Completing the Banking Union with a European Deposit Insurance Scheme: Who is Afraid of Cross-subsidisation?

Jacopo Carmassi, Sonja Dobkowitz, Johanne Evrard, Laura Parisi, André F. Silva and Michael Wedow

European Central Bank; University of Bonn; European Central Bank; European Central Bank; Federal Reserve Board; European Central Bank

Abstract: *This paper investigates the impact and appropriateness of establishing a fully mutualised European Deposit Insurance Scheme (EDIS) using a unique supervisory micro-level dataset on euro area banks' covered deposits and other liabilities. Our main findings are as follows: first, an ex-ante funded Deposit Insurance Fund (DIF,) with a target size of 0.8% of euro area covered deposits, would be sufficient to cover losses even in a severe banking crisis. Second, we show possible ways of calibrating risk-based contributions to the DIF according to different sets of bank-specific and country-specific factors: this would allow taking into account the relative riskiness that they pose to EDIS, thus contributing to addressing moral hazard concerns stemming from moving from national to a European scheme. Third, smaller and larger banks would not excessively contribute to EDIS relative to the amount of covered deposits in their balance sheet. Finally, there would be no unwarranted systematic cross-subsidisation within EDIS in the sense of some banking systems systematically contributing less than they would benefit from the DIF.*

JEL codes: G01, G20, G21, G28

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1. INTRODUCTION

Deposit insurance has become a crucial pillar of banking regulation. By removing depositors' incentives to run and withdraw uninsured deposit balances when concerned about a bank's solvency, deposit insurance protects banks against funding shocks, which can in turn reduce the likelihood of financial crises and their severeness (Diamond and Dybvig, 1983). Notwithstanding the reduced liquidity risk and other benefits such as the mobilisation of savings towards financing the economy and greater banking competition (Anginer and Demirgüç-Kunt, 2018), deposit insurance also raises concerns about market discipline by depositors and moral hazard, as it strengthens the safety net provided to the banking sector (Calomiris and Jaremski, 2018). Yet, while deposit insurance was already a key regulatory tool worldwide before the 2007-2009 global financial crisis (Demirgüç-Kunt et al., 2008), this trend was reinforced after the crisis, with 112 out of 189 countries having explicit deposit insurance schemes by 2013 and several countries such as the US considerably extending deposit guarantees (Demirgüç-Kunt et al., 2015; Lambert et al., 2017). In the European Union, coverage levels were harmonised and increased to €100,000 per depositor and bank by the end of 2010 to restore the level-playing field in a context where some Member States such as Ireland and Germany introduced unlimited coverage to restore confidence. In November 2015, the European Commission also proposed the establishment of a European Deposit Insurance Scheme (EDIS) to provide a stronger degree of depositor protection and confidence across the euro area (European Commission, 2015a).

By pooling resources of national schemes to the European level, EDIS aims to reduce the vulnerability of national deposit guarantee schemes to local and systemic shocks as well as to ensure that the level of depositor confidence is independent of a bank's location (European Commission, 2016). Elevating deposit insurance to the European level is also consistent with aligning the responsibilities of supervision and resolution of banks that were brought to the European level within the Single Supervision Mechanism (SSM) and Single Resolution Mechanism (SRM). This would also contribute to reducing the bank-sovereign nexus (Brunnermeier et al., 2017). Finally, compared to the current system with national schemes, pooling the governance of deposit insurance within a single European entity would centralise decision-making, minimising coordination costs in a crisis when bank runs are more likely.

However, there are several concerns challenging the implementation of this reform. First, the Deposit Insurance Fund's (DIF) target size of 0.8% of covered deposits might not be appropriate. Second, the possibility of a reduction of contributions for specific types of banks (e.g. large banks which are more likely to go in resolution) has also been a subject of intense discussion. Finally, EDIS might lead to unwarranted cross-subsidisation i.e. the eventuality of one or several banking systems systematically contributing more and benefitting less from the scheme than other (potentially riskier) systems. This paper investigates the validity of these arguments using a unique and confidential supervisory micro-level dataset on covered deposits and other balance sheet indicators for 2,148 euro

area banks, representing approximately 75% of total assets and 90% of covered deposits of credit institutions in the euro area.

Our empirical analysis is based on two steps. First, we compute the exposure of EDIS in the case of bank failures, considering crises of different magnitude and using information on covered deposits as well as banks' estimated probabilities of default (PD), loss given default (LGD) and banks' loss-absorbing capacity as of year-end 2017. This allows us to assess the resilience of EDIS to potential loss scenarios of different severity and under different assumptions on loss absorption by banks' liabilities. In the second step, we estimate banks' contributions to EDIS and compare them to the EDIS exposures obtained in the first step. This allows us to identify possible unwarranted cross-subsidisation across euro area countries and to examine the distribution of contributions across banks of different size. Given the focus of the paper on analysing the potential impact of the introduction of EDIS in terms of cross-border subsidisation and the potential related moral hazard it entails, our analysis centers on EDIS exposures to losses stemming from bank failures, rather than on liquidity support provided by EDIS at the time of failure.[1] This is because the liquidity provided by EDIS is expected to be repaid (e.g. via liquidation proceedings), while losses would imply effective pooling of risk.

We find that a fully-mutualised and funded DIF with a target size of 0.8% of covered deposits of participating banks would be sufficient to cover losses in extremely severe crises, i.e. even more harmful than the 2007-2009 global financial crisis.[2] This result holds when considering the exposure of EDIS to banks' losses for banking crises of multiple intensities, where the riskiest 3% or 10% of banks fail simultaneously according to their estimated probabilities of default, in combination with different loss severities ranging from 5% to 25% of total assets in resolution and between 7.5% and 37.5% in insolvency, and two variations of banks' loss-absorbing capacity.

We also provide a quantitative analysis of how the calibration of deposit insurance risk-based contributions affects the distribution of contributions across countries and banks. We develop alternative methodologies to calculate contributions, according to different sets of bank- and country-specific risk factors, and compare them to the contributions that banks would pay under the assumption of a national, rather than European, benchmark for the assessment of banks' risk. We find that our methodology to derive risk-based contributions (based on the existing guidelines for national DGSs, but benchmarked at the European rather than national level), can reflect the specificities of banks and banking systems, since it allows the distribution of the contributions to vary quite substantially according to the different risk factors included in the calculation. This would be preferable to a lowering of the EDIS target level as is currently allowed under the Deposit Guarantee Scheme Directive

[1] A deposit insurance scheme typically plays two roles in the context of a bank failure. First, it pays out covered deposits within a determined timeframe (7 days in the context of the DGSD). In this role, the deposit insurance scheme acts as a liquidity provider. Second, it can incur losses in insolvency or resolution (e.g. when insolvency proceedings relating to the failed bank do not suffice to recoup the funding used).

[2] It should be stressed that the loss scenarios we use are extremely conservative. First, our loss rate lower bound of 5% of total assets, for instance, is higher than the upper bound of 4.7% reported by the FSB for G-SIBs during the last crisis (Financial Stability Board, 2015), and twice the average estimates reported by the European Commission for the period 2007-2010 (European Commission, 2012). Second, the loss rates upper bound tested in this study are applied simultaneously to all the banks assumed to fail.

(DGSD) since it maintains the Fund's level of resilience and preserves the level playing field. In addition, adjusting the indicators in the risk-based contributions would make it possible to consider the relative riskiness of the banking sectors while the DIF is being built up and while risk reduction measures are implemented (e.g. European Commission 2015b, 2017). Furthermore, a comparison of contributions that would be paid by banks of different size shows that smaller and larger banks would not excessively contribute to EDIS relative to the amount of covered deposits in their balance sheet, suggesting that measures to reduce contributions for the smallest and/or largest banks would be unwarranted.

Finally, we investigate whether EDIS would produce any systematic cross-subsidisation between banking sectors in the different Member States. Given the very high loss rates necessary to produce cross-subsidisation, which would be considerably higher than those experienced in the last global financial crisis, the findings suggest that there would be no unwarranted systematic cross-subsidisation via EDIS in the sense of some banking systems systematically contributing less than they would benefit from the DIF. This result is robust to different simulated scenarios, e.g. in the presence of random bank-level shocks, country-specific shocks or when we assume that the biggest banks in the banking sector simultaneously default. In general, cross-subsidisation can be seen as a form of desirable risk-sharing in more severe crises. However, this is different from systematic unwarranted cross-subsidisation and is in line with the purpose of an EDIS, as pooling resources ensures that national schemes are not overwhelmed in case of severe crises, thus reducing the bank-sovereign nexus.

Overall, our results suggest that an EDIS would offer major benefits for depositor protection, strengthening the overall architecture of Banking Union while posing limited risks in terms of EDIS exposure since the probability and magnitude of interventions are likely to be low. EDIS would play a key role for confidence building while avoiding risks of self-fulfilling prophecies on bank runs. The key drivers behind these results are the following: first, a significant reduction of risk in the banking system and increase in loss-absorbing capacity have taken place in the aftermath of the global financial crisis; second, the super-priority for covered deposits further contributes to protecting EDIS; third, following a "polluter-pays" approach, appropriately-designed risk-based contributions, benchmarked at the euro area level, are crucial to establish the right incentives and strike the right balance between ensuring adequate and credible deposit protection and minimising cross-subsidisation across countries. This could help addressing any potential concerns of moral hazard linked to the move from national to a European scheme and the related pooling of risk and governance.

This paper is related to the literature investigating the interaction between deposit insurance and banking sector stability. The public policy objective of such schemes is to protect unsophisticated retail depositors, prevent bank runs and the breakdown of the financial system while, at the same time, minimising aggressive risk-taking by banks (Beck, 2004). In fact, while deposit insurance is crucial in maintaining depositors' confidence in the safeness of their deposits (Diamond and Dybvig, 1983), this type of guarantee may also have unintended consequences such as excessive bank risk-taking (moral hazard) and a

decrease in effective monitoring exercised by depositors (market discipline): Allen et al. (2011), Morrison and White (2011), Karas et al. (2013), Allen et al. (2017), Lambert et al. (2017), Egan et al. (2017), Calomiris and Jaremski (2016, 2018). Indeed, theory predicts that once insured, there is a higher incentive for bankers to enlarge the value of the deposit insurance by increasing risk (Merton, 1977). On the depositor side, there is a lower incentive to search for a safer bank to entrust their savings or to demand higher interest rates in return for higher risk (Demirgüç-Kunt and Huizinga, 2004; Ioannidou and Penas, 2010). This lack of market discipline can lead to excessive risk-taking and potentially banking crises (Demirgüç-Kunt and Detragiache, 2002; Barth et al., 2004).[3]

The adverse aspects of deposit insurance schemes can, however, be mitigated by strong banking supervision frameworks as well as robust legal systems and resolution frameworks correcting risk-taking incentives (Laeven, 2002; Anginer et al., 2014).[4] In addition, the design of deposit insurance and its implementation (notably through coverage limits and the calibration of bank's premia) can have a significant impact on how deposit insurance schemes perform in practice by forcing institutions to internalise the cost of risk taking. Such risk-based premia were progressively introduced in several countries after the United States moved away from flat contributions in the early 1990s, and empirical studies show that risk-based premia are effective in reducing risk-taking by banks (Demirguc-Kunt and Detragiache, 2002; Hovakimiam et al., 2003).

Deposit insurance may also be crucial for the entire financial system during economic downturns when contagious bank runs are more likely. Anginer et al. (2014), for instance, show that while generous deposit insurance schemes increase systemic risk via moral-hazard mechanisms before a crisis, they reduce risk and increase stability during crisis times. Consistent with this view, Gropp and Vesala (2004) find that the adoption of explicit deposit insurance schemes in the EU between 1991 and 1998 led to better market discipline and lower risk-taking since they served as a commitment device to limit the safety net and permit monitoring by uninsured subordinated debt holders. Karels and McClatchey (1999), Imai (2006) and Chernykh and Cole (2011) also find positive effects from the adoption of deposit insurance in the US, Japan and Russia, respectively. More recently, Martin et al. (2018) show that deposit insurance increases the willingness of depositors to fund distressed banks, preventing the inefficient failure of solvent banks facing liquidity issues. Iyer et al. (2017) also find that a reform that limited deposit insurance coverage in Denmark caused non-systemic banks to lose almost half of their uninsured deposits. The losses of systemic banks were much smaller, stressing the destabilising effects of too-big-to-fail banks and the

[3] One additional dimension of moral hazard in the context of deposit insurance is the fact that, contrary to other types of insurances which provide cover against clearly defined losses, depositors are covered against losses resulting from any type of banking failure, and regardless of the underlying reason for that failure. This is because the confidence building effect of a deposit insurance scheme relies on the credibility of the system.

[4] In fact, the empirical evidence on deposit protection and risk taking is heterogeneous, with some studies pointing towards an increase in banks' risk taking (e.g. Ioannidou and Penas, 2010; Gropp et al., 2014), and other suggesting deposit insurance does not lead to increase risk taking (Wheelock and Wilson, 1994; Wagster, 2007; López-Quiles Centeno and Petricek, 2018). Laeven (2002) estimates the opportunity-cost value of deposit insurance services by applying the Black and Scholes option-pricing model to value the deposit insurance per U.S. dollar of deposits. While market-based measures are effective also because they provide daily outcomes, they are rather difficult to be applied in the context of the EDIS for two reasons. First, the analysis presented in this paper focuses on a sample of 2,148 banks, most of which are not listed. Second, EDIS has not been implemented yet, meaning that ex-ante valuations based on stock prices are not feasible.

importance of deposit insurance in mitigating such financial fragility.[5] Finally, Bonfim and Santos (2018) show that depositors actively react to negative shocks that raise doubts about the credibility of deposit insurance at a national level (e.g. by moving their savings to banks whose deposits are guaranteed in other countries), highlighting the importance of having a robust and credible euro-wide deposit insurance scheme.

