national currency, α^f is the share of public debt denominated in foreign currency, i_t is the nominal implicit interest rate on government debt in year t, g_t is the nominal GDP growth rate in year t, e_t is the nominal exchange rate in year t, b_t is the government primary balance over GDP in year t, c_t is the change in age-related costs over GDP in year t relative to the base year, and f_t is the stock-flow adjustment over GDP in year t. The model further incorporates a module for the calculation of the implicit interest rate on government debt accounting for the distinction between short- and long-term debt (and interest rates), and maturing versus non-maturing debt.

Debt projections are based on the European Commission's forecasts up to the 2-year forecast horizon. Beyond that, we use GDP growth projections agreed with the Economic Policy Committee - Output

39 Results presented in this paper are based on Autumn 2014 Commission forecasts.

40 This assumed full recovery of bank recapitalisations may appear at odds with the Laeven and Valencia (2013) findings of generally low recovery rates of banking support in financial crises. The full recovery follows from the fact that SYMBOL simulations split banking recapitalisation needs into two parts: (i) a part that is not recoverable as it covers true capital shortfalls to the extent that the value of assets is below the value of liabilities, and (ii) a part that reflects a capital injection to increase the banks' capital to a (regulatory) minimum level to cover operations. The full recovery assumption applies to this latter part of the bank recapitalisation. Further, as it is a one-period model, all losses are materialised instantaneously; hence there are no hidden losses on the banks' balance sheet. The gradual uncovering of losses during a financial crisis with subsequent capital shortfalls are a further driver of the low recovery rates of bank recapitalizations as reflected in the Laeven and Valencia (2013) findings.

41 The 5-year timeframe for recovery of true capital injections follows from the old EU state aid rules that required governments to exit from the bank's capital within 5 years. This is maintained here despite the fact that the latest Commission Communication on the application of state aid rules to support measures in favour of banks in the context of the financial crisis (2013/C 216/01, published in the Official Journal of the European Union of 30/07/2013), has changed this by requiring an exit from bank's capital "as soon as possible", which will translate into an assessment on a case-by-case basis.

Gap Working Group. For inflation (GDP deflator) and the real long-term interest rate, we use the long-run convergence assumptions agreed with the Economic Policy Committee.[42] Baseline projections presented here are based on a "no-fiscal policy change" assumption, i.e. the government structural primary balance is assumed to remain constant at the level corresponding to the last forecast year, till the end of projections. The cyclical component of the government balance is calculated using standard (country-specific) semi-elasticities over the period until the output gap closes. Finally, the projected change in age-related spending is taken from the Ageing Report 2012[43] (updated to account for more recent peer-reviewed pension reforms).[44]

3.2. DEBT PROJECTION RESULTS UNDER THE STRESS-TEST SCENARIO

Debt projection results under the contingent liability risk scenario are presented in Graph 3, under the two assumptions of bank recapitalisations up to 4.5% and 8% of RWA respectively, alongside the projected debt path in the baseline scenario. Results are plotted for all countries for which SYMBOL estimates are reported in Table 3.

As already seen in Table 3 and reinforced by the plots, the impact of the banking shock on debt ratio dynamics differs across EU countries. For Hungary, for example, the impact of the banking shock would be so small that the debt ratio path under the stress-test scenario would barely distance itself from the path under the baseline scenario. The impact is minor in countries like Romania and Lithuania, where the increase in public debt brought about by the banking shock is below 0.6 percentage points (comfortably below for Romania) even under the assumption of higher bank recapitalisations, while a significant impact is shown for countries like Portugal, Spain and the Netherlands (a simulated increase in gross public debt over GDP at around or above 4 percentage points for all three countries in the year of the banking shock, with a peak of around 6 percentage points for Portugal). For all countries, after the initial simulated increase in the debt ratio (in the year of the banking shock, i.e. 2015), the distance between the debt ratio under the stress test scenario and that in the baseline decreases along the projection horizon, as governments gradually sell the financial assets acquired in the banking sector within 5 years from their acquisition. After 5 years, it is only excess losses that remain there. The difference between the two bank recapitalisation scenarios can be sizeable, as shown by the plots.

