

Reducing and sharing the burden of bank failures

by

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This report demonstrates that the contingent liabilities associated with efforts to limit the adverse externalities stemming from failures in the European banking sector are substantially decreasing as a result of new regulation. Noting that the implied shifting of losses from taxpayers to bank creditors is desirable, the report recognises that losses do not disappear. It discusses the issue of where bank recovery or resolution bail-in losses may go. It underlines that the sectoral allocation of losses matters, but concludes that our understanding needs to be further developed and that more transparency about the structure of bank creditors would be desirable. Increasing transparency in this regard would, among other things, help assure policy makers that the new tools available can be used effectively and smoothly in actual practice. Also, raising awareness of investors in bail-inable bank debt about the associated risks should enhance the credibility of the bail-in framework.

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1. Motivation

Guarantees and other contingent arrangements for financial sector claims have become increasingly important policy instruments. A key insight from the work of the OECD Committee on Financial Markets (CMF) on the topic of financial sector guarantees is that these arrangements can be beneficial, but they are not without costs. Costs arise in particular when guarantees are not properly priced, thus distorting competition and creating substantial contingent liabilities for public finances.

A topic that has attracted considerable attention is the level of contingent liabilities for governments associated with efforts to offset or minimise the impact of various risks to economic stability and growth, often involving guarantees for the liabilities of financial intermediaries. A key topic of interest in this regard is the work on implicit bank debt guarantees which attracts regular active interest from the Committee. Work under the Committee's auspices on measurement of implicit guarantees and the determinants of their value has provided important insights into the success or failure of resolution approaches in signalling and ending the too-big-to-fail status of large institutions.

The present report, prepared together with staff from the European Commission (EC) Joint Research Centre (JRC),¹ touches on the issue of contingent sovereign liabilities and on the role and sustainability of the financial safety net. In order for the financial safety net to be sustainable, the sovereign needs to be in a position to meet the demands arising from it, as well as those stemming from its actual debt and other contingent fiscal liabilities. Previous work by this Committee concluded that the wider the net is cast, the thinner it becomes (Schich and Kim, 2011).

This report focuses directly on the losses that may arise from failures in the banking sector. It also discusses how these losses may be shared among safety net participants. Such analysis is within the spirit of the OECD NAEC (New Approaches to Economic Challenges) initiative, which calls for better integration of the financial sector and related risks in the OECD's analysis, shedding light on the numerous and complex interactions between finance and the real economy.

The report presents results obtained from the European Commission model SYMBOL (Systemic Model of Bank Originated Losses), which assesses the size of potential government contingent liabilities to the European Union (EU) banking sector, conditional on a (severe) financial crisis, under various policy and regulatory scenarios; the model has also been applied for the preparation, assessment and monitoring of several EU banking regulation proposals. Results demonstrate that the contingent liabilities associated with efforts to limit the adverse externalities stemming from failures in the European banking sector are substantially decreasing as a result of new regulation. The report notes that while losses are being shifted from the taxpayer to bank creditors, which is desirable, losses do not disappear. Unfortunately, not enough is known about the possible distribution of losses and potential knock-on effects, as data on bank counterparties are sparse. The report recommends undertaking further efforts to increase transparency in

this regard, among other things to assure policy makers that the new tools available can be used effectively and smoothly in actual practise.

Section 2 describes the policy measures adopted by the EC. Section 3 discusses where the current research regarding the financial safety stands, focusing on the most recent activity in this area quantifying the impact of the crisis. The section also discusses how the losses are distributed among bank equity and bond holders, resolution funds and other safety net provisions. Section 4 expands the discussion to include specific aspects that the general framework of SYMBOL does not fully account for, in particular it discusses potential feedback loops that may arise through the bail-in of senior creditors. In this context, the note draws some preliminary policy lessons and raises some questions for discussion by the Committee. Section 5 concludes.

2. Limiting potential taxpayer liabilities: Selected regulatory initiatives

2.1. Protecting public finances

The 2008 banking crisis has had unprecedented costs for public finances in developed countries. In the case of European Union, the latest s on overall State Aid to the financial sector between 2008 and 2012 (European Commission, Directorate-General for Competition, 2013) amounts to around EUR 600 billion (roughly 5% of EU 28 GDP). In the US, the cost of the crisis reached roughly 4.5% of the GDP (Laeven and Valencia, 2013).

In order to prevent similar costs in the future and limit the perception that systemic banking risks are being socialised, different legislative reforms to protect public finances and ultimately tax payers have been proposed worldwide (see Basel Committee on Banking Supervision, 2009).

An overview of the spectrum of policy measures already taken or being considered was produced by the CMF in 2014 through a survey among members and partner countries.² The survey was motivated by the view that many of the reform measures, even if not always primarily aiming at limiting the value of implicit bank funding subsidies, could be expected to have an impact on it. The survey asked pointedly what policies respondents have either implemented or considered, that could be expected to have an impact on the value of implicit bank debt guarantees. The responses suggested that there is no single specific policy measure that could be considered a “silver bullet”, capable of fully eliminating the value of implicit bank debt guarantees. Implementing a mixture of several different policy measures was considered as offering the greatest promise in reducing the value of implicit bank debt guarantees. In fact, the various specific policy choices are seen as complementary, limiting the value of implicit bank debt guarantees through their effects both on banks and banks’ counterparty behaviour. Recurrent elements of the mix of policies include i) the implementation of internationally agreed capital and liquidity standards, ii) the tightening of supervision both in micro and macro prudential terms, and iii) efforts to make resolution more effective.

2.2. Regulatory initiatives at the European level

In Europe, as part of broader initiatives (e.g. Markets in Financial Instruments Directive, European Market Infrastructure Regulation) the EU has approved, among the others, the implementation of the Basel III international rules on capital requirements (Capital Requirement Regulation and Directive IV, CRR/CRDIV, see European Parliament and Council, 2013a,b); the Bank Recovery and Resolution Directive (BRRD, see European

Parliament and Council, 2014b), and the Single Resolution Mechanism (SRM, see European Council, 2014). The effects of these initiatives are explicitly modelled in the present report.

The first initiative transposes into legislation the Basel III Accord, thus enhancing the quality and quantity of capital that banks should have to set aside in order to better tackle unexpected losses. In particular the Directive introduces a 2.5% of risk-weighted assets capital conservation buffer on top of the 8% of risk-weighted assets minimum already implemented under Basel II. The purpose of this buffer is to enable firms to absorb losses in stressed periods.

The Bank Recovery and Resolution Directive endows resolution authorities with the powers to transfer shares and assets of a failing bank to other activities, bridge banks or asset management vehicles with the aim of ensuring an orderly resolution. Moreover authorities can also write down or convert to equity specific claims of shareholders and unsecured creditors of failing/likely to fail institutions via the so called bail-in tool. Starting at latest from January 2016, banks will be obliged to have such tool in place.

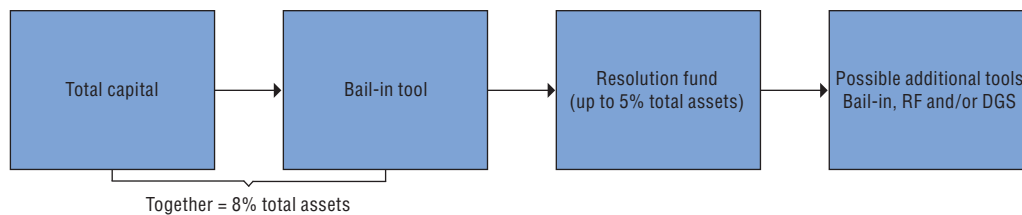
Moreover, the BRRD obliges member states to set up national Resolution Funds (RF) to be used in resolution on top of the other instruments. Each fund must be ex-ante funded and reach in 10 years a target size equal to 1% of covered deposits.³ According to the Single Resolution Mechanism and Single Resolution Fund Regulations (European Parliament and Council, 2014c), starting from 2016, the funds of the countries in the banking union will be pooled in a Single Resolution Fund (SRF), which will reach its target level in a shorter period of 8 years.

Finally, in the framework of an integrated set of policy measures to address the risks associated with systemically important financial institutions, the Financial Stability Board and the Basel Committee on Banking Supervision have developed a methodology to identify the global systemically important banks (G-SIBs), which will be required to hold by January 2019 increased required levels of loss absorbency. The size of these additional requirements is computed individually for each G-SIB and periodically reassessed; latest data can be found in Financial Stability Board (2014).

2.3. The role of the financial safety net

The financial safety net comes into action in the case of bank distress and contains arrangements that limit the probability of bank failure and the costs associated with the resolution process, should it occur. In this regard, national choices differ, at least to some extent, although in Europe the BRRD provides a common framework. Figure 1 sketches the order of intervention of the safety net tools directly modelled in this report, in line with the EU legislation just described: capital and additional bail-in funds are the first and second cushions against losses of a distressed bank. Only after these cushions have contributed to loss absorption and recapitalisation (with a minimum amount equal to 8% of total assets) resolution funds can intervene, subject to the decision of the resolution authority. The resolution fund intervention for each bank cannot exceed 5% of its total assets. 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 available, could be written down), the residual resolution funds could be called to cover losses above 5% total liabilities (including own funds) and/or the deposit guarantee schemes, under specific circumstances, could also intervene as the last tool.

Figure 1. **Implemented order of intervention of the safety net tools, in line with the EU legislation.**



Box 1. **The role of Deposit Guarantee Schemes**

The main objective of Deposit Guarantee Schemes (DGS) is to reimburse a limited amount (up to EUR 100 000 in the EU) of deposits to protected depositors whose bank has failed. From the depositors' point of view, this arrangement protects a part of their wealth from losses due to bank failures. The existence of such arrangements tend to prevent depositors from making panic withdrawals from their bank, thereby avoiding financial instability and the associated severe real economic consequences.

The functioning of deposit insurance arrangements within European countries has been harmonised by the Directive 2014/49/EU, adopted in 2014. Among the new harmonised rules on DGS functioning, the Directive sets a target level for the DGS funds equal to 0.8% of covered deposits to be collected by 3 July 2024. Banks will pay *ex-ante* contributions to the funds on a yearly basis and contributions should reflect both the amount of deposits held by the banks and their risk profile.

The collected funds should be primarily used to repay depositors (see Article 11(1) of Directive 2014/49/EU), but under specific conditions DGS funds can also be used for other purposes, as detailed in Article 11(3). In addition, Article 11(2) allows DGS funds to (partially) finance the resolution of failing banks (see Article 109 of Directive 2014/59/EU). The decision on the DGS intervention and the amount the DGS would be liable for are left at the discretion of the resolution authority, to be decided on a case-by-case basis. The costs borne by the DGS for the resolution of a failing institution cannot however exceed the costs the DGS would have borne for the normal insolvency procedure of the same financial institution. Costs to be borne by the DGS also have another ceiling: according to Article 109(5) of Directive 2014/59/EU, the contributions in resolution of a DGS cannot exceed 50% of its target level.