This paper contributes to this literature by examining the potential impact of introducing previously unexplored features in the design of deposit insurance, i.e. a shift from multiple national DGSs to a single euro-wide deposit insurance scheme pooling banks' risk-based contributions in a single Fund under a European decision-making body. In fact, unlike most of the existing literature exploiting variation in insurance limits or the introduction of deposit insurance, we provide empirical evidence to support the policy discussion on EDIS design under a framework where deposit insurance is already in place throughout the euro area, and assuming that its target size relative to covered deposits would be the same.[6]

This paper also contributes to the on-going policy discussions on the design of EDIS in the broader context of the completion of the Banking Union (e.g. Gros, 2015; Gros and Schoenmaker, 2014; Schoenmaker, 2018; Bénassy-Quéré et al., 2018). Such discussions have focused on potential ways to mitigate specific moral hazard issues that would be introduced by EDIS. This is because mutualising resources in a European scheme would imply potential moral hazard not only at the bank (and depositor) level, but also at the country level through the pooling of existing risk i.e. legacy issues in some banking systems which would imply that some banking system are riskier than others. This paper contributes to this debate by analysing two main elements: the ability of a deposit insurance with resources pooled at the European level to absorb losses stemming from bank failures, and how risk-based contributions according to different risk-adjustment factors and benchmarked at the banking union level, following a 'polluter-pays' principle, could contribute to alleviate concerns of moral hazard stemming from the pooling of legacy issues in the participating Member States. This is, to the best of our knowledge, the first paper analysing this issue using supervisory bank-level data on covered deposits and other bank liabilities to compute the contributions to the deposit insurance fund and estimate the fund's exposure in case of bank failures.

[5] Deposit insurance can provide other indirect benefits. Bernet and Walter (2009), for instance, argue that deposit insurance can strengthen the competitiveness of smaller banks, foster growth by encouraging savings, and have banks financing the deposit insurance, thereby reducing costs otherwise borne by taxpayers or depositors in case of a resolution or insolvency. Brown and Dinc (2005) also find that deposit insurance, by providing a framework for dealing with failing banks, may also reduce forbearance by regulators and politicians and facilitate prompt action to close insolvent banks.

[6] The specific focus on previously unexplored issues related to a shift from national to European deposit insurance also introduces a new dimension to the moral hazard issue. In this setup, moral hazard would not be connected to different rules regulating the scheme (e.g. higher coverage level, or more flexible rules on DGS intervention in case of banks' distress), nor to the creation of a deposit insurance scheme itself (since national DGSs are already in place): it would rather be related to the marginal increase in the absolute size of the deposit insurance fund, which might incentivise higher risk-taking by banks. Therefore, the key question concerns the incremental moral hazard related to a potential increase of banks' risk taking, if any, that the shift to the European system might entail. This type of analysis, however, goes beyond the scope of this paper and can be the object of future research. Nevertheless, risk-based contributions benchmarked at the Banking Union level rather than at the national level would in any case help to compensate for the eventual relative increase in moral hazard when moving from the national to the European design of the deposit insurance scheme. An additional element to be considered is that the establishment of a single European supervisor applying prudential rules in a consistent manner throughout the euro area can be expected to contribute to a stronger and more effective supervisory framework, hence alleviating concerns of a potential increase in banking risk-taking following the establishment of EDIS.

The paper is organised as follows. Section 2 provides background information and presents recent policy developments. Section 3 describes the data, provides the methodology to estimate the EDIS exposure in case of bank failures, and reports the main findings in terms of EDIS exposure under different simulated scenarios. Section 4 discusses the rationale, methodology and empirical findings on the EDIS contributions' and cross-subsidisation analysis. Section 5 investigates the robustness of the methodology presented in Section 2 and 3. Finally, section 6 concludes.

2. Background and recent policy developments

Designing a single deposit guarantee scheme for the banking union area involves the pooling of risk and governance at the European level. This has raised a number of policy questions regarding the optimal design of EDIS to balance the need for a resilient and credible scheme bringing about the expected benefits in terms of enhancing financial stability and harmonised depositor protection, and minimising the potential moral hazard risk stemming from the change from national schemes to a European scheme.

Under the November 2015 European Commission proposal, EDIS would be set up in three stages with increased mutualisation of resources and loss-sharing in order to address these concerns. The proposal provided a timeline with an initial phase where only limited liquidity would be provided in the form of a loan towards a fully-mutualised EDIS which would cover both liquidity needs and losses stemming from bank failure. The proposal mentioned the need to calibrate the banks' contributions to the DIF to the risks they would pose to EDIS, with a view of reducing incentives for increased risk taking under the new scheme. The proposal also included 'built-in' features, such as unified governance that would limit national bias in the decisions regarding the use of the funds, or the possibility to disqualify the access to coverage in certain circumstances. It was also argued that the creation of the SSM and SRM and the increased centralisation of prudential rule making and supervision had contributed to reduced monitoring costs and moral hazard. In its effect analysis (European Commission, 2016), the European Commission therefore concluded that a fully-mutualised EDIS, in combination with the above-mentioned safeguards, would be superior to other possible models for a European scheme in terms of balancing the objectives of risk absorption, efficiency and cost neutrality, and limiting moral hazard.[7]

The proposal was debated at length in the Council of the European Union, the European Parliament and policy fora without much progress since the publication of the Commission proposal. Discussions focused in particular on the potential need of reducing risks within the national banking systems (e.g. by increasing their loss-absorbency capacity and tackling high levels of Non-Performing Loans) before embarking on further mutualisation of risks through EDIS.

[7] The other models analysed in the Commission's effect analysis were mandatory reinsurance, mandatory lending and a mutualised fund. The mandatory reinsurance model is assessed as a steady-state option based on different levels of distribution of resources between national DGSs and the European reinsurer, plus different caps for uncovered liquidity and losses for the European reinsurer. The mandatory lending model requires participating DGSs to provide up to 0.5% of covered deposits to cover the liquidity shortfall. As all loans must be repaid in full by the borrowing DGS, the lending DGS does not incur any loss. The fully mutualised fund, which is the steady state under the EDIS proposal, replaces national DGS in providing full liquidity and absorbing any loss.

In October 2017, the European Commission published a Communication on the completion of Banking Union (European Commission, 2017) aiming at breaking the deadlock. The Commission proposed to introduce EDIS more gradually relative to its original proposal, as well as to attach certain conditions to the gradual mutualisation of losses within EDIS. For instance, the move to the second phase, i.e. co-insurance where losses in addition to liquidity needs would be shared, would not be automatic but contingent on a set of conditions to be assessed by the Commission, for example related reduction of banks' portfolios of NPLs and Level 3 assets.[8] Furthermore, the possible path of mutualisation from co-insurance to full insurance was not specified.

Political negotiations have continued in 2018 but no consensus was reached, neither on the technical features of EDIS nor on the timing and conditionality for implementation. In June 2018, the euro summit mandated the Eurogroup to start work on a roadmap for beginning political negotiations on an EDIS. In December 2018, the Eurogroup communicated that further technical work was still needed and set up a high-level working group which will work on the next steps and will present a report by June 2019. Therefore, while the initial ambition on EDIS was high, with the November 2015 proposal by the European Commission aiming to a fully-mutualised EDIS in the steady state, subsequent developments have to some extent lowered that ambition and led to an impasse. Currently, it is not possible to foresee if and when an agreement on EDIS will be reached and what its main features could be. A fully-mutualised EDIS is still on the table; however, recent policy discussions have also considered different approaches to EDIS, notably referring to a possible design under which national DGSs would intervene first, and the European deposit insurance fund would only step in as the second line of defense. Despite some technical differences, the idea of national DGSs or national compartments of EDIS bearing the first burden is common across several proposals, e.g. respectively the November 2016 draft report of the Committee on Economic and Monetary Affairs, drafted by Member of the European Parliament Esther de Lange, and the proposal by a group of French and German economists in January 2018 (Bénassy-Quéré et al., 2018). The key idea behind this approach is that having national DGSs in the first line and taking the first losses could help tackle the potential moral hazard risks and ensure that Member States maintain some "skin in the game". Schoenmaker (2018) argued, however, that keeping national compartments in a European deposit insurance system might cause destabilising effects in times of crisis, because the surviving banks would need to refill the national compartments (exhausted by the failure of the other banks) exactly in a period of crisis.[9] Schoenmaker (2018) also advocated the use of a country component in the risk-based premium for deposit insurance (e.g. the effectiveness of insolvency procedures), as also proposed by Bénassy-Quéré et al. (2018).

Against the background of the discussion on different possible designs, it is important to note that our paper focuses exclusively on the fully-fledged EDIS, as in the steady state of the 2015 European Commission proposal. Other models as well as the transition phase to a

[8] Level 3 assets are illiquid assets which cannot be evaluated on the basis of market prices or models.

[9] For further analyses on a mixed EDIS with national compartments and a European deposit insurance fund, see Carmassi et al., 2018.

fully-fledged EDIS fall outside the scope of this paper. Moreover, this focus implies that the analysis abstracts from existing national schemes including the institutional protection schemes (IPS) which exist in a number of countries. It has been argued that membership in an IPS should be considered as a risk-mitigating factor, given the possibility and tools within an IPS to prevent banks from failing before a pay-out event occurs. There are a number of ways to consider IPS in the context of EDIS which can create important trade-offs. For example, banks that are members of IPS could join an EDIS with lower contributions. However, this would imply that contributions of other banks participating in EDIS would need to increase.[10] Alternatively, IPS could continue to coexist alongside with EDIS without contributing to and benefiting from EDIS coverage. The trade-off in this context would be a considerable reduction in the resources available to EDIS and the diversification benefits of a larger membership.

3. EDIS EXPOSURE IN CASE OF BANK FAILURES

3.1. Data

Our main analysis uses confidential supervisory data from COREP (Common Reporting) and FINREP (Financial Reporting) on euro area banks' covered deposits and other balance sheet indicators as of 2017:Q4. To estimate EDIS exposure in case of bank failures and the risk-based contributions to EDIS at bank level, we complement this dataset with (i) publicly available annual financial statements from Fitch Connect[11] from 2000 to 2017, (ii) a unique dataset of bank distress events over the same period covering bankruptcies, defaults, liquidations, state aid cases and distressed mergers collected from Orbis Bank Focus, the European Commission and Fitch Connect, and (iii) several banking-sector and macro-financial variables available at the ECB's Statistical Data Warehouse.[12] The sample scrutinised comprises 2,148 euro area banks with total assets of €20.26 trillion, which amounts to about 75% of total assets of credit institutions in the euro area, and €4.9 trillion of covered deposits, corresponding to about 90% of the overall covered deposits of credit institutions in the euro area. Thus, the sample can be considered as representative, both in terms of total assets and covered deposits.[13] The target size of the DIF for the sample is approximately €39.3 billion.

[10] This is for instance the approach that was taken in the case of the calculation of banks' contributions to the SRF, through the addition of a dummy in the formula for the calculation of the banks' contributions. However, it could be argued that the introduction of a simple dummy would fall short of appropriately reflecting the underlying riskiness of banks under an IPS – as there is considerable variation in terms of governance, funding and tools that can be used by these schemes across Europe. Therefore, a reduction of risk-based contributions should be considered only if it can be shown that the membership in an IPS effectively reduces a bank's riskiness and exposure to EDIS. This however goes beyond the scope of this paper but could be considered in future research.

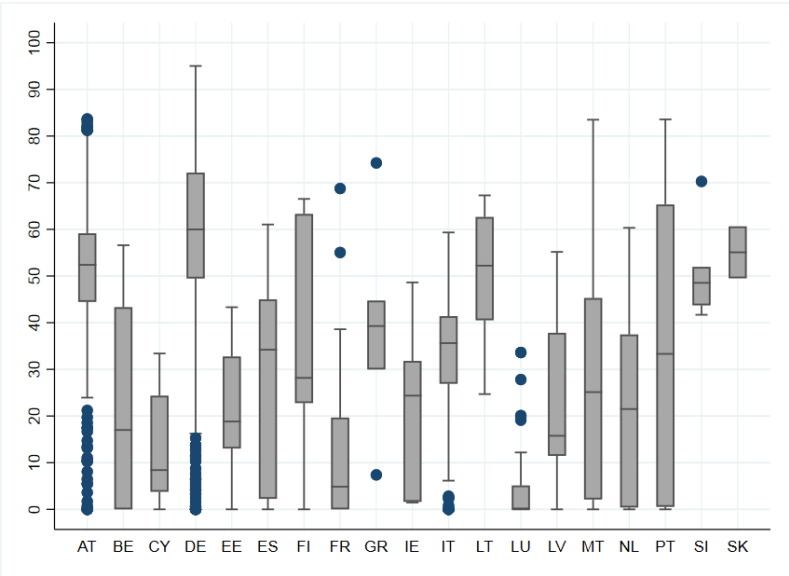
[11] To have information at the highest aggregated level and avoid double counting within the same institution, we discard unconsolidated entries if banks report consolidated data.

[12] The conclusions of the analysis are based on the assumption that banks' balance sheet structure remains the same until EDIS has been fully introduced. Although it is not possible to foresee how banks' balance sheet structures will look like at the time when EDIS will eventually be implemented, new and forthcoming regulatory requirements (e.g. Basel III rules, MREL) and current policy discussions point in the direction of an additional strengthening of banks' balance sheets in the next years.

[13] The degree of representativeness of the sample at country level is, however, heterogeneous. A more detailed description of the sample coverage is provided in the Online Appendix, Table IA2.

The box plot in Figure 1 shows the distribution of covered deposits per total assets within each country in the euro area as of year-end 2017. There is generally heterogeneity across countries both in terms of median and dispersion. German banks, for instance, have the highest median of covered deposits per total assets in the euro area, but also considerable variation in the amount of covered deposits relative to their balance sheet size.