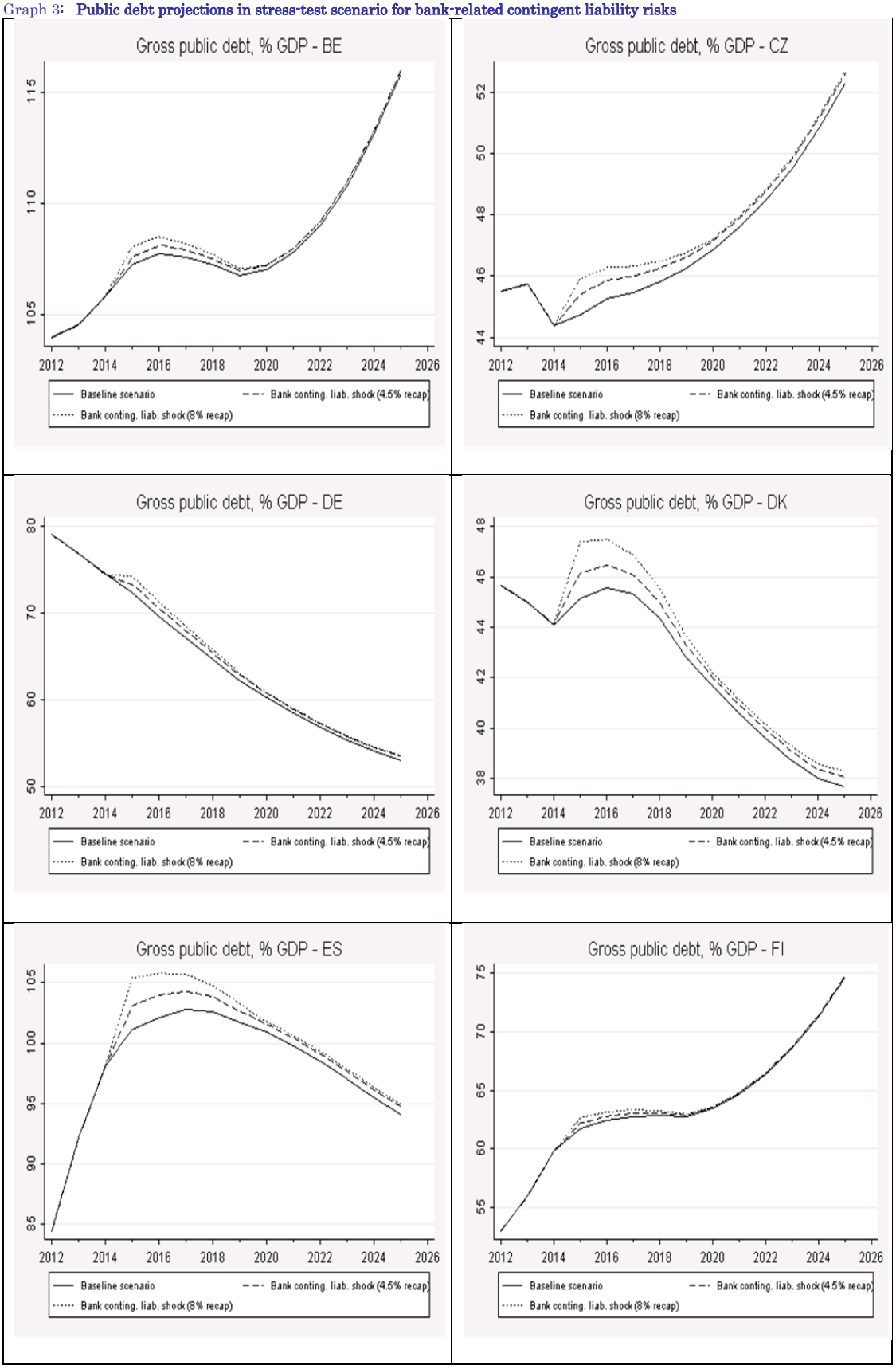
---

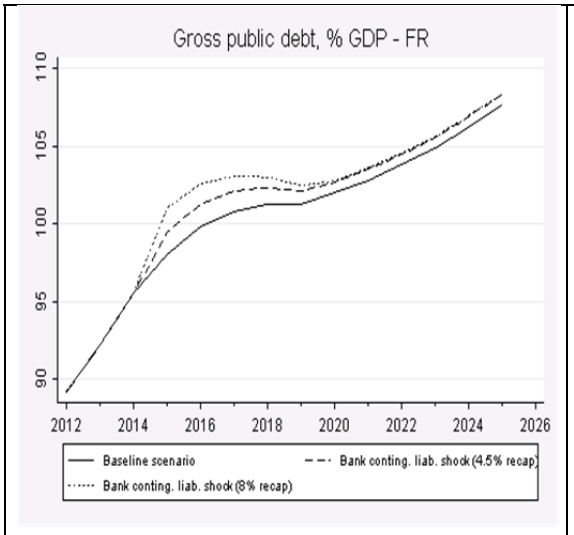
42 In particular, the inflation rate converges linearly to 2% by the output gap closure year, at T+5, and remains constant at that value thereafter. The real long-term interest rate converges linearly to 3% by the end of the 10-year projection horizon.

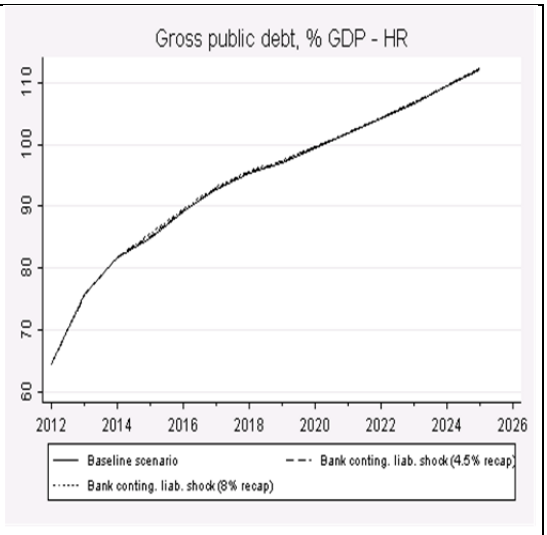
43 See European Commission (2012b).

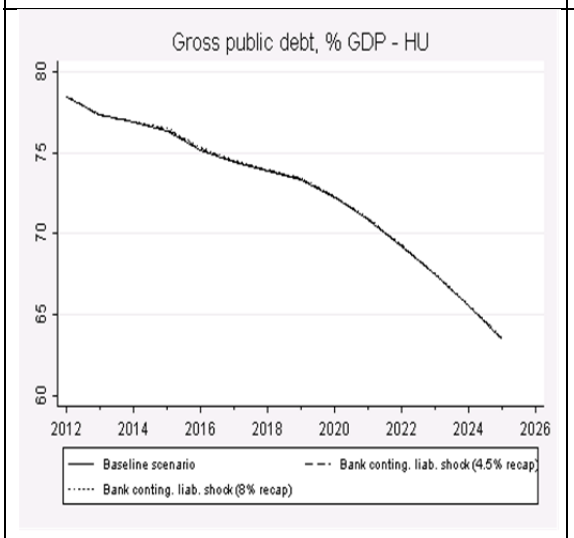
44 These are pension reforms that have already been introduced and i) have undergone the process of peer review in the Economic Policy Committee Working Group on Ageing Populations and Sustainability (where the country having introduced the pension reform presents and discusses its budgetary impact with the other national delegates, one of which acting as a reviewing country, and representatives of the European Commission) and ii) have then obtained favourable opinion from the Economic Policy Committee on the fact that the quantitative estimate of the impact of the pension reform is plausible.

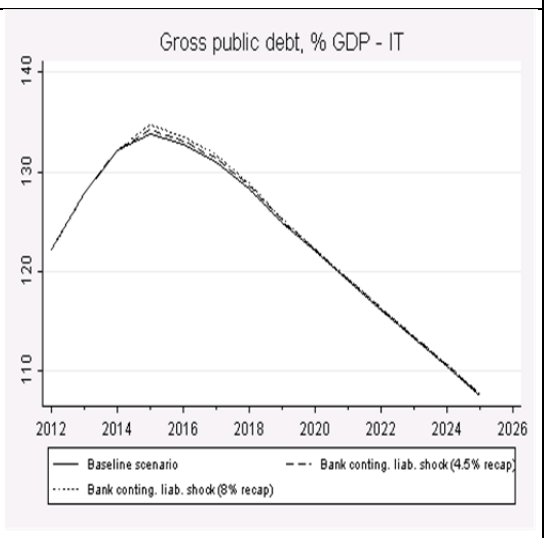
Graph 3: **Public debt projections in stress-test scenario for bank-related contingent liability risks**

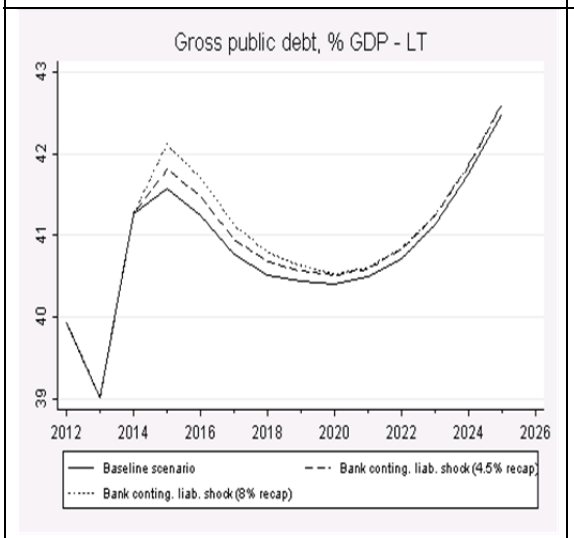


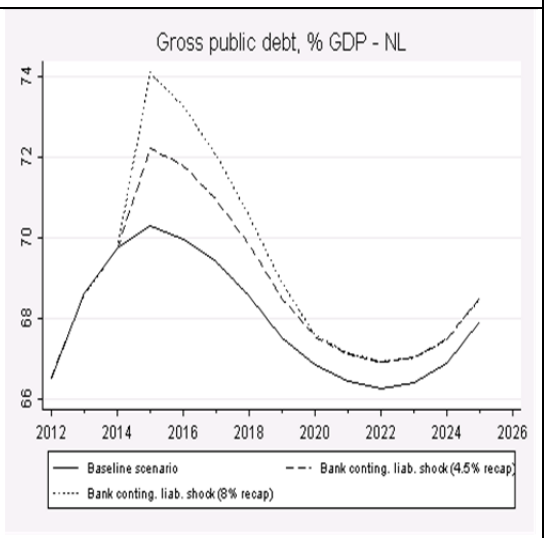

Gross public debt, % GDP - FR
110
105
100
95
90
2012
2014
2016
2018
2020
2022
2024
2026
Baseline scenario
Bank conting. liab. shock (4.5% recap)
Bank conting. liab. shock (8% recap)