The DGS involvement in the bank failure resolution process is thus not straightforward but would be expected to vary depending on the specific circumstances, which makes its modelling extremely difficult; the role of DGS is not explicitly considered in the present analysis. As mentioned also in Section 3.5, the involvement of DGS in a resolution process might further reduce the financing needs faced by other financial safety net participants.

3. Estimating banks losses and the impact of new regulation

3.1. Assessing the overall effects of financial safety net reforms

The overall impact of the financial safety net needs to be assessed through a sound and consistent modelling framework (see European Commission, 2014). In this regard, there have been several attempts to assess the overall effect, for example by looking at the

systemic importance of interconnected banks. For instance, Drehmann and Tarashev (2013) use a Vasicek (2002) model (with default probabilities from Moody's KMV estimates, see Hull et al., 2005) to simulate shocks and subsequent defaults, assessing the different contributions of banks to system-wide risks and costs. Simulations allow the authors to assess the effects of alternative network structures; however, while observed balance sheet data is considered, regulatory and financial safety net parameters are not.

Some studies look at the effects of introducing or changing specific parameters of financial safety nets, e.g. capital adequacy requirements, level and risk-sensitivity of deposit insurance premia and funds, introduction of designated resolution funds, and bail-in of bank creditors. For example, Conlon and Cotter (2014) study the change in the proportion of liabilities that authorities would have needed to bail-in to cover losses associated with the global financial crisis, based on observation of selected banks' balance sheets during the crisis. Galliani and Zedda (2014) include bail-in tools to assess the possible circular effects that a distressed banking system may transmit onto the public finances. The Macroeconomic Assessment Group (2010) and Miles et al. (2013) study the effects of changes in capital adequacy requirements. Based on the Merton (1977) framework, Duffie et al. (2003), Kuritzkes et al. (2002), and Sironi and Zazzara (2004) develop models to set actuarially fair insurance premia for deposit insurance arrangements. Schoenmaker and Siegman (2013) show that, after shareholders and certain creditors have been written down, recapitalising systemically relevant parts of banks is more efficient if decided on a central (or supra-national) rather than at a domestic level, thus providing a rationale for a common resolution fund. So far, the literature has focused on assessing the role of individual safety net tools, while quantitative assessments of the cumulative effects of changes in such tools are rare. An exception is Breuss et al. (2015), who simulates the counterfactual response of euro area GDP of a large adverse shock to the financial system under different financial safety net set-ups.

To assess the fiscal costs of banking sector stress, the New Zealand Treasury proposed a model (Snethlage, 2015) that estimates the distribution of bank failure costs between taxpayers and bank creditors, using publicly available information contained in bank credit rating. This work distinguishes between costs borne for the financial risk that a bank may fail in a given period (*ex-ante* costs), costs associated with restoring a bank after it failed (*ex-post* costs) and the value of the implicit government guarantee. The costs for each single bank are driven from a binomial model for the option to default based on the two-state world (failure versus non-failure): the bank's debt is proxied with the bank's total liabilities; the loss given default is fixed at some chosen thresholds, although alternative assumptions are also being considered; default probabilities are estimated from those associated to Moody's rating classes; bailout probabilities are derived from ratings historical default probabilities, taking into account that the major banks receive uplifts in their credit ratings because of the potential for extraordinary government support. The approach is relatively easy to implement and was initially applied to estimating the costs of a bank's failure for the four largest banks in New Zealand and is applied in the companion report "Estimating the Size and Incidence of Bank Resolution Costs for Selected Banks in OECD Countries" (Blix Grimaldi et al., 2016) to assess the changes in the size and distribution of bank failure resolution costs for a large number of banks in a wider range of OECD countries, going beyond Europe.

3.2. The European Commission's SYMBOL model

The European Commission, in cooperation with experts from academia, has developed SYMBOL, a micro-simulation model (De Lisa et al. (2011), Benczur et al. (2016)

which simulates the distribution of losses in a banking system (e.g. a country) starting from individual banks' balance sheet data.

The model fits within the Basel framework for banks minimum capital requirements. Losses for individual banks depend upon an estimate of the average default risk of the obligors in each bank's portfolio, basically a function of its total assets and risk-weighted assets. The failure of a bank is determined by the size of simulated losses and the regulatory capital available to absorb unexpected shocks. Losses are generated via Monte Carlo simulations using Basel Internal Rating Based (IRB) function.⁴

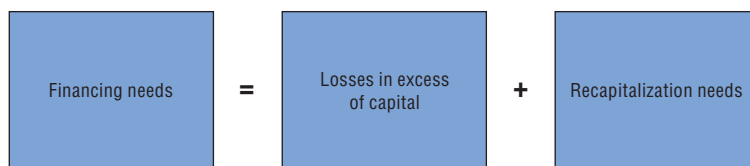
The main features of the EC model can be summarised as follows:

- The model allows estimating the distribution of losses at the system level (e.g. single country or Europe) by aggregating individual banks losses. Banks assets are correlated imposing a structure representing either the banks' common exposure to the same borrower, or to the common influence of the business cycle.
- The model relies on balance sheet data: information on minimum capital requirements and total assets are needed to estimate an average bank's portfolio default probability, via a numerical inversion of the IRB formula. This average bank's portfolio default probability is then used to simulate losses, which are compared to the declared total regulatory capital.
- It permits modelling the intervention of banking safety net tools, in particular bail-in and resolution funds, as introduced by the European legislation, although there are limits to the extent to which the effects of bail-in can be assessed, due to the fact that comprehensive data on the creditor structure of banks is not readily available.
- It is flexible enough to simulate "what-if" scenarios, by modifying the inputs for simulations (e.g. increasing the minimum level of capital or assuming a decrease in the assets). This allows ex-ante assessments of incoming legislative reforms.

The model was used by EC services to prepare the impact assessments of the Capital Requirements Directive proposal, the Bank Recovery and Resolution Directive proposal and the Economic Review of the Financial Regulation Agenda (European Commission, 2014). Section 3.3 illustrates the implementation of "what-if" scenarios in the SYMBOL framework and Annex A provides more technical details of the model.

3.3. How regulation enters the SYMBOL model

This section describes the approach used to simulate losses and to implement different "what-if" scenarios, most of which relate to specific policy initiatives. Simulations are first run in reference to a baseline scenario, which essentially represents the current situation of the EU banking sector. Based on the simulation results, we compute the distribution of losses in excess of capital and recapitalization needs for the entire banking system. In the following we will refer to "financing needs" as the sum of losses in excess of capital plus recapitalisation needs to make the banks viable, defined here as an amount of capital at least equivalent to 8% of risk-weighted assets (see Annex B for details).⁵



The SYMBOL model distinguishes between bank losses in excess of capital and bank recapitalisation needs related to the fulfilment of the minimum capital requirement imposed by regulation. This feature allows one to differentiate on how public funds would be injected in the banking sector to cover the two types of funding needs, and treat the two differently in terms of their impact on public finances. Bank losses in excess of capital could be covered by liquidity injections (subsidies) in the banking sector, affecting the public deficit, and gross and net debt equally. Recapitalisation needs could be met through the acquisition of (toxic) financial assets by the government. This would be recorded as financial transaction up to the amount that could be expected to be recoverable and would affect only gross debt through the stock-flow adjustment, and not the deficit, nor net debt; furthermore the latter, contrary to the former, could be expected to be recouped, thus “reintegrating” public finances at a later stage (an issue analysed in Benczur et al., 2015).

In the present analysis we implement a number of “what-if” scenarios where alternative levels of capital and different safety net tools are being considered. In particular, we consider the following alternatives.

- **Higher capital.** In addition to considering only current capital absorbing the simulated losses, we consider the further absorption of financing needs when introducing the increased Minimum Capital Requirements following the new Basel III capital conservation buffer, which raises the minimum level of capital to 10.5% of risk-weighted assets. We also consider the reduction of financing needs when G-SIBs also hold the prescribed additional loss absorbency capital buffer.
- **Bail-in.** As no data on the amount of unsecured debt issued by each bank are available, it is assumed that banks hold a minimum amount of Loss Absorbing Capacity (LAC = total regulatory capital plus other unsecured liabilities) equal to 8% of total assets (Figure 1 and Annex B for more details). The minimum threshold is chosen in line with existing legislation, as resolution funds can intervene only if at least 8% total assets of banks’ funds have already been used to absorb losses.⁶ In practice all banks with total capital lower than the 8% total assets threshold are assumed to meet it via bail-inable liabilities. In case a bank holds capital higher than this threshold, there would be no bail-in, and the whole capital can be used to bear losses.
- **Resolution funds.** We consider both the effects of a single resolution fund (SRF), where a single fund is available for the whole banking union, and those of national resolution funds, where funds are only available at the domestic level. The amount of funds in the resolution funds equals 1% of the aggregated amount of covered deposits in the area, in line with the legislation.⁷

The next sub-sections present related simulation results and explain the implementation of the safety net tools in this framework, while Section 4 goes beyond this discussion and focuses on which investors might be involved in the sharing of remaining financing needs.

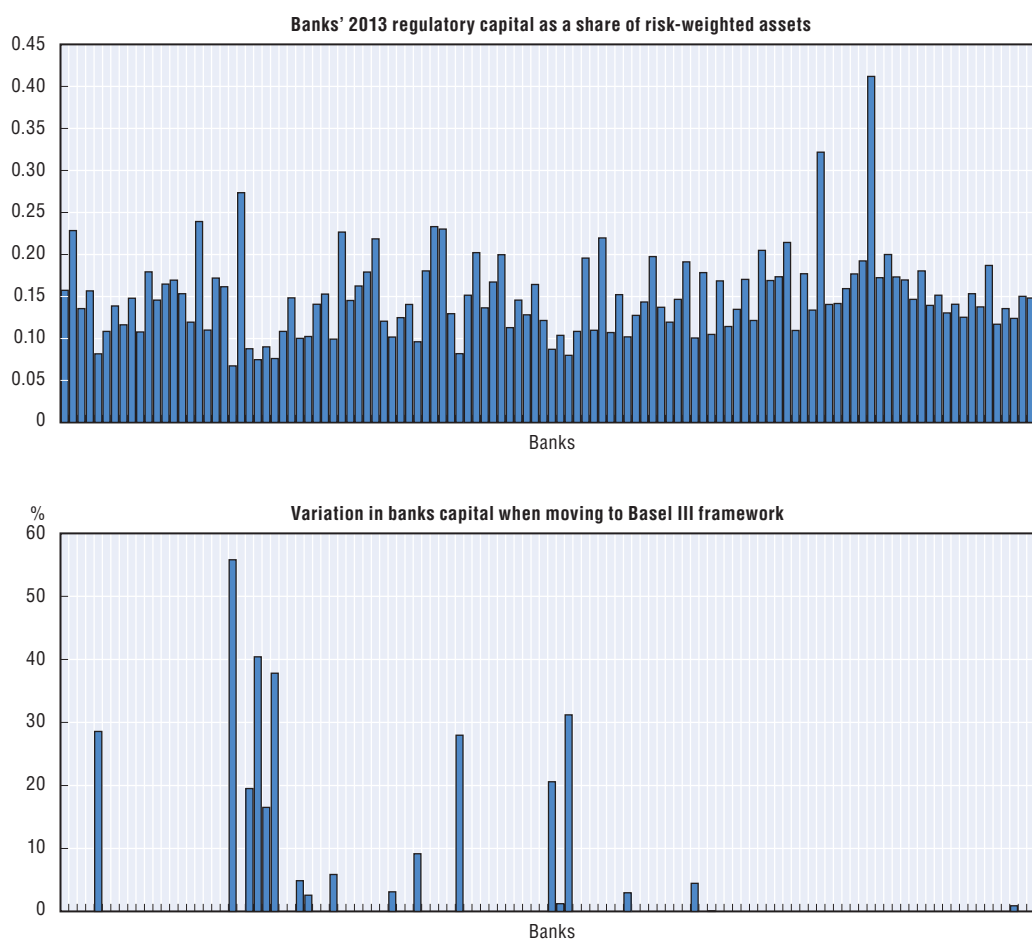
3.4. Estimated loss reductions as a result of regulatory reform – an example