Figure 1. Distribution of covered deposits to total assets by country (in %)



Notes: The bottom and top of the box represent the first and third quartiles of the within-country distribution, while the band inside the box is the second quartile (median). The ends of the whiskers are the maximum and minimum values excluding outliers. Outliers are represented by blue circles.
Sources: ECB calculations based on confidential supervisory data for 2,148 banks, reporting date 2017:Q4.

3.2. Methodology

3.2.1. Probability of default estimation

The analysis of the exposure of EDIS is based on crisis simulations following Betz et al. (2014) and Lang et al. (2018)'s methodology for calculating the Probability of Default (PD) for individual banks. Specifically, using panel data from 2000 to 2017, the PD of 5,526 euro area banks is estimated via an early warning model that accounts for different bank-specific, banking sector and macro-financial variables. The algorithm is as follows:

1. Estimate the benchmark early-warning model on the in-sample period (2000-2015), such that:

$$\Pr\left(Y_{i,c,t} = 1\right) = \Lambda(\beta' X_{i,c,t} + \delta' Z_{c,t} + \mu_c)$$

where $Y_{i,c,t}$ is the distress signal for bank *i* operating in country *c* in period *t* i.e., rather than using lagged explanatory variables, the outcome variable denoting the vulnerable (or pre-distress) state is defined as 1 within two years prior to a distress event, and 0 otherwise.[14] $\Lambda(\beta' X_{i,c,t} + \delta' Z_{c,t} + \mu_c)$ is the benchmark logit model that features bank-specific characteristics X_{ict}, banking sector and macro-financial indicators $Z_{c,t}$, as well as country fixed effects μ_c as in Constantin et al. (2018), for instance.[15]

2. Using the benchmark model from Step 1, estimate distress probabilities $\hat{p}_{i,c,2017}$ for the out-of-sample period (*t*=2017) and use the threshold λ to signal vulnerable banks. The final distress signals are given by:

$$Y^*_{i,c,2017} = \begin{cases} 1 & if \;\; \hat{p}_{i,c,2017} \geq \lambda \\ 0 & if \;\; \hat{p}_{i,c,2017} < \lambda \end{cases}$$

To estimate the coefficients used to calculate bank-specific PDs, banks in the sample are classified as either in distress/default or not in distress/default. The identification of distress events can be challenging given that actual bank failures have not been frequent in the euro area. As a result, in line with Betz et al. (2014), a bank is defined as in distress/default if: (i) the status of the bank in the Orbis Bank Focus database is either "bankruptcy", "dissolved" or "in liquidation"; (ii) the bank has negative capital; (iii) the bank was involved in a distressed merger, i.e. the merged entity has a negative coverage ratio (capital equity and loan loss reserves minus non-performing loans to total assets) one year before the merger; or (iv) the bank received state aid based on the data from the European Commission.[16]

Table 1 shows the estimated coefficients from logit regressions using various combinations of bank and country-level characteristics, with standard errors clustered at the bank-level throughout.[17] All coefficients on the bank-level variables considered are statistically significant in models (1) to (6). Consistent with existing evidence (e.g., Laeven and Levine, 2009; Beck et al., 2013), the reported coefficients indicate that banks with higher interest expenses, higher provisions for NPLs, lower tangible equity, lower deposits as a share of assets, higher cost to income ratio, as well as larger and less profitable banks have a higher probability of default. In terms of country-level characteristics, also consistent with economic theory and previous empirical evidence (e.g. Lang et al., 2018), the estimates indicate that banks' probability of default is higher in countries with higher financial assets as a share of GDP, lower change in the ratio of mortgages to loans, lower change in the ratio

[14] Following the literature standard, we use a forecast horizon of two years prior to bank distress/default events in order to identify the build-up of vulnerabilities with a sufficient lead time. As in Bussière and Fratzscher (2006), we account for post-crisis and crisis bias by not including the year when a bank distress event occurs or the year after. Post-distress periods are only included in the sample if they are also pre-distress periods.

[15] We use a logit analysis since the model's assumption of more fat-tailed error distribution corresponds better to the frequency of banking crises and bank distress events (van den Berg et al., 2008).

[16] This information is publicly available at: http://ec.europa.eu/competition/state_aid/register/. In this analysis, resort to central bank Emergency Liquidity Assistance is not considered as an indicator of distress/default, because it concerns banks that are facing temporary liquidity problems but are solvent.

[17] While the configuration of the standard errors is not relevant for the actual PD estimations, these are important for the interpretation of the marginal effects in Table 1. Table IA1 in the Online Appendix presents summary statistics for all the variables used in the estimation.

of issued debt securities to total liabilities, higher change in the 10-year government bond yield and higher inflation.

Table 1: Estimated coefficients for the early warning models

	(1)	(2)	(3)	(4)	(5)	(6)
Interest Expenses / Total Liabilities	0.287***	0.287***	0.301***	0.264***	0.281***	0.285***
	(0.053)	(0.056)	(0.058)	(0.054)	(0.054)	(0.058)
Provisions for NPLs / Total Assets	0.402***	0.403***	0.363***	0.341***	0.230***	0.256***
	(0.020)	(0.020)	(0.021)	(0.023)	(0.026)	(0.031)
Tangible Equity / Total Assets	-0.197***	-0.194***	-0.179***	-0.118***	-0.124***	-0.116***
	(0.044)	(0.044)	(0.042)	(0.043)	(0.039)	(0.036)
ln Total Assets				0.247***	0.171***	0.163***
				(0.058)	(0.053)	(0.052)
Return on Equity					-0.019***	-0.016***
					(0.005)	(0.005)
Deposits / Total Assets					-0.018***	-0.020***
					(0.003)	(0.004)
Cost to Income Ratio					0.013***	0.012***
					(0.003)	(0.003)
Financial Assets / GDP		0.000	0.000	0.000**	0.001***	-0.000
		(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
Loans / Deposits (1-year change)		-0.007**	-0.009***	-0.008***	-0.003	-0.005**
		(0.003)	(0.003)	(0.002)	(0.002)	(0.002)
Mortgages / Loans (1-year change)		-0.002	-0.054	-0.037	-0.046	-0.125**
		(0.066)	(0.062)	(0.055)	(0.050)	(0.049)
Issued debt / Total liabilities (1-year change)				-0.194***	-0.078**	-0.092***
				(0.043)	(0.037)	(0.033)
Bank Concentration					2.941***	0.097
					(0.726)	(1.166)
Total credit / GDP (3-year change)			0.005	0.002	0.001	0.010**
			(0.004)	(0.004)	(0.004)	(0.004)
10-year yield (1-year change)			0.048***	0.055***	0.043***	0.047***
			(0.012)	(0.014)	(0.011)	(0.012)
Unemployment			0.092***	0.052***	0.023	0.064*
			(0.018)	(0.020)	(0.020)	(0.033)
ln GDP per capita				-0.863*	-0.653	-1.295
				(0.484)	(0.444)	(1.826)
Inflation					0.075***	0.087***
					(0.013)	(0.015)
No. Observations	55,418	55,418	55,418	55,418	55,418	55,418
Country FE	N	N	N	N	N	Y
No. Banks	5,526	5,526	5,526	5,526	5,526	5,526
No. Distressed Banks	287	287	287	287	287	287
AUROC	0.828	0.828	0.828	0.827	0.867	0.871
Pseudo-R-squared	0.162	0.165	0.176	0.207	0.269	0.284

Notes: Standard errors clustered at the bank level in parentheses. Statistical significance at the 10%, 5% and 1% levels is denoted by *, ** and ***, respectively.
Source: ECB staff calculations based on Fitch Connect, ECB Statistical Data Warehouse, Orbis Bank Focus and European Commission dataset on state aid measures.

Given the distribution of the estimated PDs for the 2,148 banks in our sample (77 of which are Significant Institutions - SIs), we use the threshold $\lambda = 3\%$ (corresponding to the 97th percentile of banks with the highest PDs) and $\lambda = 10\%$ (corresponding to the 90th percentile of banks with the highest PDs) to single out the banks that were most likely to fail as of year-end 2017. The analysis thus conservatively assumes that, for each crisis

simulation, all banks belonging to the riskiest 3% or 10% fail simultaneously. The 97th and 90th percentiles correspond to a PD of 7.54% and 2.50%, respectively.[18]

In terms of model performance, the relatively high area under the receiving operating curve (AUROC) indicates that the early warning models can explain and predict the data well.[19] Given that the coefficient estimates are robust across specifications, and given the very high correlation between the PDs estimated with the different models reported in Table 1 (above 70% both in terms of estimated PDs and rankings), we use specification (6) throughout the paper to estimate bank-level PDs in the year 2017 for the 2,148 euro area banks for which we have available data on covered deposits and other liabilities.[20] This allows us to maximise the number of banks in the study, and thus the representativeness of our analysis, without weakening the model's performance.

We also perform two out-of-sample tests to help validating our PD estimates. First, to verify whether the banks with the highest PDs based on our estimates are the same banks that are defined to be in distress/default, we implement an exercise predicting PDs as of year-end 2015 instead. Specifically, considering the same regressors as in our benchmark specification (column 6 of Table 1), we estimate our benchmark early-warning model but on the in-sample period 2000-2013 to estimate the probability of default/distress in 2015, and then compare these estimated probabilities with actual default/distress events within the next two years. Given that the outcome of the model is a probability (continuous variable, between 0 and 1) while the observed defaults and distress events are classified as a dummy variable, two different thresholds have been used to transform the estimated PDs into dichotomic values: (i) when the estimated PD is higher than the PD corresponding to the 97th percentile of the distribution, the bank is classified as in default/distress - this choice is consistent with the 3% riskiest banks failing scenario; and (ii) when the estimated PD is higher than the PD corresponding to the 90th percentile of the distribution, the bank is classified as in default/distress - this choice is consistent with the 10% riskiest banks failing scenario.

Table IA3 in the Online Appendix summarises the performance of our PD estimation model under options (i) and (ii). The overall accuracy of the model is extremely high under both options (i) and (ii), ranging from 90.5% to 96.2%. In addition, as expected the discrimination between failing and non-failing banks based on the 90th percentile (option ii) substantially increases the sensitivity of the model.

Finally, in a second out-of-sample test we compare the estimated PDs in 2017 obtained from estimating our baseline early warning model with CDS spreads on senior unsecured debt. Using CDS spread data collected from Markit, we are able to match the estimated PDs with CDS spreads as of year-end 2017 for 73 euro area banks. The correlation between our PD estimates and 2 and 5-year CDS spreads on senior unsecured debt is 0.59 and 0.57,

[18] Due to the empirical set-up for the estimation of PDs, crisis simulations in this analysis strongly depend on observed banking failures and crises. Additionally, while the data on independent variables used to calculate banks' probabilities of failing are point in time (year-end 2017), the coefficients for the regressions to obtain PDs are calculated taking the economic and financial cycle into account. The inclusion of the recent financial crisis may influence this paper's results leading to potential discrepancies between simulated failures and those possibly materialising in the steady state.

[19] AUROC is a global measure of how well the model can classify observations into distress and non-distress periods. An uninformative model has an AUROC of 0.5, while a perfect model has an AUROC of 1.

[20] The conclusions presented throughout the paper do not change using either model to estimate PDs.

respectively, thus confirming that our model performs well in identifying banks in default/distress.

3.2.2. Loss given default

To define a range for the Loss Given Default (LGD), i.e. the amount of losses for each bank when it fails, we have considered the historical bank losses observed in the past, particularly during the recent financial crisis. The European Commission (2012) estimated average losses for 23 banks over the period of 2007-2010 to be 2.5% of total liabilities (maximum of 46.4%; minimum of 0.2%), while losses plus recapitalisation needs were on average 6% of total liabilities (maximum of 50.7%; minimum of 2.6%). The Financial Stability Board found that for G-SIBs losses as a fraction of total assets ranged from less than 1% to 4.7%, with most banks in a 2-4% range. The maximum ratio of losses and recapitalisation amounts relative to total assets was 8.8%, with most banks between 3.9% and 6.1% (Financial Stability Board, 2015).

Given the evidence above and the significant variation in the estimates of LGDs, we consider a wide range for the average LGD of banks in distress. Since one of the objectives of the simulations in this paper is to also test an extremely stressful scenario, we consider losses in resolution (with bail-in) from 5% to 25% of total assets. This is an extremely conservative range if compared to the values observed in the last crisis. The lower threshold of 5% total assets, for instance, is higher than the upper bound reported by the FSB for G-SIBs during the last crisis, and twice the average estimates reported by the Commission for the period 2007-2010. In addition, the analysis presented in this paper not only simulates extremely severe shocks, but also considers the same amount of losses simultaneously affecting a wide sample of banks, e.g. the 3% and the 10% of the euro area riskiest banks. This is a very conservative assumption, also when compared to events in the last financial crisis.

Insolvency proceedings can be particularly complex, costly and time-consuming, thus often resulting in higher average losses than when a bank is resolved. This is true even if one ignores externalities such as spillovers into the rest of the financial system and the losses that could ultimately be borne by the bank's depositors (Hardy, 2014). Therefore, to consider the complexity, cost and length of insolvency proceedings, losses in insolvency are assumed to be always 50% higher than the losses in resolution, and therefore range from 7.5% to 37.5%.