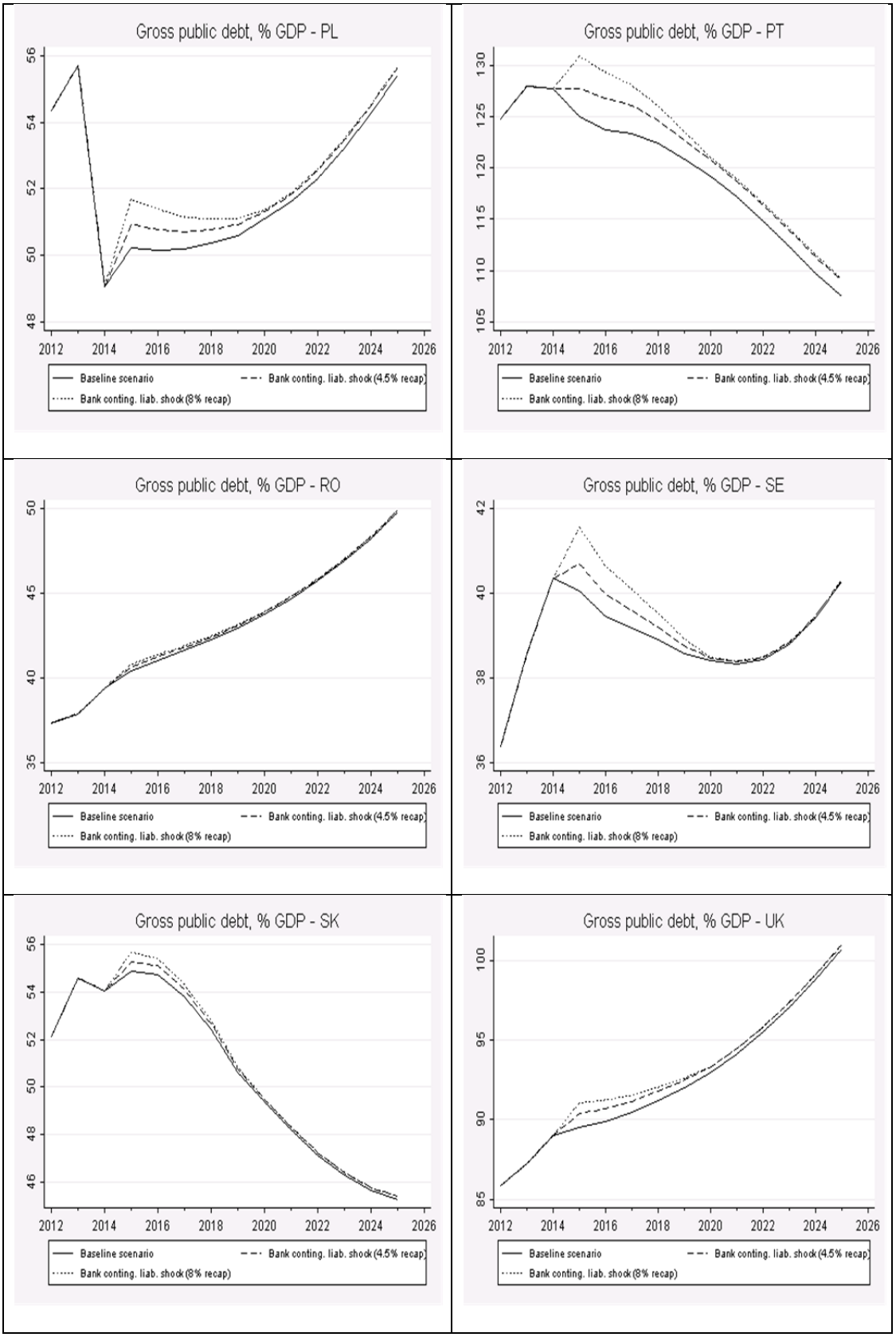

Gross public debt, % GDP - HR
110
100
90
80
70
60
2012
2014
2016
2018
2020
2022
2024
2026
Baseline scenario
Bank conting. liab. shock (4.5% recap)
Bank conting. liab. shock (8% recap)


Gross public debt, % GDP - HU
80
75
70
65
60
2012
2014
2016
2018
2020
2022
2024
2026
Baseline scenario
Bank conting. liab. shock (4.5% recap)
Bank conting. liab. shock (8% recap)


Gross public debt, % GDP - IT
140
130
120
110
2012
2014
2016
2018
2020
2022
2024
2026
Baseline scenario
Bank conting. liab. shock (4.5% recap)
Bank conting. liab. shock (8% recap)

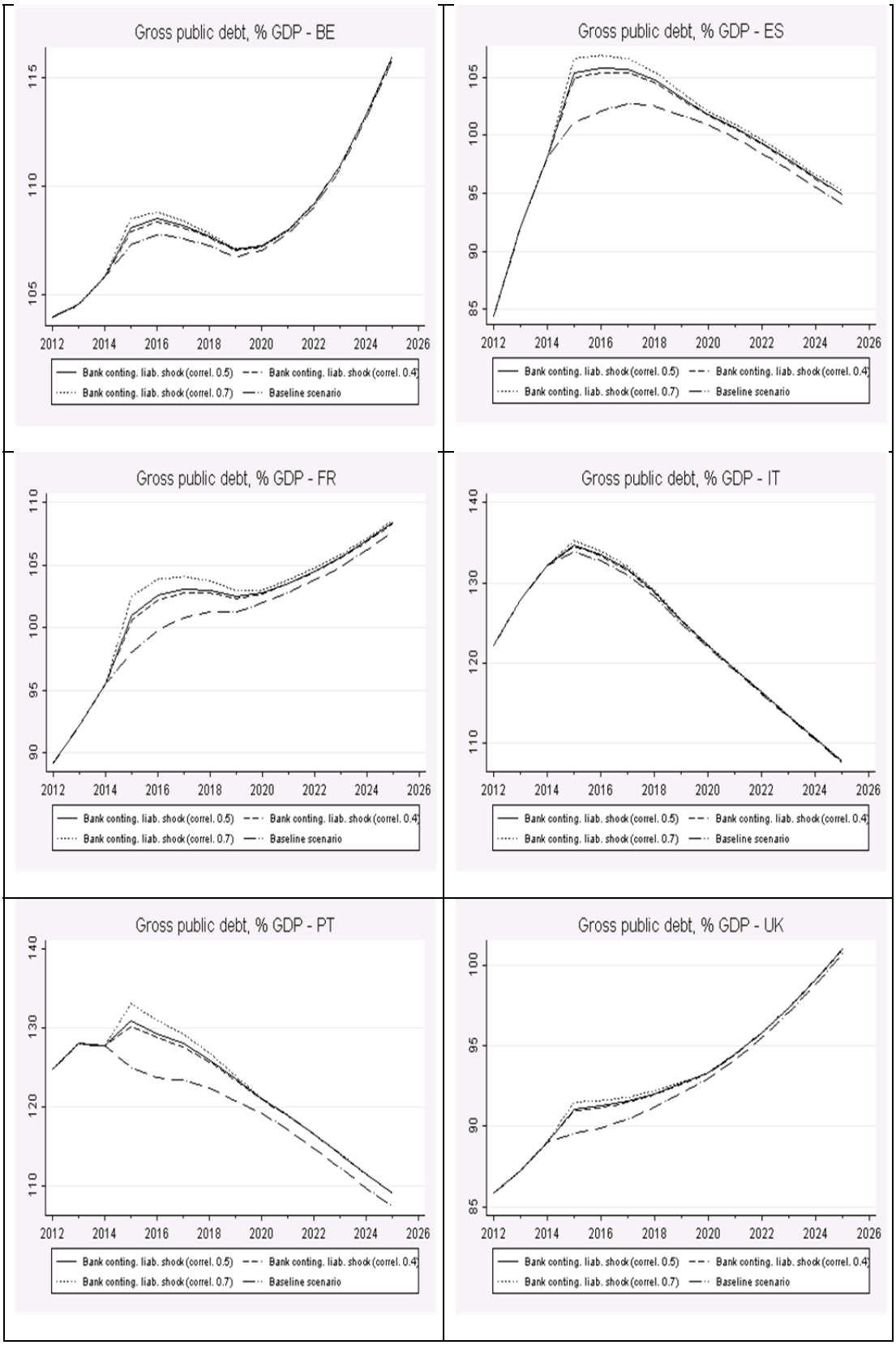

Gross public debt, % GDP - LT
43
42
41
40
39
2012
2014
2016
2018
2020
2022
2024
2026
Baseline scenario
Bank conting. liab. shock (4.5% recap)
Bank conting. liab. shock (8% recap)


Gross public debt, % GDP - NL
74
72
70
68
66
2012
2014
2016
2018
2020
2022
2024
2026
Baseline scenario
Bank conting. liab. shock (4.5% recap)
Bank conting. liab. shock (8% recap)



Source: Commission services (DG ECFIN's calculations and JRC estimates).