SYMBOL simulations shown in this section are run for the sample of financial institutions included in the last EU-wide stress testing conducted by the European Banking Authority (2014). The sample covers 117 EU large financial institutions, accounting for around 74% of the EU total assets. Balance sheet data are as of end of 2013. They mainly originate from the results of the European Banking Authority exercise and are

complemented using data from SNL financial, a commercial database. More details on the dataset can be found in Annex A.

A preliminary analysis on the capital levels of the banks in the sample demonstrates that most of them are already compliant with the new Basel III framework, as their current⁸ capital is higher than the minimum threshold of 10.5% of risk-weighted assets plus the GSIBS buffer, if the case, as can be seen from Figure 2. The top chart shows the amount of 2013 capital held by all the banks in the sample, expressed as a share of banks' risk-weighted assets, and in the bottom chart the corresponding percentage increase in capital, at bank level, when Basel III framework is assumed to be in place and GSIBS banks also hold the additional buffer.

Figure 2. Amount of banks' current capital (top chart) and corresponding percentage variation of capital when accounting for Basel III framework and GSIBS buffers (bottom chart)



Note: Banks are sorted in ascending order based on the size of their capital.

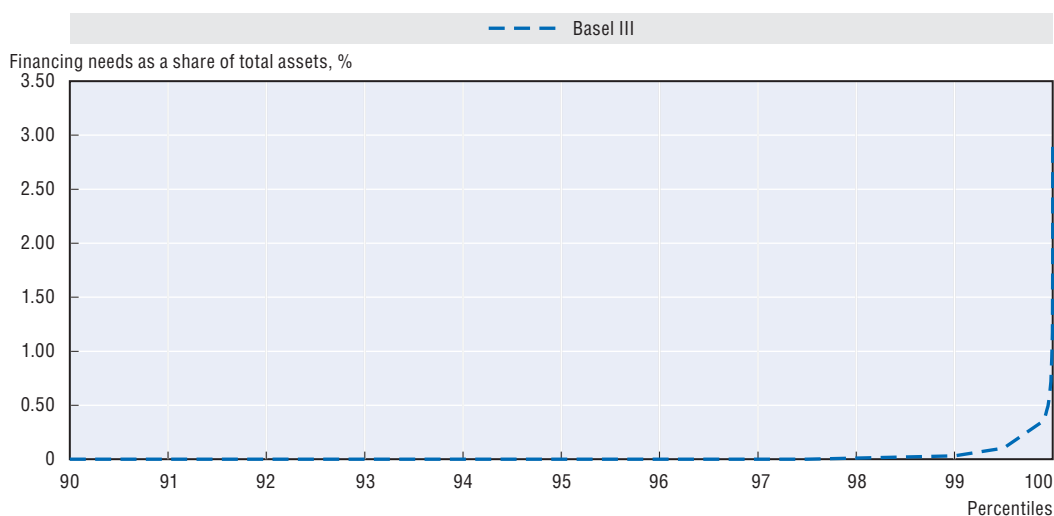
Source: Authors' calculations.

Results show that only 19 banks out of 117 would have their capital increased, while all the other institutions will not be affected by the introduction of the new framework. Though these variations in banks capital reach significant levels in relative terms (see bottom chart of Figure 2, where some banks would experience an increase of more than

30%), in absolute terms these variations are moderate and the simulated distribution of financing needs under the current framework and under a Basel III one are substantially equal. Thus the starting point of the present analysis is the simulation of financing needs under Basel III.

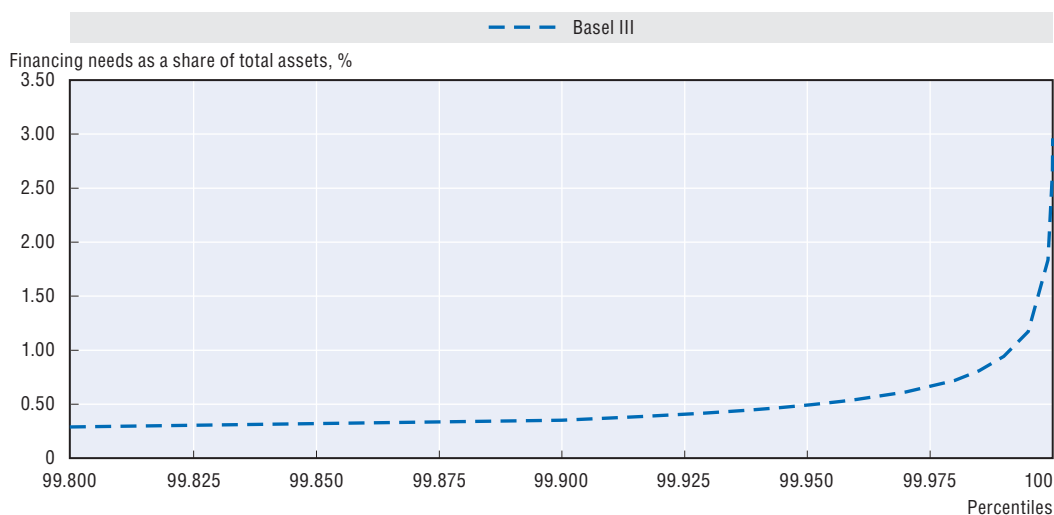
Figure 3 and Figure 4 show the simulated distribution of financing needs as a share of total assets of the sample (Figure 3 zooms in the very right tail of this distribution), when banks are assumed to hold a minimum amount capital at least equal to 10.5% risk-weighted assets plus the GSIBS additional capital buffer (Basel III, see also Section 3.5).

Figure 3. Estimated financing needs for the sample of banks considered in the exercise (as of 2013)



Source: Authors' computations, based on SYMBOL simulations.

Figure 4. Estimated financing needs for the sample of banks considered in the exercise (as of 2013, only extreme right tail)



Source: Authors' calculations, based on SYMBOL simulations.

These simulated financing needs can be compared with historical data on State Aid to the EU financial sector. The latter shows that during the recent crisis the total amount of recapitalisation measures for the period 2008-12 is roughly EUR 410 billion (European Commission, 2013). In addition, a total of roughly EUR 180 billion of funding was also provided to the financial sector via asset relief during that period. Adding up these two amounts, one obtains an estimate of total financing needs of about EUR 590 billion, which corresponds to roughly 1% of EU 27 total assets (Schoenmaker and Peek, 2014) or roughly to 5% of EU GDP. In the present simulations (Figure 3), similar results can be found between the percentiles 99.95 and 99.99 (see also Benczur et al., 2016).

It is important to stress that percentiles in the distribution of financing needs should not be read as empirical frequencies, e.g. the percentile 99.95 does not mean that the event happens with an empirical probability of at most 0.05 percent. It is more appropriate to think about the SYMBOL (and also the Basel) probabilities as “theoretical probabilities”, which partly reflect the modelling assumptions of the Basel formula determining minimum capital requirements. Their relative magnitudes, however, can inform us whether one bank or one country is at higher risk than another.⁹

3.5. Estimated loss reductions as a result of regulatory reform – various scenarios

Different scenarios are implemented in the following, using SYMBOL to assess the effect of the introduction of or change in safety net tools. Table 1 presents these scenarios reflecting the chronological order in which the different pieces of legislation agreed in the EU should be implemented.

Table 1. **Description and timeline of different scenarios**

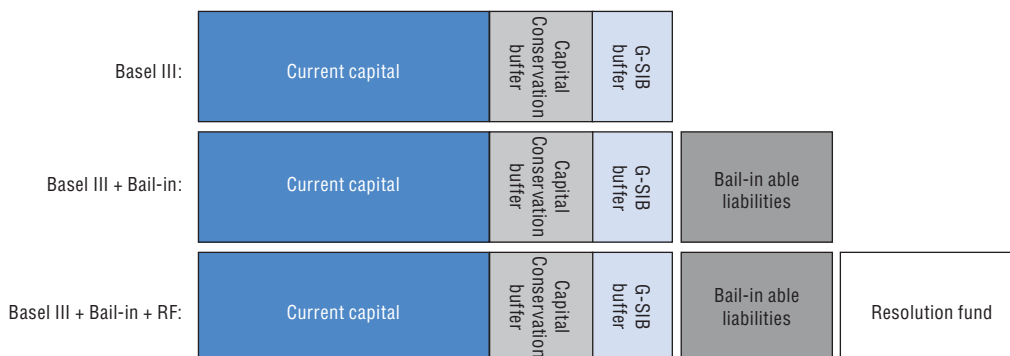
Scenarios	Tools in place						Date of full implementation
	Capital	Capital conservation buffer	G-SIB buffer	Bail-in	NRF	SRF	
Basel III	x	x	x				2019
Basel III + Bail-in	x	x	x	x			2019
Basel III + Bail-in + NRF	x	x	x	x	x		2025
Basel III + Bail-in + SRF	x	x	x	x		x	2025

Note: NRF and SRF denote national and single resolution fund, respectively. The single resolution fund will be collected over 8 years starting from 2016, which implies that full funding would be available in 2024.