3.2.3. Resolution and loss-absorption capacity

The need for an EDIS contribution in case of a bank failure depends on whether the bank goes into resolution or insolvency, and on its level of loss-absorption capacity. For the purpose of the analysis, it is assumed that a bank would be resolved if it has (i) a balance sheet size of more than €20 billion, or (ii) more than 40,000 transactional accounts, and that

it would otherwise be liquidated.[21] Since there is no available data on the number of transactional accounts for the banks in the sample, the assumption is that any bank with more than €4 billion in covered deposits is above the 40,000 threshold, i.e. that each account has €100,000 (corresponding to the maximum amount covered by deposit insurance per depositor per bank). This assumption is conservative, since on average each account has less than €100,000. Therefore, the analysis may overestimate the number of banks going into insolvency rather than resolution, which is overall conservative in terms of losses since insolvency may cause more destruction of value than resolution. In resolution, a contribution from the Single Resolution Fund (SRF) is considered in each scenario, respecting the conditions set out in the legislation. This means that SRF contributions are capped at a maximum of 5% of bank's total assets after shareholders and creditors have absorbed losses and recapitalisation costs corresponding to at least 8% of total assets.[22] In addition, cumulative SRF contributions cannot exceed the overall size of the SRF (i.e. 1% of total covered deposits in the sample which equals €49.2 billion[23]). Furthermore, the DIF contribution in resolution cannot be higher than the contribution it would have paid in insolvency.[24]

Regarding banks' loss-absorption capacity in resolution, two scenarios are used in the analysis:

A. All liabilities except for secured liabilities and covered deposits absorb losses;

B. Only regulatory capital, subordinated debt and senior unsecured bonds with a remaining maturity of at least 12 months absorb losses.

Scenario A is always used to model banks' loss-absorption capacity in liquidation. The analysis follows the existing creditor hierarchy, where covered deposits have a super-priority, both in resolution and liquidation. Indeed, the BRRD and the SRMR make it possible to subject a wide range of unsecured liabilities to losses, e.g. via a bail-in, and give a super-priority to covered deposits in the ranking of creditors. However, in practice, it is unlikely that all liabilities within the scope of bail-in will be fully loss-absorbing at the point of resolution. Therefore, scenario B considers a bail-in scenario in which only MREL-eligible liabilities are considered to be fully loss-absorbing (but deposits of large corporates above €100,000 are not included, despite being MREL-eligible, to make the scenario more conservative). It should be noted, however, that senior unsecured liabilities currently rank alongside other liabilities classes, e.g. derivatives. Thus, it is unlikely that they would be fully loss-absorbing given the "no-creditor-worse-off" principle.

[21] These assumptions broadly follow the Bank of England's proposed approach to direct institutions to maintain a minimum requirement for own funds and eligible liabilities, in their December 2015 consultation paper (Bank of England, 2015). Following feedback to the consultation, the Bank of England made two changes regarding the transactional accounts threshold: first, it clarified that accounts are defined as "transactional" on the basis of the frequency of their use (at least nine withdrawals over the previous three months); second, a range of between 40,000 and 80,000 accounts replaced a fixed threshold of 40,000; see Bank of England (2016).

[22] The BRRD (art. 44.5 and 49.3) requires that the 8% threshold to allow SRF intervention and the 5% cap on the SRF intervention are calculated on total liabilities and own funds (TLOF), taking into account netting agreements for derivatives (see European Parliament and Council of the European Union, 2014a). However, this analysis uses total assets as a proxy for TLOF due to data availability issues.

[23] For the purpose of the calculation of this cap, only ex-ante contributions are taken into account. Ex-post contributions to the SRF could raise the cap.

[24] See Article 79 of the Single Resolution Mechanism Regulation (European Parliament and Council of the European Union, 2014b). To ensure that this condition is met, the EDIS exposure for a bank subject to resolution is compared to that bank's hypothetic loss posed to EDIS if it had been liquidated. The EDIS exposure is then set to be the lower of the two.

3.3. Results

Table 2 reports the simulation results of the estimated exposure of EDIS under loss absorbency scenarios A and B in resolution, respectively. These scenarios are estimated for different levels of LGD and different PD thresholds, i.e. the 90th and 97th percentiles. Additionally, for all scenarios the simulations show the estimated EDIS exposure with and without SRF contribution assuming the requirements mentioned in the previous section are satisfied.[25]

Table 2: EDIS exposure in EUR billion for scenario A and B, with and without SRF contribution

		Scenario A in resolution				Scenario B in resolution			
		Without SRF		With SRF		Without SRF		With SRF	
1)	2)	3)	4)	5)	6)	7)	8)	9)	10)
Loss Resolution	Loss Insolvency	3% riskiest banks	10% riskiest banks	3% riskiest banks	10% riskiest banks	3% riskiest banks	10% riskiest banks	3% riskiest banks	10% riskiest banks
5%	7.5%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10%	15%	0.00	0.02	0.00	0.02	0.00	0.02	0.00	0.02
15%	22.5%	0.00	0.21	0.00	0.21	0.00	0.21	0.00	0.21
20%	30%	0.06	0.46	0.06	0.46	1.34	3.58	1.34	3.58
25%	37.5%	0.32	1.10	0.32	1.03	14.05	21.34	14.05	21.34

Note: Resolution scenario A: all liabilities except for secured liabilities and covered deposits absorb losses. Resolution scenario B: only capital, subordinated debt and senior unsecured bonds with a remaining maturity of at least 12 months absorb losses. EDIS target size rescaled on the sample amounts to EUR 39.3 bn. Loss in resolution and insolvency as % of total assets.
Source: ECB staff calculations based on Fitch Connect, COREP and Orbis Bank Focus, 2017:Q4.

The table depicts different levels of losses for scenario A (B) in columns 3 to 6 (columns 7 to 10) as a percentage of total assets, both in resolution and insolvency (columns 1 and 2). Columns 3(7) and 5(9) represent the DIF exposure when the riskiest 3% (10%) of euro area banks in the sample fail, without and with SRF contribution, respectively. For the sample of 2,148 banks, the 3% scenario implies the simultaneous failure of 65 banks which hold 13.9% of the total assets in the sample. 21 of those failing banks enter into resolution and 44 into insolvency corresponding to, respectively, 13.0% and 0.88% of the total assets in the sample. Columns 4(8) and 6(10) show the equivalent numbers for an extremely severe crisis where the riskiest 10% of euro area banks in the sample fail, respectively, both without and with SRF contribution. This implies the failure of 215 banks which hold approximately 80.8% of the total assets in the sample.

[25] The analysis takes into account the following caps: (1) a ceiling for the SRF contribution in order not to deplete the SRF (SRF contribution is capped at 1% of covered deposits of participating banks); (2) EDIS exposure for each bank cannot exceed the amount of covered deposits held by that bank; (3) a resolution cap not allowing EDIS exposure in resolution to exceed the theoretical exposure if the bank had been subject to insolvency; and 4) SRF contribution cannot exceed 5% of a bank's total assets. Note that, in this exercise, the fact that DGS contribution in resolution cannot exceed 50% of its target level as per Article 109 BRRD and Article 79 SRMR is not considered. As a result of the different caps which limit EDIS exposure, the exposure numbers are similar with and without SRF contribution calculations. Furthermore, it should also be noted that only bank losses are considered for the calculations on the EDIS exposure, while bank recapitalisation needs (which would not be borne by EDIS) are not included.

We find that the EDIS exposure never exceeds the DIF target size in the sample, equal to € 39.3bn. In other words, despite the severity of the simulated losses (up to 25% of the total assets in resolution, simultaneously applied to all the 3% and 10% riskiest banks in the sample), and the conservative assumptions on the loss absorbing capacity in resolution (Scenario B), the fund would never be depleted.

The results also suggest that a fully-funded DIF with ex-ante contributions of 0.8% of covered deposits would have only extremely limited exposure in cases of loss rates up to 20% in resolution and 30% in insolvency, in both scenarios A and B (no exposures with the 3% riskiest banks failing; maximum € 0.21bn exposures with the 10% riskiest banks failing). This finding reflects the strengthening of banks' loss-absorbing capacity and the effects of the risk-reducing measures that have been implemented so far.

Under scenario A where all liabilities except for secured liabilities and covered deposits absorb losses, EDIS exposure remains very limited in all the crisis-loss combinations, with and without SRF contribution in resolution - even with a loss rate equal to 25% of total assets in resolution, for instance, the EDIS exposure is €320 mln if the 3% riskiest banks in the sample simultaneously fail, and it goes up to a maximum of € 1.1bn (without SRF contribution) if the entire set of the 10% riskiest banks in the sample is assumed to be in distress.

Under scenario B where only regulatory capital, subordinated debt and senior unsecured bonds with a remaining maturity of at least 12 months absorb losses, EDIS exposure would become material only in case of losses at least equal to 25% of total assets in resolution. It should be emphasised that, according to the FSB estimates (see Section 3.2.2), during the last crisis only one bank reported losses higher than 8% of total assets. In order to trigger high EDIS exposures, in this study it is necessary to assume that the entire 3% (or 10%) of the banks in the sample are affected by the 25% loss rate - a scenario considerably harsher than the historical cases occurred both in Europe and the US. It is important to note, in fact, that the analysis in this paper assumes a simultaneous failure of the riskiest banks and a fixed level of losses relative to total assets rather than a distribution, which is extremely more conservative than what was observed in past crises, notably for high loss levels.

4. RISK-BASED CONTRIBUTIONS TO EDIS

4.1. Rationale

The post-crisis review of the European Deposit Guarantee Scheme Directive (DGSD) applied the concept of risk-based contributions to national DGSs to address concerns related to moral hazard. The Commission proposal on EDIS also foresees the use of risk-based contributions to the DIF. The use of a "Banking Union methodology", i.e. a methodology comparing banks across the banking union rather than within each national banking system, would have the potential to reduce the risk of cross-border subsidies compared to a system where banks' contributions would be calculated only relative to their national peers. This is because, following a "polluter-pays" principle, a national banking system would contribute

more to the DIF overall if it is riskier relative to other banking systems in the banking union. This approach would have the benefit of aligning incentives and tackling moral hazard, since banking systems which include riskier banks would contribute more to the DIF overall than they would if contributions were solely based on the amount of deposits or calculated only taking into account the riskiness of banks within the national banking system.

Since national DGSs are already in place in all Member States, the literature indicates that the introduction of EDIS (I.e. the move from national to a European scheme) could lead to a potential increase in banks' risk taking given the pooling of deposit insurance resources into a larger fund. In this context, this paper provides a comparison between the risk-based contributions that banks would pay under the two systems, with the objective of understanding which calibration of the contributions (national or European) would better reflect the relative risk that banks pose to EDIS. To do so, the results include a measure of cross-border subsidisation. As noted in the introduction, we do not quantitatively measure the implications of moral hazard in terms of a potential increase of banks' risk taking – this type of analysis falls outside the scope of this paper and could be the object of future research. Consequently, – the paper does not show empirical evidence that the risk-based contributions calculated at the Banking Union level would completely neutralise any potential increase in moral hazard in a dynamic way. However we show that, given a certain level of banks' riskiness, benchmarking the contributions at the Banking Union level is likely to reduce cross-border subsidisation with respect to the national benchmarking.[26] Since the focus of policy debates has been on the potential moral hazard stemming from pooling legacy risks (i.e. risk stemming from risk taking prior to the crisis),[27] rather than on the potential increase of banks' risk taking stemming from a pooling of DGS resources at the European level, this focus would appear to be in line with the most recent policy discussions.

4.2. Methodology

Our analysis is based on a modified version of the methodology developed by the EBA for national DGSs in which banks' contributions are risk-based given that a methodology for EDIS has not been developed. It must be stressed that, while the EBA methodology for national DGSs applies the risk adjustment at a national level, the risk adjustment in this analysis is carried out at the banking union level.

According to the EBA Guidelines (EBA, 2015), the calculation of an institution's contribution is based on five risk categories: (1) capital, (2) liquidity and funding, (3) asset quality, (4) business model and management, and (5) potential losses for the DGS (this factor is not considered in this analysis due to limited data on unencumbered assets). For the purpose of this study, the leverage ratio and the total risk-based capital ratio are included for

[26] As noted above, we also point to other features of EDIS which would dampen concerns of increased banks' risk taking, notably through the reinforcement of the European supervisory and regulatory framework as well as through in-built features of EDIS aiming at aligning incentives.

[27] This is exemplified by the focus in policy discussions on the need for a sequencing in the introduction of EDIS. Notably, some argue that existing risks in certain weaker national banking systems should be reduced prior to mutualising resources at the European level.

category (1), liquid assets per total assets[28] are included for category (2), and the Return on Equity (ROE) and Risk Weighted Assets (RWA) per total assets are used for the category representing an institution's business model and management (4). Furthermore, the analysis includes a measure of (part of) MREL-eligible liabilities.[29] The higher the MREL, the higher the likelihood of a bank going into resolution rather than liquidation, the higher the bank's expected capacity to absorb losses and, ceteris paribus, the lower the potential exposure for EDIS.[30] The combination of these indicators shall hereinafter be referred to as "DGS-baseline indicators" and is comparable to the list of indicators proposed for EDIS. As these indicators are still under discussion, the set used here does not prejudge the final calculation method that will be decided by the Council of the EU and the European Parliament. In a first modification of the baseline list of indicators, the indicator for MREL-eligible liabilities is excluded to test the impact of this indicator on the contributions. In a second modification, the established baseline set of indicators is extended by additionally including an indicator for interconnectedness measured as the sum of loans and advances from and to banks relative to the total amount of these items in the sample. The non-performing loans ratio (category (3)) is not included in the baseline analysis because of data limitations. However, it is reported separately in column 7 in Table 3, where it is added to the baseline indicators to indicate its potential relevance for the purpose of future analyses. Finally, the established baseline indicator set is extended by including the World Bank index for the strength of insolvency frameworks, since the proper functioning of the insolvency framework will have an impact on the deposit insurance's capacity to recover money in insolvency after a payout.[31]

The EBA Guidelines suggest two alternative approaches to constructing aggregate risk weights (ARW) that are used in the contribution calculation: a bucket approach and a sliding scale approach. The results presented are those for the sliding scale approach, since this approach requires fewer assumptions and uses a normalisation method that is better suited to preserving the level of information of the indicators.[32] The 25th and 75th percentiles are used as lower and upper boundaries, respectively.[33] The normalisation transforms each individual indicator value into an individual risk score (IRS) such that a lower score corresponds to a better performing bank in the respective field. In a second step, the IRSs are aggregated using a weighted arithmetic average to obtain a single aggregate risk score

[28] Defined as: (Cash & balances with central banks + Net loans and advances to banks + Level 1 assets (fair value hierarchy)) / Total Assets.