Graph 4: **Stress-test scenario for bank-related contingent liability risks under the assumption of bank recapitalisations up to 8% of RWA: sensitivity analysis on the correlation coefficient ρ for a selected group of high-debt countries**



Source: Commission services (DG ECFIN's calculations and JRC estimates).

For a selection of countries (high-public debt countries, defined as those with debt above 90% of GDP in 2014), Graph 4 reports a sensitivity analysis on coefficient ρ measuring the correlation among banks.[45] In the standard case, the shock correlation coefficient is set at 0.5 (this is the case for the results presented in Graph 3). Graph 4 also displays debt projection results for lower and higher degrees of correlation between banks, around the scenario with assumed higher bank recapitalisations. A greater ρ means a higher correlation among shocks that hit individual banks, in the sense that banking shocks become more common across banks within a given country (see Annex 1). In this sense simulations with a greater ρ can be thought of as illustrating the impact of a "more systemic" crisis.[46]

Greater correlation among banks generally leads to a stronger impact of the simulated banking crisis on the country's public debt, as bank excess losses and recapitalisation needs increase. This is shown by the plots in Graph 4. For countries like Portugal, Spain and France, a greater correlation among banks (as from an increase in ρ from 0.5 to 0.7) has a rather significant effect (a higher simulated increase in the debt ratio by almost 2 percentage points following the banking shock). Values of excess losses and recapitalisation needs for different values of the correlation coefficient ρ are also reported in Table A5.1, Annex 5.

4. CONCLUSIONS

The assessment of governments' contingent liability risks is a particularly important element of any public debt sustainability analysis that aims at being sufficiently comprehensive. The latest economic and financial crisis has further reinforced the case for integrating DSAs under this specific dimension, with particular attention to risks to public finances originating from the banking sector.

The European Commission – Directorate General for Economic and Financial Affairs has responded to this call by complementing its DSA framework with a brand new contingent liability risk module (European Commission, 2014a). Alongside the presentation of Eurostat data on contingent liabilities and a heat map indirectly capturing bank-related risks, the new module is expected to contain a stress-test scenario for contingent liability risks for countries having been identified as "vulnerable" under this specific dimension. The aim of this paper is indeed to describe this stress-test scenario, which uses results from the SYMBOL model (Systemic Model of Banking Originated Losses) developed at the European Commission Joint Research Center.

SYMBOL is a Monte Carlo micro-simulation model that allows obtaining estimates of bank losses and recapitalisation needs following a simulated banking crisis. The model has a number of important features that make it particularly well suit for using in the design of a debt projection scenario for banking risks. First, it allows distinguishing between simulated bank losses and bank recapitalisation needs. The distinction is particularly relevant when it comes to assessing the potential impact of "banking troubles" on public finances, since bank losses impact on public finances directly through the government balance (subsidies to the banking sector), while bank recapitalisation needs have an impact on gross public debt only, through the stock-flow adjustment (acquisition of banks' financial assets). The distinction is even more relevant when considering that public funding used for bank recapitalisations can eventually be recouped later, by selling the assets acquired. The second interesting feature of the model is that, through its input dataset based on individual banks' balance-sheet data, SYMBOL allows accounting for bank-level details and also differences in national banking systems that affect the potential hit on public finances. Finally, the model allows taking into account the introduction of banking safety net tools, like bail-in and the resolution fund, in the assessment of the impact of a banking crisis on public accounts. This is particularly useful in future perspective,

[45] Note that this is the correlation between banks of the same country. Since SYMBOL simulations are obtained on a country by country basis, there is no cross-country contagion. Recent improvements in the SYMBOL computational framework now allow running an EU-wide simulation, distinguishing between within- and between-country correlation coefficients (see Benczur et al, 2015 for an application). This would enable a more interesting treatment of contagion.

[46] Work is ongoing to enrich SYMBOL with the possibility to simulate interbank contagion explicitly in a more sophisticated way using interbank network data.

when the aforementioned safety net tools will be set in place along the process of implementation of the banking union legislation.

The estimated impact of simulated bank losses and recapitalisation needs on government balance and gross public debt respectively is then used in a traditional public debt projection model, to obtain the path of the debt-to-GDP ratio in the context of a banking crisis comparable in magnitude to the last one. Public debt projection results for the stress test scenario are presented in the paper for a number of EU countries. Substantial differences in the estimated hit on public finances are reported across Member States. The impact of the banking shock would be the strongest in Portugal, Spain and the Netherlands (4 to 6 percentage point simulated increase in the debt ratio in the year of the shock, under the assumption of bank recapitalisations up to 8% of risk-weighted assets). The impact would, on the contrary, be minor in countries like Hungary, Romania and Lithuania (a simulated increase in the debt ratio below, or comfortably below, 0.6 percentage points). It should nonetheless be stressed that all these simulation results are based on end-2013 banks' balance-sheet data (the latest available from Bankscope at the time of writing the paper), as well as on the assumption that no banking safety net tools (like bail-in or the resolution fund) are available yet to cushion the impact on public finances (this is because the first projection year, when the banking shock is assumed to take place, is 2015). The estimated impact on public finances is expected to decrease significantly once those safety net tools will be set in place, as shown in an annex to the paper.

Finally, for some high-public debt countries, we reported additional simulations mirroring the impact of a "more systemic" banking crisis. This is done in the model by increasing the size of the coefficient measuring the correlation among shocks that hit individual banks in a given country. A greater correlation between banks is found to have a sizable effect, in terms of a simulated extra increase in the debt ratio following the bank shock, in countries like Portugal, Spain and France.

ANNEX 1 – A MORE TECHNICAL EXPLANATION OF SYMBOL MECHANICS

A1.1. THE BASEL FORMULA

We assume there is a bank with K borrowers, each with a debt of $1/K$ (later, we will consider $K \to \infty$). Each borrower's asset value X_k is subject to a N(0,1) shock, having a common and an idiosyncratic component:

$$X_k = \sqrt{R}\beta + \sqrt{1-R}Z_k$$

where β and Z_k are respectively the common and the idiosyncratic shock components, all being i.i.d. N(0,1); and R is the coefficient of correlation among borrowers (obligors).

Borrower k defaults (fully) if its asset value goes below some common critical level $\bar{X}$. We can denote the default event of borrower k by $D_k = 1_{\{X_k \leq \bar{X}|\beta\}}$ and the total realized loss of the bank as $RL = \sum_{k=1}^{K} D_k$. We are interested in $\lim_{K\to\infty} P(RL \leq K_v)$, which is the cumulative distribution function of the realized loss distribution. One can show (citing Vasicek, 2002 or the central limit theorem in general) that:

$$P(RL \leq K_v) \xrightarrow{K\to\infty} N\left(\frac{1}{\sqrt{R}}\left(\sqrt{1-R}N^{-1}(K_v) - N^{-1}(PD)\right)\right) \quad \text{(A1)}$$

where the probability of default $PD = N(\bar{X})$.