Figure 5 provides a visual representation of the different scenarios. In the Basel III scenario, fully in place as of 2019 after a phase-in period, capital is the only tool available to absorb losses (highlighted by the black area in all scenarios): banks are assumed to comply with minimum capital requirements (dotted area) and thus actual capital is the maximum of the capital and 10.5% of risk-weighted assets. G-SIBs banks also hold the additional capital buffer (grey dotted area). On top of these financial safety net tools fully available from 2019, the subsequent scenario also assesses the combined effects of Basel III framework, capital buffers and bail-in (“Basel III + Bail-in”, dark grey area). In this scenario we assume that the total loss-absorbing capacity is set at 8% of total assets (see Annex B). That capacity consists of capital and, if the former is below the minimum 8% threshold, “bail-in able” liabilities match it. Finally, we consider the introduction of resolution funds, either at a national (NRF) or banking union level (SRF). This scenario would apply as from

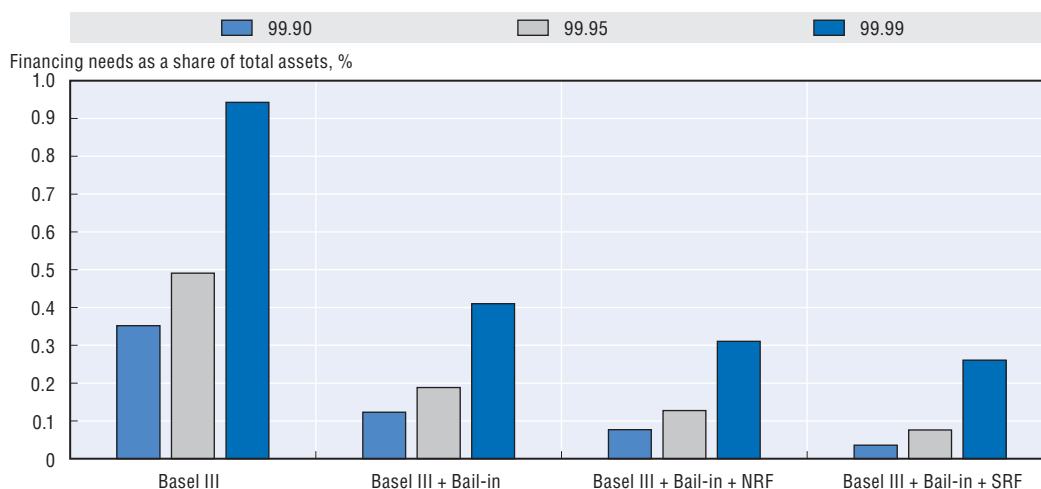
2025. Considering the different scenarios, Figure 6 shows the amount of financing needs for selected percentiles of the distribution.

Figure 5. Schematic representation of the scenarios



Note: Current capital accounts for the new definition of capital introduced in the Basel III framework; capital conservation buffer is the additional buffer of capital to comply with the Basel III increased minimum level of 10.5% of risk-weighted assets; G-SIB buffer is the additional loss absorbency capital buffer. The size of the bars does not reflect the magnitude of the different instruments. It should be kept in mind that the current level of capital of some banks already satisfy the Basel III increase minimum requirements (see Figure 2).

Figure 6. Financing needs under the different scenarios (share of total assets)

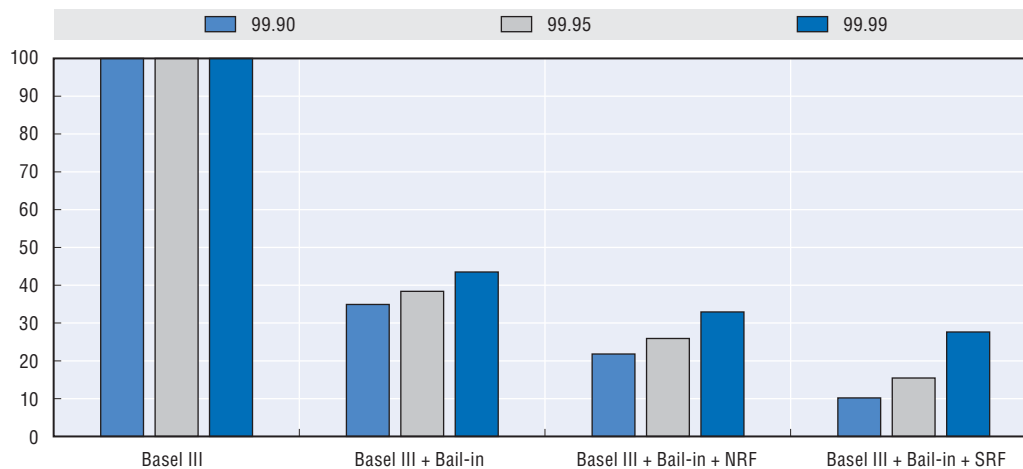


Source: Authors' calculations, based on SYMBOL simulations.

Figure 7 presents the relative decrease in losses due to different safety net tools. The results are presented for the percentiles 99.9, 99.95 and 99.99, and initial losses are normalised to 100. If, as an example, we focus on the intermediate percentile, bail-in covers around 62% of financing needs in the current framework and the introduction of Single Resolution Fund will further reduce losses of around 20 percentage points.

The amount of unused resolution funds, after the safety-net modelled in the present analysis has intervened, would be roughly 0.13% of the total assets when NRFs are in place, and it would halve when the SRF is in place. However, as already described, other tools may intervene on top of the ones implemented, subject to the discretion of the resolution authority: additional bail-in tool could be used and/or the residual RF could be called to cover losses above 5% total liabilities; also Deposit Guarantee Schemes may partially

Figure 7. **Reduction of financing needs due to introduction of/changes in various safety-net tools**



Source: Authors' calculations, based on SYMBOL simulations.

intervene (as detailed in Box 1) to reimburse the covered deposits of the defaulted banks. When considering, on top of leftover resolution funds, also the share of the DGS funds that could be used to fund resolutions, the loss absorbing capacity (part of DGS plus leftover RF) would raise to 0.2% and 0.15% of the total assets when, respectively, NRF and SRF are in place.

4. Where might bank debt bail-in financing needs go?

4.1. Who holds banking sector debt?

Section 3 discussed the distribution of financing needs across equity holders, bondholders and safety net tools. It also illustrated the quantitative importance of the reduction in public finance costs when applying bail-in rather than bail-out of bank creditors, which was the practice in the 2008-12 financial crisis. As the previous simulations showed (Section 3), moving from a bail-out to a bail-in regime shifts an estimated 62% of the financing needs from the government to the bank bondholders (and other bail-in able creditors). However, by shifting financing needs from public sector interventions to bank creditors, they do not disappear.

The effect of imposing loss absorption financing needs on bank creditors may differ depending on the types of investors concerned. To gain further insights into the potential challenges associated with allocating bank failure resolution financing needs across different types of investors, we start by using the Euro Area Accounts to obtain a ballpark estimate of holdings of bank debt by the various investors (Annex C). In particular, we consider the following domestic institutional sectors: non-financial corporations (NFC); banks (monetary financial institutions, MFIs); insurance and pension fund companies (INS); other financial intermediaries (OFI); general governments (GOV); households (HH); finally ROW, i.e. the rest of the world, accounts for foreign investors.

Using the methodology described in Annex C, Table 2 shows the estimated holdings of MFI debt securities across different institutional sectors for 7 euro area countries. Sample average s for liability holdings by institutional sectors show that most of the bank bonds are held by domestic financial institutions (MFI 33%, INS 12% and OFI 11%).¹⁰ The total

percentage of bank bonds held by residual domestic sectors (NFC, GOV and HH) is below 10%. ROW also accounts for a large share (i.e. on average 35 %; see also Figure 8). The distribution of liability holdings across different sectors in the rest of the world (ROW) is not known. In case of bail-in, such holdings might mitigate financial stability risks at the domestic level, but they may also generate international spillovers.

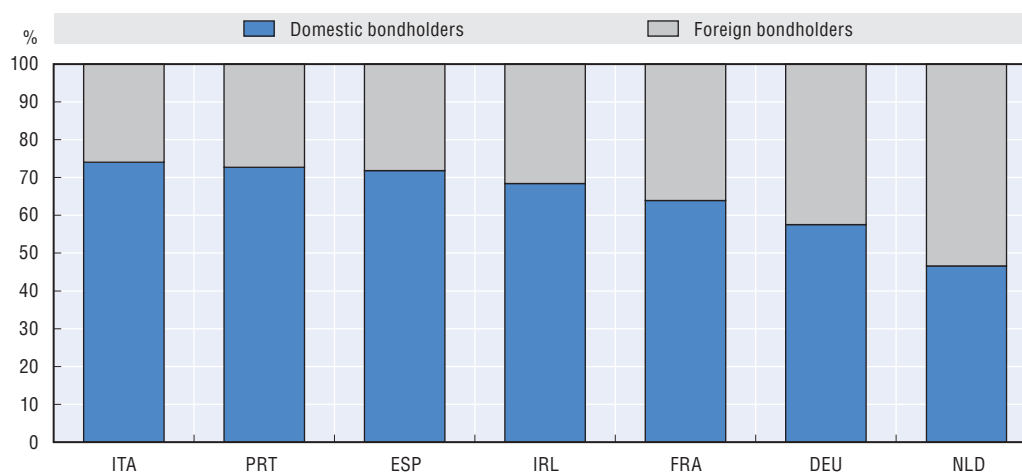
Table 2 shows that there is considerable heterogeneity across countries in terms of the relative holdings of liabilities between institutional sectors. For example, MFIs in the Netherlands hold only about 16% of outstanding domestic bank bonds, while they hold 49% in Spain. OFIs in Spain account for only 4% of bank bond holdings, but for 38% in Ireland. INS in the Netherlands and France hold respectively 23% and 20% of domestic bank bonds, while such entities in Germany and Ireland hold only approximately 5% each. The remaining sectors hold bank bonds only to a limited extent; the only exception are households in Italy, which hold 20% of Italian bank debt. While most MFI liabilities tend to be held domestically rather than abroad (Figure 8), there are some noticeable cross-country differences in this regard. For example, the fraction owned by foreign investors (ROW) is less than 30% of bank debt in Italy, Portugal, and Spain, while it is around 50% in the Netherlands.

Table 2. Estimated MFI Bondholder positions: break-down by sectors
Percent of total bonds issued by domestic MFIs

	Germany	Spain	France	Ireland	Italy	Netherlands	Portugal	Average
Non-Financial	1%	3%	1%	0%	2%	1%	1%	1%
Monetary	30%	49%	30%	25%	35%	16%	44%	33%
Other Financial	13%	4%	8%	38%	6%	7%	3%	11%
Insurance	5%	10%	23%	5%	10%	20%	12%	12%
General	3%	3%	1%	1%	1%	1%	6%	2%
Household	5%	3%	1%	0%	20%	2%	7%	5%
Rest of the World	42%	28%	36%	32%	26%	53%	27%	35%

Source: Authors' calculations based on data from Euro Area Accounts (see for details Annex C).

Figure 8. Estimated MFI Bondholder positions: domestic vs foreign
Percent of total bonds issued by domestic MFIs



Source: Authors' calculations based on data from Euro Area Accounts (methodology described in Annex C).

4.2. Considerations regarding the “capacity” of different institutional sectors to hold bank debt

Bail-in is an important instrument to reduce tax payers’ costs of financial crises and weaken the sovereign-banking loop. By allocating losses to the creditors, moral hazard and excessive risk taking is addressed. In the past, senior creditors’ involvement in the bank failure burden-sharing has been limited, and this had undesirable effects. For example, looking at the finance-growth nexus using data for several decades, Denk et al. (2015) show that the contribution of financial sector growth to real activity growth turns out to be more favourable in countries where senior creditors have incurred losses as part of bank failures than in those where senior creditors have not been involved in the burden-sharing associated with the global financial crisis.