[29] Senior unsecured bonds only: regulatory capital is not included to avoid double consideration, given that it is already used for category (1) on capital.

[30] The EDIS exposure could be lower for several reasons: for example, MREL-eligible liabilities cannot be suddenly withdrawn, e.g. in a run, because they must have residual maturity of at least one year; losses in insolvency tend to be higher than in resolution; the losses for the deposit guarantee scheme in resolution cannot be higher than in insolvency (see Article 109 of the BRRD and Article 79 of the SRMR).

[31] See Resolving Insolvency

[32] See OECD and JRC (2008). The construction of the composite risk indicator is a crucial topic in the calculation of risk-based contributions as contributions strongly depend on the choice and design of the various steps taken to calculate the ARW. The aforementioned work of the OECD and JRC gives an insightful overview of indicator construction in general.

[33] Except for the NPL ratio, where missing values are set to zero in order to keep the sample size large, the first and third quartile thresholds are both zero. To avoid division by zero and to produce a more differentiated IRS, the upper bound is set to the highest value observed.

(ARS) for each bank.[34] The relative size of the weights used in the analysis follows the EBA Guidelines. In this paper's analysis the ARS is not rescaled before it is used as an ARW in the contribution calculation.[35]

In a last step, banks' contributions are calculated as the product of the contribution rate, the ARW, the total covered deposits held by a bank and an adjustment factor that ensures that contributions add up to the target size, which is set to 0.8% of the total covered deposits in the sample. To gain some insight into the importance of the calculation method used, the results are also compared with the risk-based contributions calculated under the SRF approach.[36]

We would like to remark that the calculation of risk-based contributions is the necessary step to identify potential cross-subsidisation, meaning some banking systems systematically contributing less to EDIS than what they would receive from EDIS. Alternative methodologies to derive payments to EDIS could thus lead to changes in the identification of potential cross-subsidisation problems, as well as an incentive for banks to continue their risk-reduction process according to prioritised sources of risk, thus potentially facilitating political negotiations. The calculation of EDIS contributions under different assumptions on the bank-specific and/or banking-sector specific risk factors has been driven by two factors: on the one side the methodology would be grounded on the EBA guidelines for national DGSs that are currently implemented to calculated risk-based contributions to national DGS benchmarked at the national level, and that also allow for the introduction of additional risk indicators in the calculation. On the other hand we wanted to anchor our analysis to the current policy discussion, focused on which risk factors should be included in the calculation of banks' risk scores. In this context, we deemed it useful to reflect on proposals by some Member States and researchers (Schoenmaker, 2018) calling for country-specific components in the calculation of risk-based premia.

Finally, we note that the results of the analysis are predicated on the assumption that our methodology for risk-based contributions allows for a fair pricing of deposit insurance.

4.3. Results

Table 3 gives an overview of the amounts (in billions of euro) and the share contributed by each banking system based on the different indicator sets described above. All columns are obtained using the DGS sliding scale methodology according to the EBA Guidelines. Column 3 shows the amount and the non-risk based share contributed only on the basis of covered deposits amounts. Column 4 reports contributions and the share for each banking system on the basis of the DGS baseline indicators. The comparison between columns 3 and

[34] An alternative to this aggregation method would be a geometric average which, in contrast to the arithmetic average, does not allow for the compensation of a poor performance in one field by a very good performance in another field (OECD and JRC, 2008).

[35] Rescaling has a distorting effect on aggregate risk scores by, in this case, reducing risk scores for riskier banks more than for safer banks.

[36] The construction of the aggregate risk weight for contributions to the SRF differs in several aspects from the EBA Guidelines. For instance, for the normalisation method the relevant Commission delegated regulation prescribes a bucketing approach, applies several rescalings and makes use of geometric and linear aggregation methods. For a full description of the methodology see European Commission, 2015b.

4 provides an indication of the impact of the risk factor in the calculation of contributions. A reduction in contributions following the "polluter-pays" principle is visible for banks in Austria, Belgium, France, Ireland, Spain and the Netherlands; on the contrary, banks in Germany, Greece, and Portugal would see an increase in contributions due to their higher risk with respect to the European benchmark. Columns 5 to 8 show the modifications of the baseline indicators as described in the previous section and column 9 presents the results based on the SRF approach. The impact of the MREL indicator on the contributions becomes apparent when comparing column 4 to column 5. This indicator can be perceived as a proxy for a bank's likeliness to go into resolution instead of insolvency. The inclusion of this variable means that banks which are likely to go into resolution experience a reduction in contributions; the rationale being that these banks are expected to cause less exposure for EDIS. A reduction in contributions following the inclusion of the MREL indicator can be observed, for instance, for French, Spanish, Italian and Dutch banks, and could potentially constitute an alternative to a target level reduction in favour of countries in which a significant portion of banks is likely to go into resolution rather than insolvency. This approach would have the advantage of not reducing the overall target level of EDIS, thereby maintaining its level of resilience. It should be noted that, as our analysis is based on banks' current risk profiles, and given this composition of indicators, contributions from larger banks are likely to decrease further in the future when MREL buffers are built up.

Column 6 shows the results under the same DGS methodology, but also including an indicator for interconnectedness. This would allow the risks posed by the failure of interconnected banks to the rest of the banking system, and hence to EDIS, to be taken into account. Column 7 shows the results with the inclusion, on top of the baseline, of an indicator for NPLs, the NPL ratio (non-performing loans and advances over total gross loans and advances as reported in FINREP). Even though the ratio is only available for 1,344 banks in the sample (due to data limitations the NPL ratio is set to zero for the other banks), NPLs are likely to be an important indicator affecting the possibility of cross-subsidisation within EDIS and has featured prominently in the discussions on EDIS. Table 5 shows that the inclusion of the NPL ratio as a risk factor in the DGS methodology would decrease contributions in Germany, Spain, France and the Netherlands with respect to the baseline. Contributions would instead increase in Austria, Italy and Greece.

In addition, column 8 reports risk-based contributions when the World Bank index for the strength of insolvency frameworks is included. This is relevant given the impact of insolvency regimes in allowing DGSs to effectively recoup resources in insolvency proceedings. With respect to the baseline, the inclusion of the index modifies the contributions of banking systems in most Member States: in particular the contributions of German banks are overall significantly reduced, while they increase in Spain, France, Greece, Ireland and Italy.

Table 3: Contributions by country based on DGS sliding scale methodology

1)	2)	3) Non risk-based (0.8% of covered deposits)		4) DGS – Baseline		5) DGS without MREL indicator		6) DGS plus Interconnectedness		7) DGS plus NPL ratio		8) DGS plus insolvency indicator		9) SRF methodology with baseline indicator set	
MS	**N. banks**	EUR bn	% Fund	EUR bn	% Fund	EUR bn	% Fund	EUR bn	% Fund	EUR bn	% Fund	EUR bn	% Fund	EUR bn	% Fund
AT	333	0.79	2.0	0.69	1.8	0.61	1.6	0.70	1.8	0.82	2.1	0.82	2.1	0.75	1.9
BE	13	0.60	1.5	0.45	1.1	0.43	1.1	0.50	1.3	0.45	1.1	0.46	1.2	0.54	1.4
CY	5	0.02	0.1	0.03	0.1	0.02	0.1	0.03	0.1	0.04	0.1	0.03	0.1	0.02	0.1
DE	1375	12.35	31.4	15.37	39.1	14.20	36.1	14.11	35.9	15.14	38.5	12.48	31.8	13.31	33.8
EE	6	0.01	0.0	0.01	0.0	0.01	0.0	0.01	0.0	0.01	0.0	0.01	0.0	0.01	0.0
ES	19	7.46	19.0	7.15	18.2	7.54	19.2	7.40	18.8	6.91	17.6	7.89	20.1	7.33	18.6
FI	5	0.08	0.2	0.09	0.2	0.08	0.2	0.07	0.2	0.08	0.2	0.07	0.2	0.09	0.2
FR	34	6.89	17.5	5.44	13.8	5.83	14.8	5.99	15.2	5.21	13.3	6.61	16.8	6.44	16.4
GR	7	0.81	2.1	0.92	2.4	0.99	2.5	0.91	2.3	1.25	3.2	1.01	2.6	0.96	2.4
IE	7	0.62	1.6	0.42	1.1	0.43	1.1	0.49	1.2	0.46	1.2	0.52	1.3	0.56	1.4
IT	242	4.44	11.3	4.44	11.3	4.72	12.0	4.46	11.3	4.88	12.4	5.03	12.8	4.47	11.4
LT	5	0.09	0.2	0.07	0.2	0.04	0.1	0.07	0.2	0.07	0.2	0.08	0.2	0.08	0.2
LU	31	0.15	0.4	0.13	0.3	0.12	0.3	0.14	0.4	0.13	0.3	0.15	0.4	0.14	0.3
LV	15	0.05	0.1	0.03	0.1	0.02	0.0	0.04	0.1	0.03	0.1	0.04	0.1	0.05	0.1
MT	9	0.02	0.1	0.03	0.1	0.02	0.1	0.03	0.1	0.03	0.1	0.03	0.1	0.02	0.1
NL	16	4.23	10.8	3.13	8.0	3.33	8.5	3.53	9.0	2.92	7.4	3.16	8.0	3.78	9.6
PT	17	0.60	1.5	0.78	2.0	0.83	2.1	0.74	1.9	0.77	2.0	0.78	2.0	0.66	1.7
SI	7	0.08	0.2	0.09	0.2	0.07	0.2	0.08	0.2	0.09	0.2	0.09	0.2	0.08	0.2
SK	2	0.03	0.1	0.05	0.1	0.04	0.1	0.04	0.1	0.05	0.1	0.05	0.1	0.03	0.1
Total	2148	39.32	100.0	39.32	100.0	39.32	100.0	39.32	100.0	39.32	100.0	39.32	100.0	39.32	100.0

Notes: The DGS-baseline calculation includes the following indicators: total risk-based capital ratio, leverage ratio, highly liquid assets per total assets, RWA per total assets, MREL-eligible liabilities (only senior unsecured bonds), and ROE.
Source: ECB staff calculations based on Fitch Connect, COREP, FINREP and Orbis Bank Focus, 2017:Q4.

A comparison of contributions based on the SRF method in column 9 with non-risk adjusted contributions (based on covered deposits only) in column 3 and with contributions calculated using the EBA Guidelines (column 4) suggests that contributions based on the SRF methodology could be less risk sensitive than those based on the DGS method. SRF-based contributions fall in the range between risk-unadjusted and DGS-method-based contributions. The former are closer or equally close to the risk-unadjusted contributions as DGS-method-based contributions for all countries. This points towards a lower risk sensitivity of the SRF methodology. The reason for this finding is the effect of the rescaling of the aggregate risk scores. While it is used to calculate contributions with the SRF methodology, in this analysis a final rescaling to the risk scores under the DGS approach is not applied.[37] Indeed, when rescaling risk scores, prior to the contribution calculation, to the same range which is used in the SRF methodology [0.8, 1.5], the contributions converge towards non-risk adjusted contributions. Furthermore, they are even closer to non-risk adjusted contributions than those based on the SRF methodology.

[37] The EBA Guidelines do not explicitly require risk scores to be rescaled. Furthermore, the boundaries can be chosen freely. Choosing a range of [0,100] would leave the risk scores unchanged.

4.3.1. Distribution of contributions to the DIF across banks

Another key issue relates to the distribution of EDIS contributions across banks and to the question of whether the risk-based contributions should be further lowered for smaller banks (to ensure the proportionality principle) or whether the target level should be lowered for larger banks (as these are less likely to benefit from EDIS). Table 4 sheds light on these issues showing, for each decile of banks' total assets in our sample of 2,148 banks, the sum of contributions, the average contribution per euro of covered deposits and the smallest and largest value of contributions per covered deposits. Column 3 provides the aggregate amount of contributions paid by banks in each decile. The numbers suggest that the smallest 10 percent of banks in our sample would pay € 0.08bn, or 0.16% of the € 39.3bn target size of EDIS. In contrast, the largest 10% of banks would pay € 29.5bn, or 59% of the overall EDIS target. These numbers need to be put in relation to the actual covered deposits of the banks in each decile to check whether the largest banks bear the brunt of the cost of EDIS. In fact, column 4 suggests that the smallest and the largest banks' contribution per covered deposits on their balance sheet is relatively low on average with approximately 0.9 cent and 0.74 cent per euro, respectively.[38] It is rather the banks in the intermediate decile range that pay slightly more ranging from 1 to 1.13 cents per euro of covered deposits. This finding is further underpinned by the range of the largest and the smallest contributions per euro of covered deposits in column 5 which demonstrates that the range for each decile is by and large comparable. Together, the results indicate that smaller and larger banks would not excessively contribute to EDIS, relative to their amount of covered deposits.