Now, by the law of large numbers (i.e. the fact that $K \to \infty$) the bank can safely count on expected losses of PD. Realized losses can, however, be larger or smaller. Let us define the capital requirement C as the smallest necessary amount such that the probability of unexpected losses not exceeding that amount is at least α:

$$P(RL \leq PD + C) = \alpha$$

Using (A1), this can be transformed into:

$$C = N\left(\frac{\sqrt{R}N^{-1}(\alpha) + N^{-1}(PD)}{\sqrt{1-R}}\right) - PD \quad \text{(A2)}$$

Equation (A3) used in the next section is indeed nothing else but an enrichment of this formula obtained by allowing a less than full loss given default and some corrections.

All in all, we can say that, based on the above, under the theoretical assumption of N(0,1) shocks of a bank's obligors, a capital requirement C makes sure that loss provisions (expected losses, loss given default, *LGD,* multiplied by the probability of default, *PD*) and the minimum regulatory capital stock are depleted only with probability 1-α. Under Basel, α = 0.999, leading to highly infrequent bank insolvencies, though frequencies of true bank failures are likely to differ from the theoretical probability.

A1.2. THE IMPLIED OBLIGORS' PROBABILITY OF DEFAULT (IOPD)

In this section we discuss the determination of capital requirements and the single implied obligors' probability of default (IOPD) of a bank. As shown through the equations that follow, the capital requirement for each asset class is defined separately, and the requirements over different asset classes are then added to arrive at an aggregate bank-level capital requirement rate $\hat{C}$. Then we define the "representative" probability of default $\widehat{PD}$ such that the implied capital requirement rate on this representative portfolio is precisely $\hat{C}$. In this sense, we can say that $\widehat{PD}$ is a summary measure (almost a sufficient statistic) of the overall riskiness of a bank's loan portfolio.

So, we start from the Basel percentage capital requirement for a bank i and asset class l, $C_{i,l}$:

$$C_{i,l} = LGD_{i,l} \cdot \left(N\left(\sqrt{\frac{1}{1-R_{i,l}}} N^{-1}(PD_{i,l}) + \sqrt{\frac{R_{i,l}}{1-R_{i,l}}} N^{-1}(\alpha) \right) - PD_{i,l} \right) \cdot MATA_{i,l} \quad \text{(A3)}$$

where $PD_{i,,l}$ is the default probability of asset class l for bank i, $R_{i,l}$ is the correlation among the exposures in the asset class, $LGD_{i,l}$ is the Loss Given Default and $MATA_{i,l}$ is an adjustment term.

We then add capital requirements across all asset classes of bank i (with sizes $A_{i,l}$) to obtain the minimum capital requirement of the bank, MCR_i:

$$MCR_i = \sum_l C_{i,l} A_{i,l}$$

Now we can express the average percentage capital requirement for bank i as follows:

$$\hat{C}_i = \frac{MCR_i}{\sum_l A_{i,l}}$$

By using the regulatory baseline values for $\widehat{LGD}$, $\hat{R}_i$, and the adjustment term $\widehat{MATA}_i$ (and/or values for some of the variables underlying these terms like asset maturity $\hat{M}_i$ and obligor size $\hat{S}_i$), we can determine an implied obligors' probability of default $\widehat{PD}_i$ for bank i such as to satisfy the following condition:

$$\hat{C}_i = \widehat{LGD} \cdot \left(N\left(\sqrt{\frac{1}{1-\hat{R}_i}} N^{-1}(\widehat{PD}_i) + \sqrt{\frac{\hat{R}_i}{1-\hat{R}_i}} N^{-1}(\alpha) \right) - \widehat{PD}_i \right) \cdot \widehat{MATA}_i \quad \text{(A4)}$$

Note that, according to the Basel formula, LGD is equal to 45%, and $\widehat{MATA}_i$ also depends on $\widehat{PD}_i$ as:

$$\widehat{MATA}_i = \frac{(1 + (M - 2.5)b_i) \cdot 1.06}{1 - 1.5b_i}$$

with $b_i = \left(0.11852 - 0.05478 \ln(\widehat{PD}_i)\right)^2$ and maturity $M = 2.5$;[47] while the formula for the correlation among obligors is:

$$\hat{R}_i = 0.12 \frac{1-e^{-50\widehat{PD}_i}}{1-e^{-50}} + 0.24\left(1 - \frac{1-e^{-50\widehat{PD}_i}}{1-e^{-50}}\right) - 0.04\left(1 - \frac{\hat{S}_i - 5}{45}\right)$$

with obligor size $\hat{S}_i = 50$.

The approach is implemented by taking $\hat{C}_i$ from Bankscope, as the ratio of capital requirement and total assets (the former being multiplied by a size-dependent average QIS adjustment to account for the introduction of Capital Requirement Directive IV, as explained in section 2.2 in the main text).

A1.3. THE MONTE CARLO SIMULATION

The Monte Carlo simulation on which SYMBOL is based can be thought of as follows. Consider two banks, A and B. Each of them has a unit mass of debtors (indexed by k) with asset values evolving according to the following equations respectively:

$$X_{A,k} = \sqrt{R_A}\left(\sqrt{\rho}\beta + \sqrt{1-\rho}\beta_A\right) + \sqrt{1-R_A} Z_{A,k}$$

$$X_{B,k} = \sqrt{R_B}\left(\sqrt{\rho}\beta + \sqrt{1-\rho}\beta_B\right) + \sqrt{1-R_B} Z_{B,k}$$

[47] In general, MATA is a correction for maturity. The term 1.06 represents an additional correction, motivated by the following argument: "Total risk-weighted assets are determined by multiplying the capital requirements for market risk and operational risk by 12.5 (i.e. the reciprocal of the minimum capital ratio of 8%) and adding the resulting figures to the sum of risk-weighted assets for credit risk. The Committee applies a scaling factor in order to broadly maintain the aggregate level of minimum capital requirements, while also providing incentives to adopt the more advanced risk-sensitive approaches of the Framework. The scaling factor is applied to the risk-weighted asset amounts for credit risk assessed under the IRB approach" and "The current best estimate of the scaling factor is 1.06". See footnote 11 of paragraph 44 in Bank for International Settlements (2011).

For each bank $i = A, B$ there is an idiosyncratic shock $Z_{i,k}$ to all its individual debtors, and a common shock β_i across all debtors of bank i. The common shocks differ between the two banks but a common component β is present as well. Parameter R_i measures the degree of commonality among debtors of bank i (bank-specific component), while ρ measures the strength of co-movement between the two banks.

In the simulations, we draw random numbers for β, β_A, β_B as i.i.d. N(0,1), which allows us to calculate the conditional loss for bank i as follows:

$$P_i(\beta, \beta_A, \beta_B) = N\left(\frac{N^{-1}(PD_i) - \left(\sqrt{\rho}\beta + \sqrt{1-\rho}\beta_i\right)\sqrt{R_i}}{\sqrt{1-R_i}}\right) \tag{A5}$$

Having obtained the losses for both banks A and B, the drawing of random numbers for β, β_A, β_B is then repeated until deemed necessary to derive the joint distribution of losses of banks A and B.