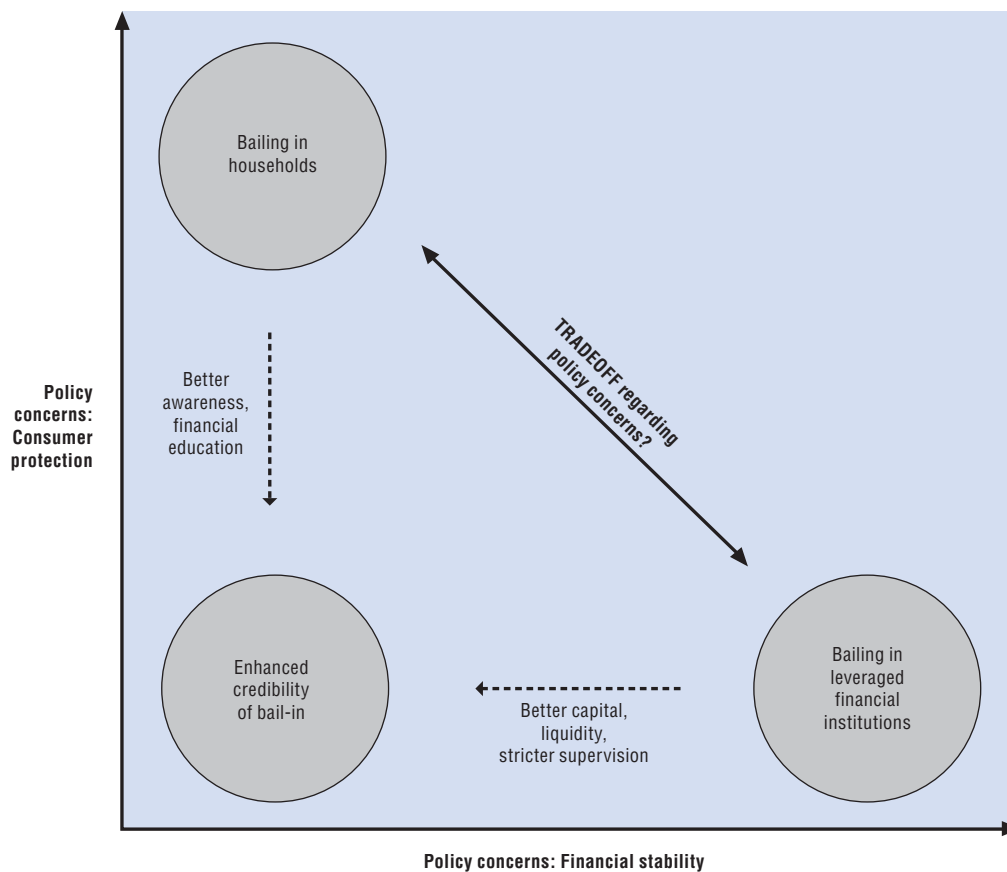
If the government’s loss absorption backstop is reduced, private sector risk tends to increase. The capacity to manage and bear such risks differs however across various (private) sectors. In response to the changed risk profile of bail-inable senior bank debt that is implied by bank regulatory reform, holdings of such debt can be expected to change across sectors. Whatever the specific allocations of bail-inable bank debt among different institutional sectors, two perhaps conflicting policy concerns may exist. Figure 9 provides a stylised representation of these policy concerns and the possible trade-off that may arise when exposure to bail-inable bank debt securities shifts away from the leveraged sector. On the one hand, the exposure of the leveraged financial sector to bail-inable debt should be limited so as to contain potential contagion risks and financial instability: this motivates the proposals to limit the exposure of MFIs to MFI debt. On the other hand, households may not be fully aware of the risks associated with bail-inable debt, thus potentially raising consumer protection concerns. In this respect, ad-hoc policy intervention may enhance bail-in credibility.

Focusing on contagion risk, it could be considered desirable if holdings of bail-inable debt shifted from leveraged financial institutions towards a sector with limited financial leverage, such as non-financial corporations and households. When banks suffer substantial losses on their asset holdings, capital shortfalls may arise, in particular in situations of systemic banking crises. If severe enough, the effect on banking sector capital may also reduce the availability of bank credit to the real economy, which in turn would deepen any economic downturn. For example, Avgouleas and Goodhart (2014) suggest that the holdings of MFI debt securities across the financial sector may limit the benefits of bail-in where a number of banks have simultaneously entered into difficulties or in the event of the failure of a large complex cross-border bank, unless the failure was clearly idiosyncratic. By contrast, shocks to the balance sheets of households (and firms) sectors are likely to be confined to slower-moving – and possibly less severe – macroeconomic effects (e.g. in terms of reduced consumption and/or investment).

Recent experiences with and attempts to bail-in (junior) debt have however raised concerns regarding the economic and social impact of bail-in. Chief among them is the concern that it might not be desirable to bail-in uninformed households. In fact, in situations where large parts of potentially bail-inable debt were held by households, bank failure resolution has often involved some element of bail-out and/or some compensation was provided.

On a related issue, Avgouleas and Goodhart (2014) suggest that households may be less appropriate investors in bail-inable debt than others as they may not have the

Figure 9. **Stylised representation of potential trade-off between different policy concerns**



expertise to assess the risk or to become owners of a bank (e.g. in the case of conversion of debt into equity), or to be involved in the resolution process (technical financial competences and resources).¹¹ Some concerns in the context of bail-in of bank creditors in the different sectors can be or are being addressed by other (accompanying) policies directly tackling the sources of concerns. Strengthening of financial sector regulatory capital and liquidity requirements and supervision enhances the capacity to shoulder losses within the banking sector, while existing and evolving consumer financial protection policies and efforts to enhance investor awareness of risk-return trade-offs should go some in reducing consumer protection concerns.

4.3. Additional considerations regarding the size of banking sector debt

An additional issue to be considered is the size of MFI debt: MFI debt is large in absolute terms as well as relative to the balance sheet size of other specific domestic institutional sectors.

How “large” is bank debt? Relating the amount of domestic bank bonds to the size of the financial assets of each sector, Figure 10 shows the ratio of debt issued by domestic banks over the total financial assets of that specific institutional sector. The interpretation

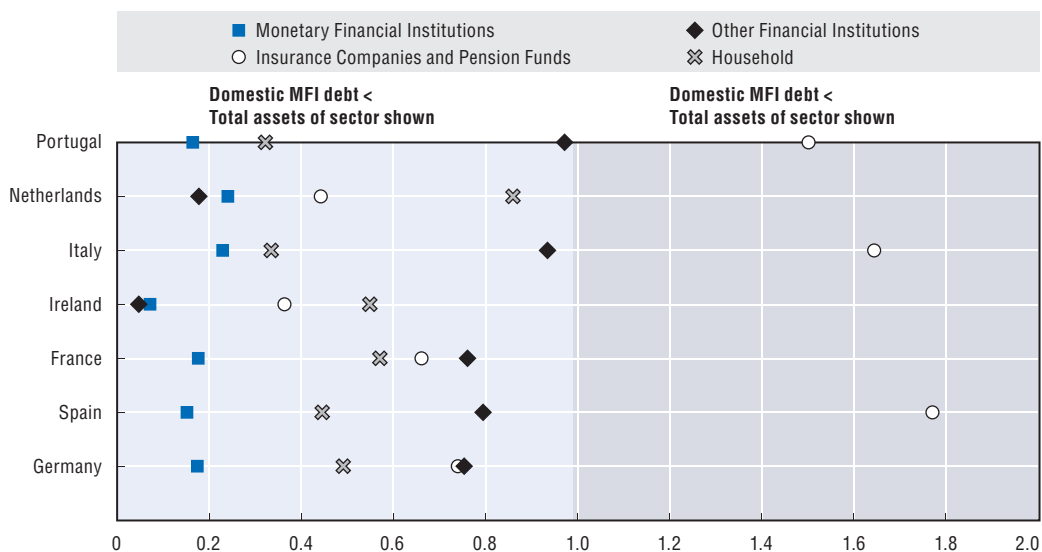
is as follows. If the ratio is greater than 1, that specific sector would simply be unable to hold all MFI debt. By contrast, when the ratio is lower than or equal to 1, that sector could in theory hold all domestic bank bonds.¹²

The ratio could be interpreted as a simple measure of the “financial capacity” of different domestic institutional sectors to absorb MFI debt. As can be seen from Figure 10, MFIs have the largest “financial capacity” to hold MFI debt. For example, MFIs are so large that buying up all MFI debt would only imply an exposure of 20% of their overall portfolio. Given the strong interconnectedness of MFIs and high leverage, current regulatory reforms are however aiming to limit MFI investments in MFI debt. Who else might be a major investor in MFI debt? By the above measure, households seem to have more “financial capacity” to be major holders of domestic bank debt. But, as already pointed out before, whether they are “appropriate” investors in bail-inable debt is another question.

Krahnert and Moretti (2015) suggest that pension funds and insurance companies can be a kind of “investor-of-last-resort” in bank debt. Figure 10 illustrates that, in several countries the domestic insurance and pension funds sector are however simply not large enough to hold all domestic bank bonds, in particular in Spain, Italy and Portugal.

Moreover, in practice, these institutional investors typically only invest a fraction of their financial assets in bank bonds and they do not seem to be inclined to increase their exposure to bank debt and in particular to subordinated or bail-inable bank debt. Take the example of insurance companies. According to data collected by the OECD’s Survey on Large Insurance Companies, the investment of respondent insurance companies in bank debt never exceeded 14% and typically represented about 3% to 4% of their total financial investments (Figure 11). Their exposure to bank debt tends to be in form of senior debt securities, accounting for an estimated close to 70% of all bank debt exposure. Summarising, there is little empirical evidence suggesting that insurance companies could be expected to be major investors in the more risky debt securities issued by banks. Unfortunately, the data available to authors only covers a set of insurance companies and similar data is not readily available for other investor categories.