Table 4: Contribution distribution across different bank sizes

1)	2)		3)		4)	5)	
Decile group by total assets	**Interval total assets**		**Total contribution per decile group**		**Contribution per EUR of covered deposits, average**	**Contribution per EUR of covered deposits, interval**	
	Smallest in EUR billion	Largest in EUR billion	EUR billion	% of DIF		Lower bound	Upper bound
10	0.00	0.10	0.08	0.16	0.0090	0.0029	0.0167
20	0.10	0.17	0.16	0.32	0.0094	0.0016	0.0163
30	0.17	0.27	0.26	0.52	0.0100	0.0021	0.0166
40	0.27	0.40	0.42	0.84	0.0105	0.0000	0.0162
50	0.40	0.64	0.60	1.21	0.0106	0.0018	0.0167
60	0.64	0.98	0.94	1.88	0.0110	0.0020	0.0171
70	0.98	1.50	1.54	3.08	0.0113	0.0024	0.0169
80	1.50	2.42	2.34	4.67	0.0110	0.0028	0.0168
90	2.42	5.09	3.47	6.93	0.0105	0.0017	0.0171
100	5.14	1750.35	29.51	58.97	0.0074	0.0009	0.0164

Notes: Each decile corresponds to 167 or 168 banks; Contribution based on DGS baseline indicator set.
The value in column 1 indicates the upper bound of the interval the observation belongs to (for example, "20" refers to all banks with total assets being above the 10th and below or equal to the 20th percentile).
Source: ECB staff calculations based on Fitch Connect, COREP and Orbis Bank Focus, 2017:Q4.

[38] To note, this contribution is not a "one-off" but is rather built-up over the years as EDIS is being filled.

4.3.2. Cross-subsidisation

We measure cross-subsidisation as the ratio between EDIS exposures and contributions paid to EDIS, aggregated at the country level. A value of this ratio exceeding one indicates that the banks in a country would contribute to EDIS less than what they would receive from EDIS in case of a certain simulated crisis, thus providing an indication of cross-border subsidisation. Therefore, by definition, our measure aims at identifying ex-post cross-subsidisation, i.e. arising after a bank crisis and in case EDIS is used to cover losses.[39]

Tables 5 and 6 provide information about the magnitude of cross-subsidisation across banking systems under simulated crises of different magnitude and under two assumptions on EDIS contributions. First, the 3% riskiest banks (65 banks, representing the 13.9% of the total assets of the entire sample) are assumed to fail and to be hit by losses from 5% (7.5%) to 25% (37.5%) of total assets in resolution (insolvency). The same loss levels are then applied to the 10% riskiest banks failing (215 banks, representing approximately the 81% of the total assets of the entire euro area sample), thus simulating an extremely severe crisis. In both cases, EDIS exposures are compared to EDIS contributions obtained using two different methodologies: non-risk based contributions (implying that the DIF target size in each country is equal to 0.8% of domestic covered deposits) and risk-based contributions (calculated following the DGS-baseline indicators as reported in Table 3).

Table 5 reports the results referred to the 3% riskiest banks failing, under resolution scenario B and with potential SRF intervention. The first two columns refer to a given LGD value under resolution and insolvency. Rows 1, 4, 7, 10 and 13 show the EDIS exposures per euro contributed for banking systems in each country under the assumption of non-risk based contributions: this is equal to the sum of the EDIS exposure posed by all banks located in a country divided by the sum of the contributions paid by the same banks conditional on the national target level of the fund being equal to 0.8% of domestic covered deposits. A value exceeding one (red cells in the Tables below) indicates that the banks in a country would contribute less than what they would receive from EDIS in the simulated crisis when 3% of the riskiest banks fail.[40] Rows 2, 5, 8, 11 and 14 show the same EDIS exposures per euro contributed in each member state, but under the assumption of risk-based contributions calculated as in the DGS-baseline methodology. Finally, rows 3, 6, 9, 12 and 15 report EDIS exposure in euro billion for given LGD values. For a crisis in which 3% of the banks in the sample fail simultaneously, the analysis shows that there is never an EDIS

[39] Cross-subsidisation could also be measured from an ex-ante perspective i.e. before a default occurs. Moving from national to a European deposit insurance scheme could produce two different effects: first, it could change the amount of risk-based contributions that a bank has to pay to the scheme, because riskiness would be assessed at the banking union level rather than at the national level; second, it might affect the interest rate that a bank has to pay on deposits. For example, a bank could end up paying more contributions under EDIS (since its relative riskiness at the European level is higher than its relative riskiness assessed at the national level), but might also benefit from a European deposit insurance system via higher perceived safety from depositors and hence lower interest rates. If such benefit is higher than the increase in risk-based contributions, then this would entail ex-ante cross-subsidisation. Assuming the volume of deposits remains constant and given the change in banks' risk-based contributions, the assessment of ex-ante cross-subsidisation should thus measure how big the decrease in the interest rate on deposits should be in order to overcome the increase in contributions. Such an assessment of potential ex-ante cross-subsidisation is outside the scope of this paper but is certainly an interesting topic for future research.

[40] This methodology is used as a proxy for cross-subsidisation and is based on several assumptions, including those for the estimation of PDs and the calculation of risk-based contributions. Among the various caveats, as explained in Section 4.2.1, is the fact that the coefficients to calculate PDs are estimated using through-the-cycle data while PDs are obtained using point-in-time data for the independent variables. Risk-based contributions are also based on point-in-time data. The effectiveness of the risk-based contributions as a tool to mitigate cross-subsidisation is therefore subject to the aforementioned limitations.

exposure and, consequently, no cross-subsidisation (under both contributions' options) for loss rates in resolution up to 15% of total assets. Some EDIS exposure only starts to materialise in Belgium and Greece for loss rates in resolution of 20% of total assets: in this scenario, cross-subsidisation would occur in Belgium with both contributions' calculations. Cross-subsidisation is found in Belgium, Spain, Greece and Slovakia for loss rates of 25% in resolution (37.5% in insolvency) and with both contributions' calculations with the exception of Greece, where cross-subsidisation would occur only in case of non-risk based contributions (equivalent to having national DGSs rather than a European deposit insurance scheme): similarly, cross-subsidisation significantly decreases in case of risk-adjusted contributions to EDIS also in Slovakia.

Table 6 reports the results referred to the 10% riskiest banks failing, under resolution scenario B and with potential SRF intervention as in Table 5. The number of banks affected by losses is now 215, which is approximately three times bigger than in Table 5. In addition, these banks have assets corresponding to about 80% of the total assets of euro area banks in the sample, meaning that hitting all these 215 banks simultaneously with losses in resolution (insolvency) ranging from 5% (7.5%) to 25% (15%) of total assets creates a scenario much more severe than the last crisis. As in Table 5, the red cells indicate exposures per euro contributed above 1, meaning that banks in a country, for a certain loss rate, would contribute less than what they would receive from EDIS in case of a crisis, thus indicating cross-subsidisation.

The first evidence of EDIS exposure is found for loss rates of 10% and 15% in resolution (15% and 22.5% in insolvency), although extremely limited and equal to € 20mln and € 210mln, respectively. In both cases, EDIS exposures occur in Germany and Portugal. Consistently with the results reported in Table 5, the first evidence of cross-subsidisation is visible in Belgium for loss rates equal to 20% of total assets in resolution: for these LGD values also banks in Germany, Spain, Greece, Malta and Portugal would be exposed to EDIS, even though their contributions would exceed their EDIS exposures. The results thus show very limited evidence of cross-subsidisation despite the severity of the simulated crisis. Losses equal to 25% of total assets in resolution (37.5% in insolvency) are necessary to observe cross-subsidisation in more countries, precisely in Belgium, Spain, Greece, Malta and Slovakia. In the latter three cases, the results also show that risk-based contributions strongly decrease cross-subsidisation with respect to non-risk-based contributions.[41] Given the high loss rates[42] necessary to produce cross-subsidisation (and given that such rates are set equally high for all banks, making the crisis more severe than in actual crises where loss

[41] The same analysis has been applied also to data up to 2015Q4, although on a smaller sample of euro area banks due to data limitations. In particular, the sample adopted in the previous analysis comprised 1,675 banks, accounting for € 4.7bn of covered deposits. As a consequence, also the amount and size of the riskiest banks assumed to fail were lower than the numbers presented in this Section. In the 10% riskiest banks scenario, for instance, with 2015:Q4 data we included in the riskiest tail only 167 banks, accounting for 40% of the total assets in the sample. 2017:Q4 data allowed us to improve the sample, thus also increasing the number of the 10% riskiest banks (215 institutions, accounting for 80% of the total assets in the sample). Despite such increase in the sample coverage and the severity of the simulated scenarios, we observed a reduction in the overall EDIS exposures. Considering again as an example the 10% riskiest banks simultaneously failing, EDIS exposures reduced from € 30.4bn (2015:Q4 data) to € 21.3bn (2017:Q4 data). This is due to the increased loss-absorbing capacity of banks, in terms of both regulatory capital and senior unsecured bonds (eligible for the bail-in tool). Same conclusions can be applied also in case we assume the 3% riskiest banks in the sample to simultaneously fail.

[42] As a term of comparison, see the loss rates referred to the last crisis in Section 2.2.2.

rates vary across banks), these findings suggest that there is no unwarranted systematic[43] cross-subsidisation via EDIS in the steady state.[44]

The estimation of banks' default probabilities is the first methodological step implemented in this study to identify the riskiest banks in the sample, which are subsequently hit by hypothetical losses so to derive potential EDIS exposures in case of a simulated crisis. It could be argued that the shift from national to European deposit insurance might increase moral hazard at the bank level, in particular because of the larger amount of financial means available via the European fund. If we assume that some additional moral hazard would be triggered by EDIS – an assumption that should be carefully proved, but that falls beyond the scope of this paper – then the introduction of EDIS could increase bank risk-taking and their riskiness thus potentially affecting bank PDs, and this mechanism could possibly create endogeneity problems. This also depends on the fact that, in our analysis, the PDs have been estimated in a time period where only national DGSs were in place, and therefore they do not account for any possible increase in banks' riskiness due to the introduction of EDIS. However, what matters for the purposes of this study (i.e. considering a methodological framework with a fixed percentage of banks assumed to fail in each scenario) is not the absolute level of banks' default probabilities, but rather their relative ranking, which determines which banks in the sample fall in the right tail of the PD distribution. If all PDs symmetrically increase e.g. due to moral hazard, then the results of the analysis would remain valid since the riskiest banks in the sample would not change. Conversely, if PDs are asymmetrically affected by the potential increase in moral hazard, then the composition of the riskiest banks in the sample could change, possibly leading to changes in EDIS exposures. However, even this latter scenario is taken into account in our study, precisely by randomly sampling the riskiest banks among the entire sample regardless of their estimated default probability. Overall, we believe that even assuming that an increase in the amount of available financial means in the fund would increase moral hazard, this would not be automatically sufficient to alter the results of this study; and even if this was the case, we provide empirical tests to check the robustness of our results. Therefore, while we do not address the possible endogeneity problem related to the potential vicious circle between default probabilities and increased size of the deposit insurance fund, the implications for our results are likely to be contained, if any.

[43] We do not propose any hard threshold to define cross-subsidisation as "systematic", because such threshold would be inevitably arbitrary. However, conceptually the "systematic" nature of cross-subsidisation can be associated to cases where cross-subsidisation is identified for more than one country and across all LGD levels.

[44] An assessment of the possible cross-subsidisation in the transition to the steady state would require a different quantitative analysis and is not the object of this paper. Furthermore, due to the lack of granular information on the nationality of deposit holders, no specific consideration and treatment have been given to cross-border deposits, i.e. deposits at one bank headquartered in a Member State which are held by counterparts from other Member States. This implies that the results could in principle overestimate the extent of cross-subsidisation.

Table 5: Cross-subsidisation: Fund exposure per euro contributed and in EUR billion - 3% riskiest banks failing

Loss resolution (%TA)	Loss Insolvency (%TA)	Country	AT	BE	CY	DE	EE	ES	FI	FR	GR	IE	IT	LT	LU	LV	MT	NL	PT	SI	SK	TOT
		Non risk-based contributions (EUR bn)	0.79	0.60	0.02	12.35	0.01	7.46	0.08	6.89	0.81	0.62	4.44	0.09	0.15	0.05	0.02	4.23	0.60	0.08	0.03	39.32
		Risk-based contributions (EUR bn)	0.69	0.45	0.03	15.37	0.01	7.15	0.09	5.44	0.92	0.42	4.44	0.07	0.13	0.03	0.03	3.13	0.78	0.09	0.05	39.32
			EDIS exposure																			
5%	7.50%	(1) per EUR contributed: non risk-based	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		(2) per EUR contributed: risk-based	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		(3) in EUR bn	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10%	15%	(4) per EUR contributed: non risk-based	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		(5) per EUR contributed: risk-based	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		(6) in EUR bn	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15%	22.5%	(7) per EUR contributed: non risk-based	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		(8) per EUR contributed: risk-based	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		(9) in EUR bn	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20%	30%	(10) per EUR contributed: non risk-based	0.00	**2.12**	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		(11) per EUR contributed: risk-based	0.00	**2.84**	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		(12) in EUR bn	0.00	**1.27**	0.00	0.00	0.00	0.00	0.00	0.00	**0.06**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.34
25%	37.5%	(13) per EUR contributed: non risk-based	0.00	**5.53**	0.00	0.00	0.00	**1.29**	0.00	0.00	**1.01**	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.28	0.00	**1.83**	
		(14) per EUR contributed: risk-based	0.00	**7.41**	0.00	0.00	0.00	**1.34**	0.00	0.00	0.89	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.21	0.00	**1.12**	
		(15) in EUR bn	0.00	**3.32**	0.00	0.00	0.00	**9.58**	0.00	0.00	**0.83**	0.00	**0.10**	0.00	0.00	0.00	0.00	0.00	**0.16**	0.00	**0.05**	14.05

Notes: EDIS exposure per euro contributed for each country is calculated as the sum of EDIS exposures to all banks within a country divided by the sum of contributions of all banks of that country; The table refers to loss-absorbency scenario B in resolution with 90th-percentile crisis simulation and with potential SRF intervention; Banks' contributions to EDIS are based on DGS sliding scale method and DGS-baseline indicators. *Source:* ECB staff calculations based on Fitch Connect, COREP and Orbis Bank Focus, 2017:Q4.