It can be shown easily that this procedure is equivalent to drawing $N^{-1}(\alpha_i)$ correlated random numbers (with mean zero, standard deviation of 1 and correlation of ρ), and then calculating:

$$P_i(\beta, \beta_A, \beta_B) = N\left(\frac{N^{-1}(PD_i) + N^{-1}(\alpha_i)\sqrt{R_i}}{\sqrt{1-R_i}}\right). \tag{A6}$$

ANNEX 2 – DESCRIPTION OF THE SYMBOL INPUT DATABASE BY MEMBER STATE

Table A2.1: **Sample used in SYMBOL simulations: selected variables (year 2013)**

	SYMBOL sample							ECB total assets (bn €)**	Share of covered deposits ***	RWA/ TA	TA/ K	K/ RWA
	Banks	G1* banks	Total assets (bn €)	RWA (bn €)	Customer deposits (bn €)	Capital (bn €)	Sample ratio					
BE	24	2	506	169	302	25	61%	829	43%	33%	20	15%
CZ	13	0	142	72	92	9	82%	173	52%	51%	15	13%
DE	1,176	7	4,562	1,728	2,194	229	63%	7,299	48%	38%	20	13%
DK	67	3	673	268	199	43	68%	995	50%	40%	16	16%
ES	41	4	1,651	884	781	109	55%	3,014	44%	54%	15	12%
FI	10	1	348	78	81	10	70%	497	55%	23%	34	13%
FR	165	14	6,500	2,370	2,064	268	84%	7,753	55%	36%	24	11%
HR	26	0	52	34	33	6	89%	58	57%	67%	9	17%
HU	11	1	35	18	19	3	32%	108	47%	53%	12	16%
IT	429	8	2,314	976	856	177	61%	3,797	58%	42%	13	18%
LT	8	0	19	13	13	2	99%	20	74%	65%	11	13%
NL	21	3	1,613	769	632	98	75%	2,163	50%	48%	16	13%
PL	23	3	242	178	176	21	69%	354	61%	73%	11	12%
PT	15	3	306	197	157	20	64%	482	50%	64%	16	10%
RO	13	0	49	27	33	4	58%	84	46%	55%	11	16%
SE	61	3	593	185	251	28	53%	1,114	45%	31%	21	15%
SK	10	0	48	29	37	4	85%	57	54%	59%	13	13%
UK	61	10	6,437	2,016	2,445	270	105%	6,116	42%	31%	24	13%
AT	117	0	269	116	135	16	30%	902	50%	43%	17	14%
BG	13	0	26	19	20	3	58%	45	64%	75%	10	14%
CY	4	0	11	4	9	1	13%	84	51%	39%	19	14%
EE	2	0	8	8	6	1	58%	14	48%	93%	6	18%
GR	7	4	315	182	168	21	79%	397	59%	58%	15	11%
IE	4	3	265	188	137	21	29%	919	36%	71%	13	11%
LU	32	2	433	156	155	28	54%	803	13%	36%	16	18%
LV	13	0	18	11	13	1	69%	27	36%	61%	12	13%
MT	6	0	8	4	7	1	15%	50	24%	59%	15	11%
SI	15	0	33	23	21	3	74%	45	69%	70%	12	12%
Tot	2,387	71	27,479	10,725	11,035	1,420		38,197				

Source: Bankscope, ECB and Commission services (DG JRC estimations).
Notes:
For the last ten countries in the table, we only report descriptive statistics, but no SYMBOL results.
* G1 banks are those with Tier 1 capital larger than 3 bn euros.
** ECB total assets are defined as total MFI assets minus total assets of branches of credit institutions.
*** The share of covered deposits is an estimate based on data collected from EU deposit guarantee schemes and ECB data, applying the methodology of Cannas et al. (2014).

ANNEX 3 – SYMBOL SIMULATIONS UNDER MORE ADVANCED STAGES OF IMPLEMENTATION OF THE BANKING UNION LEGISLATION

Tables A3.1 and A3.2 report SYMBOL simulation results for scenarios in which the banking safety net tools (bail-in, resolution fund) are already in place at the time of the banking shock. In particular, Table A3.1 presents results for a scenario assuming that bail-in already applies with a loss absorbing capacity (the sum of capital and bail-inable liabilities) of 8% of banks' total assets.[48] The logic for this assumption is based on Article 38 of the Bank Recovery and Resolution Directive, which states the Resolution Fund can contribute to resolution only after capital and bail-in cover losses and recapitalization needs up to at least 8% of total assets (though the Directive does not establish any harmonized level of bail-inable funding for banks). In reality, the actual amount of funding that would be obtained from bail-in is clearly subject to a certain degree of uncertainty. It will depend on the amount of liabilities eligible for bail-in that banks will decide to hold after the implementation of the Bank Recovery and Resolution Directive, and on the haircut that would be applied in case of activation of the bail-in tool. In all other respects (for instance, the way the impact of the introduction of the Capital Requirement Directive IV is accounted for), the scenario underlying results in Table A3.1 is designed the same way as for results in Table 3 in the main text.

Table A3.1: **Simulated bank losses in excess of bank capital and simulated bank recapitalisations up to 4.5% and 8% of risk-weighted assets (RWA) for selected EU countries (based on end-2013 bank balance-sheet data), assuming bail-in already in place**

Country	Simulated bank (excess) losses impacting on gov't balance, % GDP	Simulated bank recap. (up to 4.5% RWA) impacting only gross public debt, % GDP	Simulated bank recap. (up to 8% RWA) impacting only gross public debt, % GDP
BE	0.02%	0.03%	0.07%
CZ	0.08%	0.28%	0.71%
DE	0.06%	0.19%	0.61%
DK	0.11%	0.25%	0.63%
ES	0.17%	1.33%	3.12%
FI	0.02%	0.03%	0.07%
FR	0.07%	0.18%	0.76%
HR	0.07%	0.19%	0.54%
HU	0.02%	0.05%	0.14%
IT	0.07%	0.15%	0.45%
LT	0.06%	0.18%	0.50%
NL	0.06%	0.64%	2.02%
PL	0.23%	0.60%	1.43%
PT	0.64%	1.82%	4.26%
RO	0.02%	0.07%	0.19%
SE	0.02%	0.07%	0.23%
SK	0.11%	0.33%	0.73%
UK	0.03%	0.13%	0.47%

Source: Commission services (DG JRC estimations, based on Bankscope data).

[48] This scenario will be generally relevant as of simulated banking shocks from 2016 onwards.

Table A3.2 reports results for a scenario in which both bail-in and (national) resolution funds[49] are assumed to be already in place.[50] The scenario assumes a full use of the resolution fund.[51] The bail-in tool works exactly as defined in the previous scenario (a loss absorbing capacity of 8% of total assets). This scenario further assumes that the minimum capital requirements from the Capital Requirement Directive IV, including the capital conservation buffer,[52] are fully implemented. Practically, with this scenario we are assuming full implementation of EU legislation in the field has already occurred.

A comparison between results in Tables A3.1-A3.2 and those in Table 3 in the main text highlights how significant the reduction in the simulated hit on public finances is expected to be following the implementation of the banking union legislation.

Table A3.2: **Simulated bank losses in excess of bank capital and simulated bank recapitalisations up to 4.5% and 8% of risk-weighted assets (RWA) for selected EU countries (based on end-2013 bank balance-sheet data), assuming bail-in and resolution fund already in place**

Country	Simulated bank (excess) losses impacting on gov't balance, % GDP	Simulated bank recap. (up to 4.5% RWA) impacting only gross public debt, % GDP	Simulated bank recap. (up to 8% RWA) impacting only gross public debt, % GDP
BE	0.00%	0.00%	0.00%
CZ	0.01%	0.11%	0.40%
DE	0.00%	0.00%	0.13%
DK	0.01%	0.10%	0.32%
ES	0.04%	0.92%	2.65%
FI	0.00%	0.01%	0.04%
FR	0.00%	0.02%	0.16%
HR	0.07%	0.19%	0.54%
HU	0.00%	0.00%	0.00%
IT	0.00%	0.00%	0.05%
LT	0.01%	0.09%	0.37%
NL	0.00%	0.31%	1.54%
PL	0.04%	0.46%	1.25%
PT	0.27%	1.41%	3.77%
RO	0.00%	0.01%	0.04%
SE	0.00%	0.00%	0.00%
SK	0.01%	0.14%	0.52%
UK	0.00%	0.02%	0.18%

Source: Commission services (DG JRC estimations, based on Bankscope data).

[49] Given that this scenario is meant to capture the situation from 2023 onwards, it would be more appropriate to consider a single resolution fund. The existing methodology does not allow for that, since simulations are run country by country. Benczur et al (2015) does consider both national and a single resolution fund in a similar setting, but only at the EU level. Results are very similar. Though the approach of that paper could be applied to the DSA as well, it is not clear how the losses not covered by the Single Resolution Fund would be allocated among Member States.