Figure 10. Domestic MFI debt and size of selected institutional sectors

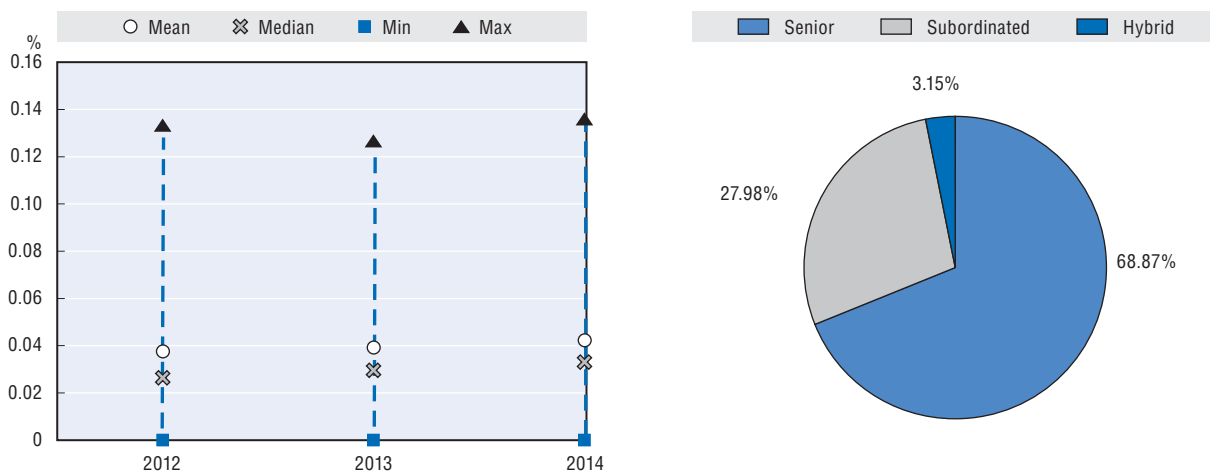


Note: Ratio of debt issued by domestic banks over the total financial assets of that specific institutional sector. The ratio is lower than 1 (white area) if the domestic MFI debt is lower than the total assets of a specific sector the ratio is lower than 1. The ratio is greater than 1 (grey area) if the domestic MFIs debt is greater than the total assets of a specific domestic sector.

Source: Authors' calculations based on data from Euro Area Accounts.

Figure 11. Insurance company investments in bank debt

Percentage as of total investment in left-hand panel; bank debt category breakdown in right-hand panel



Notes: The OECD Survey of Large Insurance Companies asks the question to what extent the respondent (company) has made or is considering material investments in subordinated bonds or preferred stocks and hybrid issues by banks, as part of the company's evolving asset management strategy. Up to 19 companies responded to the question and reported data on their relative exposure to bank issued debt as of total financial investments (the latter being defined as all forms of investment with a value associated to an insurance company; the total should be the sum of the following asset classes: "Cash and deposits", "Fixed income", "Loans", "Listed equity", "Land and buildings", "Private equity", "Unlisted infrastructure investment", "Hedge funds", "Commodities" and "Other investments") for either 2012, 2013, or 2014. Up to 15 companies reported detailed data on the breakdown of bank debt securities into senior, subordinated and preferred stocks/hybrid securities. Taking the observations for all three years together, there are altogether 56 observations for the share of insurance company investments in bank debt as of total financial investments and 33 observations for the breakdown of such debt into different categories. The shows summary statistics of the 56 observations in the left-hand panel and the mean values based on 33 observations regarding the breakdown in the right-hand panel.

Source: Authors' calculations based on data from responses to OECD Survey of Large Insurance Companies, as of 2015.

5. Concluding remarks and CMF discussions

The euro area sovereign debt crisis has illustrated that a strong nexus between sovereign and banking sector credit risk exists. It also highlighted that when such risks materialise, the distribution of the burden-sharing can have important real activity and fiscal effects. Regulatory and resolution regime changes and policy makers announcements suggest that bail-in rather than bail-out of bank creditors is to become the norm, which should have positive effects for real economic growth and public finances.

The report presents estimates of the extent to which new banking regulation reduces the size of government contingent liabilities associated with efforts to limit the effect of risks on economic stability and growth stemming from banking sector stress. It discusses the distribution of losses among bank equity holders, bond holders and other safety net tools (such as deposit insurance) and shows that the implementation of bail-in of bond holders as foreseen in new banking regulation can substantially decrease the potential public finance costs of extreme banking sector stresses.

The report also discusses the issue of where bank failure recovery or resolution bail-in losses may go. It notes that bank debt is large, especially when measured against the balance sheet size of other domestic institutional sectors. For example, in some countries, the total financial assets under management by insurance companies and pension funds taken together are smaller than the amount of domestic bank debt outstanding. The note argues that the sectoral allocation of losses matters, but concludes that our understanding of loss absorption capacity and implications across sectors needs to be further developed and that more transparency about the structure of bank creditors would be desirable. An improved understanding of the composition of bank creditors should make policy makers and supervisors feel more comfortable applying some of the new bail-in instruments that are becoming available. Also, further raising the awareness of unsophisticated investors about the risks involved in investing in bail-inable debt will be a useful complement, likely to make the use of these instruments more credible.

The OECD Committee on Financial Markets discussed at length the present and its companion report (Blix Grimaldi et al., 2016) and was very supportive of the work. Some member suggested that the estimates could be used to inform the setting of requirements related to total loss-absorption capacity and minimum requirement for own funds and eligible liabilities for bail-in. Others were more critical, however. There was also discussion around whether the estimates could be used to estimate the potential impact on bank funding costs if/when market expectations of bail-in bed in. A number of members expressed the concern that publishing estimates of implicit guarantees by national authorities embeds existing perceptions that such guarantees exist, even if estimates have come down in recent years. The issue of communication of results obtained by fiscal, supervisory or fiscal authorities in relation to implicit contingent liabilities was discussed controversially and the Committee encouraged follow-up work on how the results could be communicated and used in day-to-day policy.

Notes

1. The OECD's Committee on Financial Markets (CMF), at its 120th session on 23-24 April 2015 in Paris, provided strong support for continued work on the topic of implicit bank debt guarantees and bank failure resolution issues. The European Commission (EC) Joint Research Centre (JRC) expressed its intent to continue its collaboration with the Secretariat in this area, applying and

expanding the tools developed in support of the EC adopted bank legislation. The present report is the result of this ongoing collaboration.

2. The response rate among members was 97 per cent; for further results see Schich and Aydin (2014).
3. According to European Parliament and Council (2014a), specific classes of deposits are eligible for protection by Deposits Guarantee Schemes (DGS) in case of banks' failure. If this happens, the DGS will reimburse deposits up to EUR 100 000: the amount obtained after the EUR 100 000 threshold has been applied is referred to "covered deposit".
4. See e.g. Basel Committee on Banking Supervision (2005, 2006, 2011, 2013), Vasicek (2002), Merton (1974).
5. It should be noted that in SYMBOL the distinction between capital and subordinated debt is ignored and that losses on subordinated bonds as part of wider definitions of capital (e.g. Tier 2 capital, which also includes subordinated debt) are treated like losses on equity-holders.
6. Note that here LAC is different from the TLAC concept used in the Financial Stability Board framework.
7. Covered deposits are estimated based on data collected from EU deposit guarantee schemes and European Central Bank data, applying the methodology of Cannas et al. (2013). The updated report with 2013 and 2014 s is forthcoming.
8. Current capital is read from balance sheet data and then it is corrected to account for the new definitions of Basel III only (see European Banking Authority (2013) and the Committee of European Banking Supervisors (2010)). It implies that, after the correction, if the value of capital falls below the minimum threshold set by Basel III rules, such number is left unchanged.
9. The Basel II criteria are based on the notion 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 estimation, as well as other model uncertainties" (see Basel Committee on Banking Supervision, 2005). Laeven and Valencia (2013) identify 17 systemic banking crisis episodes in the period 2008-11 worldwide, and 147 episodes since 1970. Based on this, it is safe to say that the Basel models tend to under predict the actual frequency of bank defaults, which then carries over to model estimates.
10. Not all debt classes (senior/junior; covered/unsecured) may be evenly distributed across sectors. The distribution of bail-in losses across investor classes may differ from the estimated distribution of holdings of MFI debt securities if in particular the collateralised and uncollateralised bonds are unevenly distributed.
11. In this context, it should be noted that even institutional investors have not been particularly effective in monitoring and disciplining bank management prior to the recent global financial crisis (see OECD, 2009).
12. While a ratio below one would allow in theory absorption of all MFI debt securities by the sector, in view of portfolio risk management considerations, average exposure to MFI debt securities in a single sector exceeding 10 or 20% of the total financial assets of that sector appear to be unlikely and undesirable. Note, however, that the data considered here regarding asset holdings is confined to financial assets. In the case of households and non-financial corporations in many countries, real estate assets (which are not considered here) are an important part of overall wealth.

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ANNEX A

Technical details of the symbol model

SYMBOL relies upon the following assumptions.

- All risks are approximated as if they were credit risks; no other risk categories (e.g. market, liquidity or counterparty risks) are explicitly modelled.
- It is implicitly assumed that the IRB formula adequately represents the (credit) risks that banks are exposed to.
- No time dimension is explicitly considered in the simulated events, i.e. all losses occur at the same time in a given run.

The dataset

The simulations presented in this paper are run for the sample of financial institutions included in the last EU-wide stress testing conducted by the European Banking Authority (2014). This sample includes 117 EU banking groups (though the original sample used for the stress-test exercise comprised 123 banks) and they account for more than EUR 28 billion of total assets, representing around 74% of the EU total assets. Consolidated data on capital and risk-weighted assets are published at bank level together with the results of the stress test; data on consolidated total assets come from SNL Financial, a commercial database, and data on deposits come from Bankscope, a proprietary database of banks' financial statements produced by Bureau van Djik.

Figure A.1 shows aggregated values of the main variables of the dataset (data on aggregated banks' total assets per country come from Schoenmaker and Peek (2014)).

Table A.1. 2013 aggregated consolidated amount of selected variables for the banks in the sample

Year	Banks' sample bnEUR						Population total assets bnEUR
	Number of banks	Total assets	RWA	Customer deposits	Capital	Coverage ratio	
2013	117	28 223	10 743	10 918	1 563	74%	38 197

The key input data necessary to run SYMBOL are the following:

- Total assets;
- Risk-weighted assets;
- Total capital and/or capital ratios.

Data on covered deposits held by each bank are also key to determine the amount of funds available to the resolution funds in the safety net. Since they are not available in Bankscope, they are estimated starting from country-level data on deposits and on covered deposits¹: for each country the ratio of covered deposits over customer deposits is computed and then this ratio is applied to the customer deposits held by each bank to get an estimate of the amount of covered deposits for each bank.

Steps of the simulation

The following discusses all the steps involved in the model.

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

The main ingredient of this model is the average implied obligor probability of default of a bank. It is a single parameter describing its entire loss distribution. It is obtained by numerical inversion of the Basel IRB formula for credit risk, based on total minimum capital requirements declared in the balance sheet. Individual bank data needed to estimate the implied obligor probability of default are banks' risk-weighted assets and total assets.