Table 6: Cross-subsidisation: Fund exposure per euro contributed and in EUR billion - 10% riskiest banks failing

Loss resolution (%TA)	Loss Insolvency (%TA)	Country	AT	BE	CY	DE	EE	ES	FI	FR	GR	IE	IT	LT	LU	LV	MT	NL	PT	SI	SK	TOT
		Non risk-based contributions (EUR bn)	0.79	0.60	0.02	12.35	0.01	7.46	0.08	6.89	0.81	0.62	4.44	0.09	0.15	0.05	0.02	4.23	0.60	0.08	0.03	39.32
		Risk-based contributions (EUR bn)	0.69	0.45	0.03	15.37	0.01	7.15	0.09	5.44	0.92	0.42	4.44	0.07	0.13	0.03	0.03	3.13	0.78	0.09	0.05	39.32
		EDIS exposure																				
5%	7.50%	(1) per EUR contributed: non risk-based	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		(2) per EUR contributed: risk-based	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		(3) in EUR bn	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10%	15%	(4) per EUR contributed: non risk-based	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	
		(5) per EUR contributed: risk-based	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	
		(6) in EUR bn	0.00	0.00	0.00	**0.01**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.01**	0.00	0.00	0.02
15%	22.5%	(7) per EUR contributed: non risk-based	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	
		(8) per EUR contributed: risk-based	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	
		(9) in EUR bn	0.00	0.00	0.00	**0.14**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.07**	0.00	0.00	0.21
20%	30%	(10) per EUR contributed: non risk-based	0.00	**2.12**	0.00	0.02	0.00	0.25	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.26	0.00	0.20	0.00	0.00	
		(11) per EUR contributed: risk-based	0.00	**2.84**	0.00	0.02	0.00	0.26	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.15	0.00	0.00	
		(12) in EUR bn	0.00	**1.27**	0.00	**0.28**	0.00	**1.84**	0.00	0.00	**0.06**	0.00	0.00	0.00	0.00	0.00	**0.01**	0.00	**0.12**	0.00	0.00	3.58
25%	37.5%	(13) per EUR contributed: non risk-based	0.00	**5.53**	0.00	0.03	0.00	**2.17**	0.00	0.00	**1.01**	0.00	0.03	0.00	0.00	0.06	**3.09**	0.00	0.59	0.00	**1.83**	
		(14) per EUR contributed: risk-based	0.00	**7.41**	0.00	0.03	0.00	**2.26**	0.00	0.00	0.89	0.00	0.03	0.00	0.00	0.10	**2.53**	0.00	0.45	0.00	**1.12**	
		(15) in EUR bn	0.00	**3.32**	0.00	**0.41**	0.00	**16.16**	0.00	0.00	**0.83**	0.00	**0.14**	0.00	0.00	**0.003**	**0.07**	0.00	**0.35**	0.00	**0.05**	21.34

Notes: EDIS exposure per euro contributed for each country is calculated as the sum of EDIS exposures to all banks within a country divided by the sum of contributions of all banks of that country; The table refers to loss-absorbency scenario B in resolution with 90th-percentile crisis simulation and with potential SRF intervention; Banks' contributions to EDIS are based on DGS sliding scale method and DGS-baseline indicators.
Source: ECB staff calculations based on Fitch Connect, COREP and Orbis Bank Focus, 2017:Q4.

5. ADDITIONAL TESTS

5.1. EDIS exposures and cross-subsidisation with random shocks

The results on EDIS exposures and cross-subsidisation presented before depend on the banks that are assumed to be in distress. Thus, as a robustness test we also explore an alternative scenario in which banks are not assumed to be in distress on the basis of a model, but randomly. This test has two advantages. First, it helps understanding whether the model to estimate PDs is actually able to identify the riskiest banks in the sample: if the average results obtained with the random shocks are lower than the EDIS exposures presented in Tables 5 and 6, then we have a further indication that the PD model performs well and effectively captures the riskiest banks in the sample. Second, the random-sampling test addresses the consequences of possible endogeneity problems in the sense of some banks shifting their risk appetite as a result of the shift from national to a European deposit insurance scheme. Thus, the results from this exercise gauge how much EDIS exposures would change (on average) in case variations in banks' risk taking completely change the composition of the riskiest banks in the sample. Specifically, the outcomes reported in Table 7 are obtained by assuming that the distressed banks (i.e. the banks suffering losses according to certain LGD values) are chosen as a random subsample corresponding to the 3% of the sample in terms of number of institutions. The analysis is then reiterated 10,000 times (meaning that 10,000 random subsamples are extracted, and EDIS exposures are derived for each of them), and the results obtained are the averages across all simulations.[45] We perform the same type of exercise for the 10% failing banks scenario, with the corresponding average results reported in Table 8.

The results in both Tables 7 and 8 confirm that, on the one hand, the EDIS would be largely sufficient to cover losses even in extremely severe scenarios (LGD in resolution equal to 25% of total assets, simultaneously applied to a subsample representing the 10% of the sample in terms of number of institutions) and, on the other hand, that the EDIS would not pose any risk of unwarranted cross-subsidisation since countries would receive less from EDIS than what they would contribute to EDIS in all the simulated scenarios (varying in terms of loss rates and amount/size of failing banks). In addition, the numbers referred to EDIS exposures and, consequently, cross-subsidisation presented in this section are lower than the same numbers obtained with the selection of the 3% and 10% riskiest banks based on the PD estimation model. This provides further evidence that the PD model is able to correctly identify the riskiest banks.[46]

[45] The same exercise has been performed with 20,000 random subsample selections, to confirm that the number of simulations is enough to ensure the convergence of the average results.

[46] Note that the selection of the subsample is not based on some banks' parameters, but is purely random: thus, each bank probability of being included in each simulation run is sampled from a uniform distribution, meaning that all the financial institutions have the same probability of being selected. The countries for which our sample coverage is higher would thus result to be more likely to be exposed to EDIS, since their banks are more likely to be sampled in each simulation run. This explains the relatively high numbers obtained for Germany.

5.2. EDIS exposures and cross-subsidisation with country-specific shocks

The results presented in Section 4.3.2 refer to simulated losses applied to the 3% and 10% riskiest banks at the banking union level. The selection of the 3% and 10% riskiest banks in the sample of euro area banks is not based on any country-specific shocks and is carried out only on the basis of the riskiness of banks relative to all the other euro area banks in the sample. As a result, we also provide additional and complementary information, showing the results on cross-subsidisation in a scenario where country-specific shocks are simulated.

The country-specific shocks are designed to mimic the European shock simulated above, on the basis of the share of total assets of the banks assumed to fail. Therefore, the first set of results has been obtained by assuming that the riskiest banks in each country, representing up to the 13.9% of the domestic banking system total assets, simultaneously fail. The choice of the 13.9% total assets threshold is based on the fact that the 3% riskiest banks assumed to fail in the euro area scenario (results reported in Table 7) represent 13.9% of the total assets of the euro area banks in the sample. The second set of results is obtained under the assumption that the riskiest banks in each country, representing up to the 81% of the domestic banking system total assets, simultaneously fail. This choice is in line with the scenario with the 10% riskiest banks failing at the euro area level (results reported in Table 6), whose assets represent approximately 81% of total assets of euro area banks in the sample.

Table 9 presents the results, expressed in terms of EDIS exposure and cross-subsidisation, referred to the assumption that the riskiest banks in each country, representing the 13.9% of the domestic bank total assets, simultaneously fail. First, regardless of the severity of the loss rates imposed to the failing banks, the DIF would be largely sufficient to cover all financial needs, even in case the country-specific shocks occur all at the same time. Second, cross-subsidisation becomes material only in Spain, and only for loss rates equal to 25% in resolution (37.5% in insolvency). In all the other countries EDIS exposures, if any, remain extremely limited (never exceeding € 20mln) even under the most adverse simulated conditions.

Table 7. Cross-subsidisation: Fund exposure per euro contributed and in EUR billion – 3% random banks failing

Loss resolution (%TA)	Loss Insolvency (%TA)	Country	AT	BE	CY	DE	EE	ES	FI	FR	GR	IE	IT	LT	LU	LV	MT	NL	PT	SI	SK	TOT
		Non risk-based contributions (EUR bn)	0.79	0.60	0.02	12.35	0.01	7.46	0.08	6.89	0.81	0.62	4.44	0.09	0.15	0.05	0.02	4.23	0.60	0.08	0.03	39.32
		Risk-based contributions (EUR bn)	0.69	0.45	0.03	15.37	0.01	7.15	0.09	5.44	0.92	0.42	4.44	0.07	0.13	0.03	0.03	3.13	0.78	0.09	0.05	39.32
		EDIS exposure																				
5%	7.50%	(1) per EUR contributed: non risk-based	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		(2) per EUR contributed: risk-based	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		(3) in EUR bn	0.00	0.00	0.00	**0.002**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10%	15%	(4) per EUR contributed: non risk-based	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		(5) per EUR contributed: risk-based	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		(6) in EUR bn	0.00	0.00	0.00	**0.09**	0.00	0.00	0.00	**0.03**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
15%	22.5%	(7) per EUR contributed: non risk-based	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	
		(8) per EUR contributed: risk-based	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	
		(9) in EUR bn	0.00	0.00	0.00	**0.37**	0.00	**0.01**	0.00	**0.06**	0.00	0.00	0.00	0.00	0.00	0.00	**0.001**	0.00	0.00	0.00	0.00	0.45
20%	30%	(10) per EUR contributed: non risk-based	0.02	0.00	0.00	0.09	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.01	0.00	0.00	
		(11) per EUR contributed: risk-based	0.03	0.00	0.00	0.07	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	
		(12) in EUR bn	**0.02**	0.00	0.00	**1.13**	0.00	**0.01**	0.00	**0.11**	0.00	0.00	0.00	0.00	0.00	0.00	**0.001**	0.00	**0.004**	0.00	0.00	1.27
25%	37.5%	(13) per EUR contributed: non risk-based	0.05	0.00	0.00	0.19	0.00	0.00	0.10	0.02	0.01	0.00	0.00	0.01	0.00	0.00	0.15	0.00	0.01	0.00	0.05	
		(14) per EUR contributed: risk-based	0.06	0.00	0.00	0.15	0.00	0.00	0.10	0.03	0.01	0.00	0.00	0.01	0.00	0.00	0.12	0.00	0.01	0.00	0.03	
		(15) in EUR bn	**0.04**	0.00	0.00	**2.32**	0.00	**0.02**	**0.01**	**0.15**	**0.01**	0.00	**0.02**	**0.001**	0.00	0.00	**0.003**	0.00	**0.01**	0.00	**0.002**	2.59

Notes: For each country, EDIS exposures are calculated as the EDIS exposures of the banks belonging to that country in every simulation, and then averaged at the country-level across all simulations; EDIS exposure per euro contributed for each country is calculated as the average country-specific EDIS exposure divided by the sum of contributions of all banks of that country; The table refers to loss-absorbency scenario B in resolution with 97th-percentile crisis simulation in each run and with potential SRF intervention; Banks' contributions to EDIS are based on DGS sliding scale method and DGS-baseline indicators. *Source:* ECB staff calculations based on COREP and Bankscope data, 2015:Q4.

Table 8. Cross-subsidisation: Fund exposure per euro contributed and in EUR billion – 10% random banks failing

Loss resolution (%TA)	Loss Insolvency (%TA)	Country	AT	BE	CY	DE	EE	ES	FI	FR	GR	IE	IT	LT	LU	LV	MT	NL	PT	SI	SK	TOT
		Non risk-based contributions (EUR bn)	0.79	0.60	0.02	12.35	0.01	7.46	0.08	6.89	0.81	0.62	4.44	0.09	0.15	0.05	0.02	4.23	0.60	0.08	0.03	39.32
		Risk-based contributions (EUR bn)	0.69	0.45	0.03	15.37	0.01	7.15	0.09	5.44	0.92	0.42	4.44	0.07	0.13	0.03	0.03	3.13	0.78	0.09	0.05	39.32
		EDIS exposure																				
5%	7.50%	(1) per EUR contributed: non risk-based	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		(2) per EUR contributed: risk-based	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		(3) in EUR bn	0.00	0.00	0.00	**0.01**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
10%	15%	(4) per EUR contributed: non risk-based	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		(5) per EUR contributed: risk-based	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		(6) in EUR bn	0.00	0.00	0.00	**0.29**	0.00	0.00	0.00	**0.09**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.38
15%	22.5%	(7) per EUR contributed: non risk-based	0.01	0.00	0.00	0.10	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.01	0.00	0.00	
		(8) per EUR contributed: risk-based	0.02	0.00	0.00	0.08	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.01	0.00	0.00	
		(9) in EUR bn	**0.01**	0.00	0.00	**1.24**	0.00	**0.02**	0.00	**0.21**	0.00	0.00	0.00	0.00	0.00	0.00	**0.001**	0.00	**0.01**	0.00	0.00	1.49
20%	30%	(10) per EUR contributed: non risk-based	0.08	0.00	0.00	0.30	0.00	0.00	0.00	0.05	0.01	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.02	0.01	0.00	
		(11) per EUR contributed: risk-based	0.09	0.00	0.00	0.24	0.00	0.00	0.00	0.06	0.01	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.02	0.01	0.00	
		(12) in EUR bn	**0.06**	0.00	0.00	**3.74**	0.00	**0.03**	0.00	**0.35**	**0.01**	0.00	**0.01**	0.00	0.00	0.00	**0.003**	0.00	**0.01**	**0.001**	0.00	4.21
25%	37.5%	(13) per EUR contributed: non risk-based	0.17	0.00	0.00	0.62	0.00	0.01	0.34	0.07	0.02	0.00	0.01	0.02	0.00	0.02	0.46	0.00	0.04	0.01	0.18	
		(14) per EUR contributed: risk-based	0.20	0.00	0.00	0.50	0.00	0.01	0.31	0.09	0.02	0.00	0.01	0.02	0.00	0.03	0.38	0.00	0.03	0.01	0.11	
		(15) in EUR bn	**0.14**	0.00	0.00	**7.71**	0.00	**0.06**	**0.03**	**0.50**	**0.02**	0.00	**0.06**	**0.002**	0.00	**0.001**	**0.01**	**0.01**	**0.02**	**0.001**	**0.01**	8.56

Notes: For each country, EDIS exposures are calculated as the EDIS exposures of the banks belonging to that country in every simulation, and then averaged at the country-level across all simulations; EDIS exposure per euro contributed for each country is calculated as the average country-specific EDIS exposure divided by the sum of contributions of all banks' of that country; The table refers to loss-absorbency scenario B in resolution with 90th-percentile crisis simulation in each run and with potential SRF intervention; Banks' contributions to EDIS are based on DGS sliding scale method and DGS-baseline indicators. *Source:* ECB staff calculations based on COREP and Bankscope data, 2015:Q4.