[50] This scenario will be relevant as of banking shocks from 2023 onwards, given that the target level of 1% of covered deposits indicated in the regulation for the resolution fund is to be collected over a time period of 8 years starting from 2015.

[51] Article 38 of the Bank Recovery and Resolution Directive states that the Resolution Fund can contribute to the resolution by absorbing losses up to 5% of total assets of the failing bank. After this, the order of intervention of the remaining safety tools is subject to the discretion of the resolution authority. For instance, the residual Resolution Fund could be called to cover losses above the 5% total liabilities (including own funds) after all unsecured non-preferred liabilities, other than eligible deposits, have been written down or converted in full. Based on this, a full use of the Resolution Fund is assumed.

[52] The capital conservation buffer is a new prudential tool introduced by Basel III and implemented by the CRD IV. It is a capital buffer of 2.5% of total exposures of a bank that needs to be met with an additional amount of the highest quality of capital (i.e. CET1 capital). It sits on top of the 4.5% CET1 capital requirement. The capital conservation buffer increases the total regulatory capital of a bank up to 10.5% of RWA.

ANNEX 4 – SYMBOL SIMULATION RESULTS UNDER DIFFERENT "WAVES" OF BANKSCOPE DATA

Tables A4.1 reports a comparison of SYMBOL simulation results for the scenario presented in the main text (no bail-in; no resolution fund) based on end-2013 and end-2012 Bankscope data. A notable feature is that, for all EU countries analysed in the paper, simulated losses and recapitalization needs based on latest bank balance-sheet data are lower (or substantially lower) when using 2013 instead of 2012 data.

Table A4.1: **Simulated bank losses in excess of bank capital and simulated bank recapitalisations up to 4.5% and 8% of risk-weighted assets (RWA), baseline scenario (no bail-in, no RF): comparison end-2013 and end-2012 Bankscope data**

Country	End-2013 Bankscope data (A)			End-2012 Bankscope data (B)			Difference (A-B)		
	Simulated bank (excess) losses impacting on gov't balance, % GDP	Simulated bank recap. (up to 4.5% RWA) impacting only gross public debt, % GDP	Simulated bank recap. (up to 8% RWA) impacting only gross public debt, % GDP	Simulated bank (excess) losses impacting on gov't balance, % GDP	Simulated bank recap. (up to 4.5% RWA) impacting only gross public debt, % GDP	Simulated bank recap. (up to 8% RWA) impacting only gross public debt, % GDP	Simulated bank (excess) losses impacting on gov't balance, % GDP	Simulated bank recap. (up to 4.5% RWA) impacting only gross public debt, % GDP	Simulated bank recap. (up to 8% RWA) impacting only gross public debt, % GDP
BE	0,20	0,23	0,76	0,60	1,70	3,26	-0,40	-1,47	-2,50
CZ	0,26	0,51	1,07	0,37	0,58	1,28	-0,11	-0,08	-0,21
DE	0,53	0,71	1,73	0,63	0,71	1,80	-0,10	0,00	-0,07
DK	0,25	0,88	2,22	0,77	1,35	2,81	-0,52	-0,48	-0,59
ES	0,54	1,83	4,28	1,97	3,22	7,45	-1,43	-1,39	-3,18
FI	0,09	0,42	0,92	0,65	2,03	3,88	-0,56	-1,61	-2,96
FR	0,68	1,11	2,78	1,22	1,37	3,34	-0,54	-0,26	-0,56
HR	0,09	0,21	0,59	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
HU	0,05	0,07	0,18	0,59	0,58	1,28	-0,55	-0,51	-1,10
IT	0,18	0,31	0,89	0,34	0,44	1,20	-0,17	-0,13	-0,31
LT	0,11	0,18	0,52	0,25	0,61	1,27	-0,15	-0,43	-0,75
NL	0,82	1,60	3,72	1,43	2,45	4,94	-0,61	-0,84	-1,22
PL	0,23	0,60	1,45	0,38	0,76	1,84	-0,14	-0,16	-0,39
PT	1,42	2,48	5,96	2,54	3,99	8,57	-1,12	-1,51	-2,60
RO	0,10	0,17	0,33	0,20	0,31	0,77	-0,10	-0,15	-0,43
SE	0,05	0,66	1,57	0,59	1,10	2,15	-0,53	-0,44	-0,58
SK	0,13	0,34	0,78	0,23	0,48	1,12	-0,10	-0,14	-0,34
UK	0,47	0,79	1,66	1,01	1,14	2,54	-0,54	-0,34	-0,88

Source: Commission services (DG JRC estimations, based on Bankscope data).

The change (evident for most countries) is due to the sizeable improvement in capitalization and leverage situations of European banks.[53] In particular, the data reflects the balance sheet repair process that has been going on in the banking sector, and the related deleveraging of non-core assets. The banking sectors of the countries that have been most strongly hit by the financial crisis are generally also those that experienced the most pronounced structural changes.

Indeed, an analysis of the determinants behind the changes highlighted in Table A4.1 reveals that changes in the QIS adjustment coefficients (see Section 2.2 for explanations) are the most important source of differences in simulation results based on 2012 and 2013 data.[54] In particular, using 2013 balance-sheet data with 2012 (as opposed to 2013) QIS adjustments yields results that are much closer to those based on 2012 data. Within the QIS adjustments, it is the improvement in bank capital that seems to matter the most. This most likely reflects the fact that banks have been getting ready for the ECB's stress tests by improving capital quality.

[53] European Central Bank (2014), the October 2014 Banking Structure Report documents a 10% decline in total assets from 2012 to 2013 (see page 8 and Chart 2), and substantial increases in bank capitalization and decreases in leverage (see Charts 32-35).

[54] Just to provide an example: if 1 unit of capital in 2012 was reassessed as being only 0.7, while it is assessed as 0.8 in 2013, even without a change in the balance sheet numbers, there is an approximately 14% increase in "effective capital".

ANNEX 5 – SYMBOL SIMULATION RESULTS UNDER DIFFERENT CORRELATION COEFFICIENTS

Tables A5.1 reports a comparison of SYMBOL simulation results for the scenario presented in the main text (no bail-in; no resolution fund) under two different values for the correlation coefficient ρ (0.4 and 0.7). In general, a higher correlation coefficient leads to larger losses. For recapitalization needs up to 8%, this is true without any exception. For some countries, the increase is quite sizable.

Table A5.1: **Simulated bank losses in excess of bank capital and simulated bank recapitalisations up to 4.5% and 8% of risk-weighted assets (RWA), baseline scenario (no bail-in, no RF), for different values of the correlation coefficient (ρ)**

	ρ = 0.4			ρ = 0.7		
	Simulated bank (excess) losses impacting on gov't balance, % GDP	**Simulated bank recap (up to 4.5% RWA) impacting only gross public debt, % GDP**	**Simulated bank recap (up to 8% RWA) impacting only gross public debt, % GDP**	**Simulated bank (excess) losses impacting on gov't balance, % GDP**	**Simulated bank recap (up to 4.5% RWA) impacting only gross public debt, % GDP**	**Simulated bank recap (up to 8% RWA) impacting only gross public debt, % GDP**
BE	0.19%	0.23%	0.57%	0.15%	0.42%	1.25%
CZ	0.23%	0.51%	1.00%	0.24%	0.55%	1.46%
DE	0.47%	0.65%	1.48%	0.57%	1.00%	2.51%
DK	0.27%	0.83%	1.88%	0.25%	1.14%	2.80%
ES	0.52%	1.75%	3.82%	0.75%	2.21%	5.49%
FI	0.10%	0.39%	0.83%	0.14%	0.34%	1.21%
FR	0.62%	1.06%	2.36%	0.83%	1.57%	4.26%
HR	0.09%	0.20%	0.48%	0.07%	0.27%	0.87%
HU	0.04%	0.05%	0.12%	0.04%	0.06%	0.40%
IT	0.15%	0.24%	0.69%	0.20%	0.51%	1.45%
LT	0.12%	0.15%	0.39%	0.09%	0.25%	0.77%
NL	0.91%	1.44%	3.22%	0.60%	2.08%	5.11%
PL	0.21%	0.59%	1.27%	0.22%	0.77%	2.08%
PT	1.46%	2.32%	5.16%	1.27%	3.36%	8.41%
RO	0.09%	0.17%	0.32%	0.10%	0.18%	0.41%
SE	0.03%	0.60%	1.46%	0.10%	0.70%	1.84%
SK	0.14%	0.30%	0.67%	0.13%	0.40%	1.05%
UK	0.43%	0.80%	1.55%	0.48%	0.89%	2.22%

Source: Commission services (DG JRC estimations, based on Bankscope data).