For each exposure l in the portfolio of bank i , the Basel IRB formula derives the corresponding capital requirement $CR_{i,l}$ needed to cover unexpected losses² over a time horizon of one year, with a specific confidence level equal to 99.9%. The formula to compute the $CR_{i,l}$ is the following:

$$CR_{i,l}(PD_{i,l}) = \left[LGD \cdot N \left(\sqrt{\frac{1}{1-R(PD_{i,l})}} N^{-1}(PD_{i,l}) + \sqrt{\frac{R(PD_{i,l})}{1-R(PD_{i,l})}} N^{-1}(0.999) \right) - PD_{i,l} \cdot LGD \right] \cdot M(PD_{i,l})$$

where $PD_{i,l}$ is the default probability of exposure l for bank i , R is the correlation function among the exposures in the portfolio, defined in Basel regulation as

$$R(PD_{i,l}) = 0.12 \cdot \frac{1-e^{-50PD_{i,l}}}{1-e^{-50}} + 0.24 \left(1 - \frac{1-e^{-50PD_{i,l}}}{1-e^{-50}} \right) - 0.04 \left(1 - \frac{S_i-5}{45} \right),$$

and in this framework the obligor size S_i is set at the regulatory value of 50.

LGD is the Loss Given Default³ and $M(PD_{i,l})$ is a maturity adjustment defined as

$$M(PD_{i,l}) = \frac{(1+(M-2.5) \cdot b_i) \cdot 1.06}{1-1.5 \cdot b_i}$$

where $b_i = (0.11856 - 0.05478 \cdot \ln(PD_i))^2$ and maturity $M = 2.5$. Note that all the parameters are set at their regulatory default values.

The minimum capital requirement MCR_i of each bank i is, in principle, obtained summing up the capital requirements for all exposures:

$$MCR_i = \sum_l CR_{i,l} \cdot A_{i,l},$$

where $A_{i,l}$ is the amount of the exposure l .

As there are no available data on banks' exposures towards each obligor, the model estimates the default probability of a single obligor (Implied Obligor Probability of Default, IOPD) equivalent to the portfolio of exposures held by each bank by inverting the above formulas. Mathematically speaking, the model computes the IOPD by numerically searching the value that satisfies the following equation:

$$IOPD_i: CR(IOPD_i) \cdot \sum_l A_{i,l} = MCR_i$$

where MCR_i and $\sum_l A_{i,l}$ are respectively the Basel minimum capital requirement, set equal to 8% of the risk weighted assets, and the total assets of the banks. These data are available in banks' balance sheets.

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

Based on the estimated average $IOPD_i$, the model simulates correlated losses hitting banks via Monte Carlo using the same IRB formula and imposing a correlation structure among banks. This correlation exists as a consequence of the banks' common exposure either to the same borrower or, more generally, to a particular common influence of the business cycle. In each simulation run $n=1, \dots, N_0$, losses for bank i are simulated as:

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

where N is the normal distribution function, $N^{-1}(\alpha_{n,i})$ are correlated normal random shocks with pre-defined correlation matrix, and $IOPD_i$ is the average implied obligors' probability of default estimated for each bank in Step 1. SYMBOL is often run imposing an equal correlation factor of 50% among all banks, but the model allows defining *ad-hoc* correlation matrices.

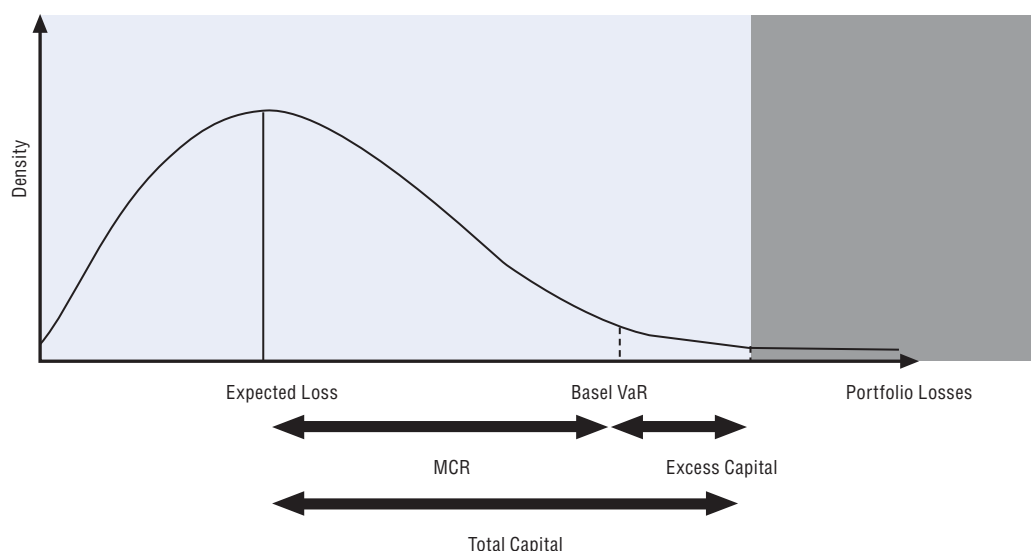
STEP 3: Determination of the failure event.

As illustrated in Figure A.1, a bank is assumed to fail when simulated economic losses exceed the sum of the expected losses (EL) and the total capital (K) given by the sum of its minimum capital requirement plus the bank's excess capital, if any:

$$Failure := L_{n,i} - EL_i - K_i > 0$$

Expected losses, which are equal to the average value of the losses, are subtracted from simulated losses because the bank is obliged to set aside technical provisions to face expected shortfalls.

Figure A.1. Individual bank loss probability density function



The light grey-shaded area in Figure A.1 represents the region where losses are covered by provisions and total capital, while the dark grey-shaded one shows when banks fail under the above definition. 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 simulations usually ends when $N_0 = 100\,000$ runs with at least one default are obtained. The large number of runs ensures a sufficient degree of stability in the tail of the loss distributions.⁴ As a consequence, the model can run for a few millions of iterations for small samples and hundreds of thousands iterations for medium or large samples.

STEP 4: Aggregated distribution of losses for the whole system.

Aggregate losses are obtained by summing losses in excess of capital plus potential recapitalisation needs of all distressed banks in the system (i.e. both failed and undercapitalised banks) in each simulation run.

Notes

1. Covered deposits are estimated based on data collected from EU deposit guarantee schemes and European Central Bank data, applying the methodology of Cannas et al. (2013). The updated report with 2013 and 2014 data is forthcoming.
2. Banks are expected to cover their expected losses on an ongoing basis, e.g. by provisions and write-offs. The unexpected losses, on the contrary, relates to potentially large losses that occur rather seldom. According to this concept, capital would only be needed for absorbing unexpected losses.
3. Set in Basel regulation equal to 45%.
4. With 100 000 runs with at least one default the uncertainty with respect to the Monte Carlo draws is small enough to guarantee the stability of results.

ANNEX B

Technical details of the safety net implementation

This framework aims at modelling the tools foreseen by the EC legislation and their intervention to absorb losses; however, a number of assumptions must be considered while modelling the impact of the safety net tools:

- Concerning the size of bail-in able liabilities, each individual bank is assumed to satisfy the minimum threshold of 8% total assets of capital plus other liabilities eligible for bail-in. Additional liabilities, eligible for bail-in, on top of this minimum are not accounted in the analysis as no data on their size is available in the dataset. The threshold is set at 8% because the BRRD states that the resolution fund can intervene only if at least 8% total assets of capital and other liabilities eligible for bail-in have already been used to absorb losses. However, resolution authorities have the power to set the amount of liabilities eligible for bail-in on a case-by-case basis, based on selected criteria set out in the BRRD. It could thus be expected that the resolution authority will require banks, and especially large ones, to hold more than the minimum level. This is also aligned with the discussion on the total amount of loss absorbing capacity for G-SIBs launched by the Financial Stability Board.
- According to BRRD, the final decision on the use of resolution funds is left to the resolution authorities. As this discretion cannot be mathematically modelled, in the present exercise the resolution funds are assumed to intervene whenever necessary.
- Though not explicitly designed in the EC legislation, the additional tools in the dashed boxes of Figure 1 are likely to further reduce losses. The s presented in Section 3 refer to the three grey boxes only and thus these results should be read as overestimations of the true financing needs, as the additional tools, not modelled, might further reduce financing needs leftover to the system.

The modelling starts from the SYMBOL output, i.e. the matrix of losses $L_{n,i}$, where n is the simulation run and i refers to the i -th bank and EL_i is the expected loss for each bank i . Capital K_i is the first cushion to absorb losses (first block of Figure 1). In this framework a bank is assumed to fail when simulated losses exhaust all available capital:

$$\text{Failure} := L_{n,i} - EL_i - K_i > 0.$$

Also recapitalisation needs up to 8% risk-weighted assets for defaulted banks are considered.¹ This reflects the level of minimum capitalization under which a bank is considered viable under Basel rules and the minimum level to which banks were recapitalised by public interventions in the past crisis.

Mathematically speaking, a bank is assumed to be undercapitalised when:

$$K_i - (L_{n,i} - EL_i) < 8\% \cdot RWA_i.$$

Following the terminology introduced in Section 3, this leads to a matrix of financing needs $Excl_{n,i}$:

$$Excl_{n,i} = \max\{L_{n,i} - EL_i - K_i + 8\% \cdot RWA_i, 0\}.$$

In case capital is not sufficient, each bank i makes use of its bail-in able liabilities ($Bailin_i$), which are set such that its total loss absorbing capacity (LAC_i) is 8% of its total assets (TA_i):

$$LAC_i = Bailin_i + K_i = 8\% \cdot TA_i.$$

Thus, the additional bail-in able liabilities (second block in Figure 1) each bank can make use of amount to:

$$Bailin_i = \max\{LAC_i - K_i, 0\}.$$

Financing needs after bail-in are thus:

$$L_{n,i}^B = \max\{Excl_{n,i} - Bailin_i, 0\}.$$

In the next step (third block in Figure 1) the RF intervenes and it can cover losses up to a ceiling equal to 5% TA_i , in line with BRRD, thus financing needs pertaining to RF are

$$L_{n,i}^{RF} = \min\{L_{n,i}^B, 5\% \cdot TA_i\}.$$

while the remaining financing needs $L_{n,i}^B - L_{n,i}^{RF}$ will remain uncovered.

Two possibilities for the RF are considered: it can operate via national compartments (NRF, National Resolution Fund) or there will be a single fund for all the banks participating to the banking union (SRF, Single Resolution Fund).

Under the NRF, in each country C the RF has at its disposal a target fund equal to 1% of the amount of covered deposits:

$$T^{NRF,C} = 1 \cdot \sum_{i \in C} CovDep_i,$$

and the financing needs that each NRF is assumed to absorb is equal to:

$$L_n^{RF} = \sum_{i \in C} L_{n,i}^{RF}.$$

Under the SRF the target is equal to

$$T^{SRF} = 1 \cdot \sum_{i \in \text{banking union}} CovDep_i.$$

and the financing needs that SRF is assumed to absorb is equal to:

$$L_n^{RF} = \sum_{i \in \text{banking union}} L_{n,i}^{RF}.$$

In the following we will indicate the generic target fund of the Resolution Fund as T^{RF} . In each simulation run n , the size of the Resolution Fund could be smaller than L_n^{RF} . In this case, the financing needs will remain uncovered.

Summarising, in each run n the total financing needs² not covered by any of the considered tool are:

$$L_n^{Leftover} = \sum_i (L_{n,i}^B - L_{n,i}^{RF}) + \max\{L_n^{RF} - T^{RF}, 0\}.$$

Notes

1. Recapitalisations needs are estimated also for banks suffering from losses but not exhausting all their capital ($L_{n,i} - EL_i > 0$ and $L_{n,i} - EL_i - K_i < 0$). However it should be noted that recapitalisation needs in simulations where no failure is observed are not included, since losses in these runs are not stored for computational reasons.
2. Though aggregated losses remain unchanged, losses at single bank level depend upon the order of intervention of the RF. The model does not take into account this issue and thus different orders might be considered (from largest to smallest banks, vice versa or random). Financing needs at single bank level are given by the following:

$$L_{n,i}^{Leftover} = \max \left\{ L_{n,i}^{RF} - \max \left\{ T^{RF} - \sum_{j=1}^{i-1} L_{n,j}^{RF}, 0 \right\}, 0 \right\} + \max \{ L_{n,i}^B - 5\% \cdot TA_i, 0 \}$$

where the inner *max* operator represents the residual fund after the RF intervened to cover losses of banks prior to bank *i*; the second addend represent the share of losses beyond the scope of the RF, if any.

ANNEX C

Data and methodology used to estimate the institutional sector breakdown of bank debt holdings

The Euro Area Accounts (EAA), published jointly by Eurostat and the European Central Bank, provide financial balance sheets for the institutional sectors of the economy (with the analytical framework being provided in the European System of Accounts 1995 – ESA95). The domestic sectors are non-financial corporations (NFC); banks (monetary financial institutions, MFIs); insurance and pension fund companies (ICPF); other financial intermediaries (OFI); general government (GOV); and households (HH). In addition, the sector “rest of the world” (ROW) is used to record transactions with non-residents and the financial claims of residents on non-residents, or vice versa. The financial positions, both on the asset and the liability sides, include various categories, the main ones are debt securities, deposits, loans and shares. The individual national data are internally consistent, meaning the sum of (transactions in) financial assets equals the sum of (transactions in) liabilities for each financial category (e.g. the sum of debt issued l_i by all institutional sectors is equal to the sum of debt held a_i by all sectors $\sum_{i=1}^N a_i = \sum_{i=1}^N l_i$). Financial accounts data are valued at market prices, at a particular point in time. Changes in financial balance sheets are due to both the accumulated flows recorded in the financial transactions account and other changes, such as revaluations. The EAA are available on a quarterly basis for the euro area countries since 1999, and the estimates discussed in the main text use data for 2012.

Table C.1 shows the framework of EAA. It provides both the amount of the liabilities in each asset class z , i.e. the amount of bonds issued and outstanding by each sector i (l_i) and the amount of the assets in each asset class, i.e. the amount of bonds held by each sector i (a_i).

Table C.1. Euro Area Accounts

Sectors	Debt securities		Loans		Deposits		Shares		Total	
	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities
Non-financial corporations	$a_{NFC,DEBT}$	$l_{NFC,DEBT}$	$a_{NFC,LOANS}$	$l_{NFC,LOANS}$	$a_{NFC,DEPOSITS}$	$l_{NFC,DEPOSITS}$	$a_{NFC,SHARES}$	$l_{NFC,SHARES}$	$\sum_{z=1}^Z a_{NFC,z}$	$\sum_{z=1}^Z l_{NFC,z}$
Monetary financial institutions	$a_{MFI,DEBT}$	$l_{MFI,DEBT}$	$a_{MFI,LOANS}$	$l_{MFI,LOANS}$	$a_{MFI,DEPOSITS}$	$l_{MFI,DEPOSITS}$	$a_{MFI,SHARES}$	$l_{MFI,SHARES}$	$\sum_{z=1}^Z a_{MFI,z}$	$\sum_{z=1}^Z l_{MFI,z}$
Other financial intermediaries	$a_{OFI,DEBT}$	$l_{OFI,DEBT}$	$a_{OFI,LOANS}$	$l_{OFI,LOANS}$	$a_{OFI,DEPOSITS}$	$l_{OFI,DEPOSITS}$	$a_{OFI,SHARES}$	$l_{OFI,SHARES}$	$\sum_{z=1}^Z a_{OFI,z}$	$\sum_{z=1}^Z l_{OFI,z}$
Insurance corporations and pension funds	$a_{ICPF,DEBT}$	$l_{ICPF,DEBT}$	$a_{ICPF,LOANS}$	$l_{ICPF,LOANS}$	$a_{ICPF,DEPOSITS}$	$l_{ICPF,DEPOSITS}$	$a_{ICPF,SHARES}$	$l_{ICPF,SHARES}$	$\sum_{z=1}^Z a_{ICPF,z}$	$\sum_{z=1}^Z l_{ICPF,z}$
General government	$a_{GOV,DEBT}$	$l_{GOV,DEBT}$	$a_{GOV,LOANS}$	$l_{GOV,LOANS}$	$a_{GOV,DEPOSITS}$	$l_{GOV,DEPOSITS}$	$a_{GOV,SHARES}$	$l_{GOV,SHARES}$	$\sum_{z=1}^Z a_{GOV,z}$	$\sum_{z=1}^Z l_{GOV,z}$
Households	$a_{HH,DEBT}$	$l_{HH,DEBT}$	$a_{HH,LOANS}$	$l_{HH,LOANS}$	$a_{HH,DEPOSITS}$	$l_{HH,DEPOSITS}$	$a_{HH,SHARES}$	$l_{HH,SHARES}$	$\sum_{z=1}^Z a_{HH,z}$	$\sum_{z=1}^Z l_{HH,z}$
Rest of the world	$a_{ROW,DEBT}$	$l_{ROW,DEBT}$	$a_{ROW,LOANS}$	$l_{ROW,LOANS}$	$a_{ROW,DEPOSITS}$	$l_{ROW,DEPOSITS}$	$a_{ROW,SHARES}$	$l_{ROW,SHARES}$	$\sum_{z=1}^Z a_{ROW,z}$	$\sum_{z=1}^Z l_{ROW,z}$
Total	$\sum_{i=1}^N a_{i,DEBT}$	$\sum_{i=1}^N l_{i,DEBT}$	$\sum_{i=1}^N a_{i,LOANS}$	$\sum_{i=1}^N l_{i,LOANS}$	$\sum_{i=1}^N a_{i,DEPOSITS}$	$\sum_{i=1}^N l_{i,DEPOSITS}$	$\sum_{i=1}^N a_{i,SHARES}$	$\sum_{i=1}^N l_{i,SHARES}$		

First we consider the amount of debt securities issued by the MFI sector, $l_{MFI,DEBT}$, in each country. Then, bilateral positions of institutional sectors in a single security type (e.g. debt securities) at country level might be represented as follows:

$$\mathbf{X} = \begin{pmatrix}
 x_{NFC,NFC} & \mathbf{x}_{MFI,NFC} & x_{OFI,NFC} & x_{ICPF,NFC} & x_{GOV,NFC} & x_{HH,NFC} & x_{ROW,NFC} & \sum_{j=1}^N a_{NFC} \\
 x_{NFC,MFI} & \mathbf{x}_{MFI,MFI} & x_{OFI,MFI} & x_{ICPF,MFI} & x_{GOV,MFI} & x_{HH,MFI} & x_{ROW,MFI} & \sum_{j=1}^N a_{MFI} \\
 x_{NFC,OFI} & \mathbf{x}_{MFI,OFI} & x_{OFI,OFI} & x_{ICPF,OFI} & x_{GOV,OFI} & x_{HH,OFI} & x_{ROW,OFI} & \sum_{j=1}^N a_{OFI} \\
 x_{NFC,ICPF} & \mathbf{x}_{MFI,ICPF} & x_{OFI,ICPF} & x_{ICPF,ICPF} & x_{GOV,ICPF} & x_{HH,ICPF} & x_{ROW,ICPF} & \sum_{j=1}^N a_{ICPF} \\
 x_{NFC,GOV} & \mathbf{x}_{MFI,GOV} & x_{OFI,GOV} & x_{ICPF,GOV} & x_{GOV,GOV} & x_{HH,NFC} & x_{ROW,GOV} & \sum_{j=1}^N a_{GOV} \\
 x_{NFC,HH} & \mathbf{x}_{MFI,HH} & x_{OFI,HH} & x_{ICPF,HH} & x_{GOV,HH} & x_{HH,HH} & x_{ROW,HH} & \sum_{j=1}^N a_{HH} \\
 x_{NFC,ROW} & \mathbf{x}_{MFI,ROW} & x_{OFI,ROW} & x_{ICPF,ROW} & x_{GOV,ROW} & x_{HH,ROW} & x_{ROW,ROW} & \sum_{j=1}^N a_{ROW} \\
 \hline
 \sum_{i=1}^N l_{NFC} & \sum_{i=1}^N l_{MFI} & \sum_{i=1}^N l_{OFI} & \sum_{i=1}^N l_{ICPF} & \sum_{i=1}^N l_{GOV} & \sum_{i=1}^N l_{HH} & \sum_{i=1}^N l_{ROW} &
 \end{pmatrix}$$

In the above matrix, a general element $x_{i,j}$ represents the amount of bonds held by sector i and issued by sector j .

For each country, the above 7x7 matrix of bilateral exposures can be estimated using the EAA aggregate data. We exploit the EAA data defining $a_j = \sum_{i=1}^N x_{i,j}$ and $l_i = \sum_{j=1}^N x_{i,j}$. For example, $a_{MFI} = \sum_{i=1}^N x_{i,MFI}$ and $l_{MFI} = \sum_{j=1}^N x_{MFI,j}$ are, respectively, the total amount of bonds issued by the MFI sector and held by all sectors i , and the total amount of bonds owned by the MFI sector and issued by all sectors j .

An approach commonly used in the contagion literature to estimate bilateral exposures from balance sheet data when no detailed information (priors) are available on the financial structure is to assume a uniform distribution (see e.g. Upper, 2011). In this way the entropy maximization of X does not introduce any structure beyond the one contained in the assets and liabilities. Using this methodology, first applied to EAA by Castrén and Rancan (2014), it is possible to estimate to what extent MFI bonds are held by each sector, $x_{MFI,i}$ (the column in bold in matrix above).

Data on government bonds held by individual banks are publicly available (through the European Banking Authority (EBA) as a result of the 2012 bank stress tests) and by aggregating this information at country level we refine our estimations. We input the

actual government bond bank holding information $x_{GOV,MFI}^*$ in Equation (1). By specifying $x_{GOV,MFI}^*$ all estimated values change accordingly. As a result, the new holdings of bank bonds across sectors are more accurate.

Finally, we rely on the EAA to compare the debt issued by domestic MFI and the size of selected institutional sectors (see Figure 10). The size of an institutional sector i is approximated by the sum of all financial classes in term of assets, $\sum_{z=1}^Z a_{i,z}$ (in Table C.1 the gray-shaded cells).



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