REFERENCES

Bank for International Settlements (2011), "Part 2: The First Pillar—Minimum Capital Requirements", http://www.bis.org/publ/bcbs128b.pdf

Basel Committee on Banking Supervision (2005), "An explanatory note on the Basel II IRB risk weight functions", http://www.bis.org/bcbs/irbriskweight.pdf

Basel Committee on Banking Supervision (2006), "International Convergence of Capital Measurement and Capital Standards", http://www.bis.org/publ/bcbs128.pdf

Basel Committee on Banking Supervision (2010), "A global regulatory framework for more resilient banks and banking systems", http://www.bis.org/publ/bcbs189_dec2010.pdf

Basel Committee on Banking Supervision (2011), "A global regulatory framework for more resilient banks and banking systems (revised version)", http://www.bis.org/publ/bcbs189.pdf

Benczur P., G. Cannas, J. Cariboni, E. Di Girolamo, S. Maccaferri, and M. Petracco Giudici (2015), "Evaluating the effectiveness of the new EU bank regulatory framework: a goodbye to too-big-to-fail?", JRC, mimeo.

Berti K. (2013), "Stochastic public debt projections using the historical variance-covariance matrix approach for EU countries", *European Economy Economic Paper* No. 480.

Berti K., M. Salto, and M. Lequien (2012), "An early-detection index of fiscal stress for EU countries", *European Economy Economic Paper* No. 475.

Cannas G., J. Cariboni, L. K. Veisari, and A. Pagano (2014), "Updated estimates of EU eligible and covered deposits", *JRC Technical Report.*

Cariboni J., E. Di Girolamo, S. Maccaferri, and M. Petracco Giudici (2015), "Assessing the potential reduction of DGS funds according to Article 10(6) of Directive 2014/49/EU: a simulation approach based on the Commission SYMBOL model", *JRC Scientific and Policy Reports*, forthcoming.

De Lisa R., S. Zedda, F. Vallascas, F. Campolongo, and M. Marchesi (2011), "Modeling deposit insurance scheme losses in a Basel II framework", *Journal of Financial Services Research* 40(3).

European Banking Authority (2013), "Basel III monitoring exercise Results based on data as of 31 December 2013", http://www.eba.europa.eu/documents/10180/534414/Basel+III+monitoring+report+%28results+as+of+December+2013%29.pdf/9b9a96b4-0c23-4ea5-bf8e-4651acfa2acd

European Central Bank (2014), "Banking Structure Report October 2014", http://www.ecb.europa.eu/pub/pdf/other/bankingstructuresreport201410.en.pdf

European Commission (2011), "2011 Report on Public Finances in EMU", *European Economy* 3/2011.

European Commission (2012a), "Fiscal Sustainability Report 2012", *European Economy* 8/2012.

European Commission (2012b), “The 2012 Ageing Report. Economic and budgetary projections for the 27 EU Member States (2010-2010)”, *European Economy* 2/2012.

European Commission (2014a), “Assessing Public Debt Sustainability in EU Member States: A Guide“, *European Economy Occasional Paper* No. 200.

European Commission (2014b), “State Aid Scoreboard 2014”, DG COMP, http://ec.europa.eu/competition/state_aid/scoreboard/amounts_used_2008-2013.xls

European Financial Stability Facility and European Stability Mechanism (2013), "ESM direct bank recapitalization instrument - Main features of the operational framework and way forward”, http://www.eurozone.europa.eu/media/436873/20130621-ESM-direct-recaps-main-features.pdf

European Parliament and Council (2011a), “Regulation No. 1176/2011 of 16 November 2011 on the prevention and correction of macroeconomic imbalances”, http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32011R1176&from=en

European Parliament and Council (2011b), “Regulation No 1174/2011 of 16 November 2011 on enforcement measures to correct excessive macroeconomic imbalances in the Euro Area”, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2011:306:0008:0011:EN:PDF

European Parliament and Council (2013), “Directive 2013/36/EU of the 26 June 2013 on access to the activity of credit institutions and the prudential supervision of credit institutions and investment firms, amending Directive 2002/87/EC and repealing Directives 2006/48/EC and 2006/49/EC, 2013”, Official Journal of the European Union, L 176/338, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:176:0338:0436:EN:PDF

European Parliament and Council (2014), “Directive 2014/59/EU of the European Parliament and of the Council of 15 May 2014 establishing a framework for the recovery and resolution of credit institutions and investment firms and amending Council Directive 82/891/EEC, and Directives 2001/24/EC, 2002/47/EC, 2004/25/EC, 2005/56/EC, 2007/36/EC, 2011/35/EU, 2012/30/EU and 2013/36/EU, and Regulations (EU) No 1093/2010 and (EU) No 648/2012, of the European Parliament and of the Council, L 173/190”, http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014L0059&from=EN

IMF (2013), “Staff Guidance Note for public debt sustainability analysis in market-access countries”, 9 May 2013.

Laeven L., and F. Valencia (2013), “Systemic Banking Crises Database”, *IMF Economic Review* 61, pp. 225–270.

Merton R. (1974), “On the Pricing of Corporate Debt: the Risk Structure of Interest Rates”, *Journal of Finance* 29, pp. 449–470.

Medeiros J. (2012), “Stochastic debt simulation using VAR models and a panel fiscal reaction function: results for a selected number of countries”, *European Economy Economic Paper* No. 459.

Pagano A., J. Cariboni, and M. Petracco Giudici (2012), “SYMBOL model database and analyses for public finance sustainability”, *JRC Technical Report.*

Sironi A., and C. Zazzara, (2004), “Applying credit risk models to deposit insurance pricing: empirical evidence from the Italian banking system”, *Journal of International Banking Regulation*, Vol. 6, pp. 10-32.

Vasicek O. A. (2002), “Loan portfolio value”, *Risk*.

ECONOMIC PAPERS

As of n° 120, Economic Papers can be accessed and downloaded free of charge at the following address:
http://ec.europa.eu/economy_finance/publications/economic_paper/index_en.htm

Alternatively, hard copies may be ordered via the "Print-on-demand" service offered by the EU Bookshop: http://bookshop.europa.eu.

HOW TO OBTAIN EU PUBLICATIONS

Free publications:

- one copy:
  via EU Bookshop (http://bookshop.europa.eu);

- more than one copy or posters/maps:
  - from the European Union's representations (http://ec.europa.eu/represent_en.htm);
  - from the delegations in non-EU countries (http://eeas.europa.eu/delegations/index_en.htm);
  - by contacting the Europe Direct service (http://europa.eu/europedirect/index_en.htm) or calling 00 800 6 7 8 9 10 11 (freephone number from anywhere in the EU) (*).

(*) The information given is free, as are most calls (though some operators, phone boxes or hotels may charge you).

Priced publications:

- via EU Bookshop (http://bookshop.europa.eu).

KC-AI-15-548-EN-N

Publications Office