Table 10 reports the results referred to the assumption that the riskiest banks in each country, representing the 81% of the domestic bank total assets, simultaneously fail. Even if the crisis simulated in this scenario is extremely severe - the 81% of the total assets of each country simultaneously stressed with losses from 5% to 25% (in resolution) of the banks' balance sheet - the overall exposure of the deposit insurance fund slightly exceeds the EDIS target size (equal to € 39.3bn for the sample). In terms of cross-subsidisation, only for very high loss rates five countries would receive payouts from EDIS of more than what they would pay into EDIS: Belgium, Germany, Spain, Finland and Slovakia, and Belgium and Germany starting with loss rates equal to 20% in resolution. The case of Germany is particularly interesting, since with a loss rate equal to 20% of total assets cross-subsidisation disappears if EDIS contributions are risk-based rather than based on the amount of covered deposits only. We also remark that the high EDIS exposures for German banks might be due to the limited amount of MREL-eligible liabilities of the banks included in our sample and assumed to fail: this is in line with the numbers in Table 3, showing that the overall contributions of German banks increase if an indicator for MREL is included in the calculation of risk-based contributions (comparison between columns 5 and 4).

Even though the 13.9% and 81% thresholds calibrated on total assets are consistent with the crisis simulated, respectively, with the 3% and 10% riskiest banks failing at the euro area level (Section 3.3.2, Tables 5 and 6), the results differ in some countries: in particular, and differently from the results in Tables 5 and 6, Tables 9 and 10 reveal no evidence of cross-subsidisation in Greece and Malta. This can be explained by the fact that when a sample of riskiest banks is selected at the euro area level, such banks may be concentrated in some countries, thus representing a very high portion of the domestic bank total assets; when the same share of riskiest banks is instead selected at the national level, it may happen that some banks, even if risky at the euro area level, are not included among the riskiest ones at the domestic level.

Finally, the comparison of the results reported in Tables 9 and 10 reveals that, even in the most adverse scenario (80% of the total assets at the country level failing simultaneously), loss rates below 25% of total assets would lead to limited EDIS exposures, very much below the EDIS target size, even considering the country shocks all occurring simultaneously: note that this would correspond to an extremely big black-swan situation, far beyond any conservative hypothesis on cross-country contagion and/or spillover effects. While looking at the country-by-country results in isolation, instead, we can conclude that EDIS would be sufficient to mitigate idiosyncratic shocks in all countries, even if occurring in huge banking systems such as the German one.

Overall, the key results of the analysis are consistent across both a banking union shock and country-specific shocks. First, an EDIS exposure would only materialise for very high loss rates - considerably higher than those experienced in the 2007-2009 global financial crisis. Second, cross-subsidisation would generally materialise only for extremely high loss rates, and only few countries would be affected.[47] As a result, our analysis confirms that there would be no unwarranted systematic cross-subsidisation via EDIS in the steady state.

5.3. EDIS exposure with largest banks failing

To better gauge whether the EDIS fund would be sufficient even under extremely severe conditions, an additional scenario has been built assuming the biggest banks in the sample are under distress and thus resolved, regardless of the likelihood of such an event to occur. In particular, we assumed that the three, five and ten largest banks in the sample simultaneously default: please note that the three largest banks account for € 4.66tn (approximately the 23% of the sample in terms of total assets), while the ten largest banks in the sample account for € 10.64tn (representing more than half of the entire sample in terms of total assets). If we shock all these banks with loss rates ranging from 5% to 25% of total assets, we obtain an EDIS exposure equal to zero, and we observe no cross-subsidisation throughout the Banking Union. This depends on the high loss-absorbing capacity of the biggest banks in our sample, that are able to suffer even extremely severe shocks without creating outstanding exposures for the deposit insurance scheme. EDIS exposures become positive only for loss rates at least equal to 35% of banks' total assets, ranging from € 27.3bn (3 biggest banks failing) to € 47.2bn (10 biggest banks failing). We remark that the banks under distress in this last exercise have enormous dimensions: a 35% loss rate measured in terms of total assets and simultaneously applied to the three, five or ten biggest banks in the euro area corresponds to immensely adverse conditions, much more severe than what has been observed on any previous crisis.

Table 9. Cross-subsidisation: Fund exposure in EUR billion and per euro contributed - riskiest banks in each country, representing up to the 14% of the domestic total assets, failing

Loss resolution (%TA)	Loss Insolvency (%TA)	Country	AT	BE	CY	DE	EE	ES	FI	FR	GR	IE	IT	LT	LU	LV	MT	NL	PT	SI	SK	TOT
		Non risk-based contributions (EUR bn)	0.79	0.60	0.02	12.35	0.01	7.46	0.08	6.89	0.81	0.62	4.44	0.09	0.15	0.05	0.02	4.23	0.60	0.08	0.03	39.32
		Risk-based contributions (EUR bn)	0.69	0.45	0.03	15.37	0.01	7.15	0.09	5.44	0.92	0.42	4.44	0.07	0.13	0.03	0.03	3.13	0.78	0.09	0.05	39.32
		EDIS exposure																				
5%	7.50%	(1) per EUR contributed: non risk-based	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		(2) per EUR contributed: risk-based	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		(3) in EUR bn	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10%	15%	(4) per EUR contributed: non risk-based	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		(5) per EUR contributed: risk-based	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		(6) in EUR bn	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15%	22.5%	(7) per EUR contributed: non risk-based	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		(8) per EUR contributed: risk-based	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		(9) in EUR bn	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20%	30%	(10) per EUR contributed: non risk-based	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		(11) per EUR contributed: risk-based	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		(12) in EUR bn	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25%	37.5%	(13) per EUR contributed: non risk-based	0.00	0.00	0.00	0.00	0.00	**1.29**	0.00	0.00	0.00	0.00	0.00	0.19	0.00	0.06	0.00	0.00	0.00	0.00	0.00	
		(14) per EUR contributed: risk-based	0.00	0.00	0.00	0.00	0.00	**1.34**	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.10	0.00	0.00	0.00	0.00	0.00	
		(15) in EUR bn	0.00	0.00	0.00	0.00	0.00	**9.58**	0.00	0.00	0.00	0.00	**0.01**	**0.02**	0.00	**0.003**	0.00	0.00	0.00	0.00	0.00	9.61

Notes: EDIS exposure per euro contributed for each country is calculated as the sum of EDIS exposures to all banks within a country divided by the sum of contributions of all banks' of that country;
The table refers to loss-absorbency scenario B in resolution with 97th-percentile crisis simulation and with potential SRF intervention with SRF contribution;
Banks' contributions to EDIS are based on DGS sliding scale method and DGS-baseline indicators
Source: ECB staff calculations based on COREP and Bankscope data, 2015:Q4.

Table 10. Cross-subsidisation: Fund exposure in EUR billion and per euro contributed - riskiest banks in each country, representing up to the 80% of the domestic total assets, failing

Loss resolution (%TA)	Loss Insolvency (%TA)	Country	AT	BE	CY	DE	EE	ES	FI	FR	GR	IE	IT	LT	LU	LV	MT	NL	PT	SI	SK	TOT
		Non risk-based contributions (EUR bn)	0.79	0.60	0.02	12.35	0.01	7.46	0.08	6.89	0.81	0.62	4.44	0.09	0.15	0.05	0.02	4.23	0.60	0.08	0.03	39.32
		Risk-based contributions (EUR bn)	0.69	0.45	0.03	15.37	0.01	7.15	0.09	5.44	0.92	0.42	4.44	0.07	0.13	0.03	0.03	3.13	0.78	0.09	0.05	39.32
		EDIS exposure																				
5%	7.50%	(1) per EUR contributed: non risk-based	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		(2) per EUR contributed: risk-based	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		(3) in EUR bn	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10%	15%	(4) per EUR contributed: non risk-based	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		(5) per EUR contributed: risk-based	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		(6) in EUR bn	0.00	0.00	0.00	**1.45**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.45
15%	22.5%	(7) per EUR contributed: non risk-based	0.00	0.00	0.00	0.42	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		(8) per EUR contributed: risk-based	0.00	0.00	0.00	0.34	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		(9) in EUR bn	0.00	0.00	0.00	**5.21**	0.00	**0.31**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.52
20%	30%	(10) per EUR contributed: non risk-based	0.00	**2.12**	0.00	**1.08**	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		(11) per EUR contributed: risk-based	0.00	**2.84**	0.00	0.86	0.00	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		(12) in EUR bn	0.00	**1.27**	0.00	**13.29**	0.00	**1.84**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.40
25%	37.5%	(13) per EUR contributed: non risk-based	0.01	**5.53**	0.00	**2.21**	0.00	**1.89**	**2.75**	0.00	0.00	0.00	0.02	0.19	0.00	0.06	0.00	0.00	0.28	0.00	**1.83**	
		(14) per EUR contributed: risk-based	0.01	**7.41**	0.00	**1.77**	0.00	**1.97**	**2.57**	0.00	0.00	0.00	0.02	0.24	0.00	0.10	0.00	0.00	0.21	0.00	**1.12**	
		(15) in EUR bn	**0.01**	**3.32**	0.00	**27.24**	0.00	**14.08**	**0.22**	0.00	0.00	0.00	**0.10**	**0.02**	0.00	**0.003**	0.00	0.00	**0.16**	0.00	**0.05**	45.21

Notes: EDIS exposure per euro contributed for each country is calculated as the sum of EDIS exposures to all banks within a country divided by the sum of contributions of all banks' of that country;
The table refers to loss-absorbency scenario B in resolution with 90th-percentile crisis simulation and with potential SRF intervention with SRF contribution;
Banks' contributions to EDIS are based on DGS sliding scale method and DGS-baseline indicators
Source: ECB staff calculations based on COREP and Bankscope data, 2015:Q4.

6. Conclusion

EDIS has been described as a logical step in completing the European Banking Union. Compared to the existing set-up where deposit insurance is maintained at the national level, EDIS aims to reduce the vulnerability of national deposit guarantee schemes to local and systemic shocks and to increase depositor confidence in the safety of their deposits. Ensuring a uniform protection of depositors across the entire Banking Union, regardless of geographic location, is crucial to preserve depositors' trust and thus avoid bank runs and protect financial stability, while also contributing to the reduction of the bank-sovereign nexus. In addition, establishing EDIS would elevate deposit insurance to the European level, as was done with the responsibilities for bank supervision and resolution. Finally, pooling the governance of deposit insurance within a single entity at the European level would centralise decision-making, potentially minimising coordination costs in a crisis when bank runs are more likely. Despite these expected benefits, the introduction of EDIS may also raise issues about moral hazard and, as a result, several concerns have been voiced challenging the implementation of this reform. The analysis in this paper provides four main insights that support the policy discussion on the introduction of EDIS.

First, we find that a fully-funded deposit insurance fund with ex-ante contributions of 0.8% of covered deposits (€ 39.3bn in the sample analysed) would be sufficient to protect depositors from losses in a banking crisis, even in case of hypothetical losses much higher than those experienced during the 2007-2009 global financial crisis. Considering a scenario where the riskiest 3% of euro area banks fail simultaneously and only MREL-eligible liabilities are bailed-in (with the exception of large corporate deposits above €100,000), losses in resolution and insolvency up to, respectively, 15% and 22.5% of banks' total assets are not enough to create exposures of the DIF in any country. Our conclusions hold when considering a scenario where the 10% riskiest banks in the euro area fail simultaneously. In fact, up to losses in resolution equal to 15% of total assets (corresponding to 22.5% losses in insolvency), EDIS exposures are, if any, extremely limited - zero, € 20mln and € 210mln with losses equal to, respectively, 5%, 10% and 15% of total assets in resolution. These loss scenarios are considerably more severe than historical losses both in Europe and in the US. Exposures of the DIF are triggered only in case of an extremely severe crisis, where the 3% or 10% riskiest banks simultaneously fail and are all affected by losses in resolution at least equal to 20% or 15% of total assets, respectively. Even in these extremely severe cases, however, the DIF is never depleted.

Second, we show that the relative riskiness of banks and of banking systems should be taken into account in the risk-based contributions to the deposit insurance fund, which is preferable to the lowering of the EDIS target level for certain types of banks – as has been suggested in the policy debate. The features of banks and banking systems can be appropriately reflected in the risk-based contributions using a "polluter pays" approach.

This would have the benefit of keeping the credible target level of EDIS, which as we show would be appropriate in contributing to loss absorption in severe banking crises. Furthermore, risk-based contributions could be calibrated on the basis of a wide range of factors reflecting the relative riskiness of banks or banking systems, as has been suggested in the policy debates. For instance, including an indicator for MREL-eligible liabilities provides an indication of banks' loss-absorbing capacity and could also be a proxy for the likelihood of a bank going into resolution rather than insolvency. Therefore, including this variable implies that banks that are likely to go into resolution may have their contributions reduced because of their higher loss-absorbing capacities and the resulting potentially lower exposure for EDIS. This could cater for the fact that a banking system composed of larger institutions would be less likely to benefit from EDIS as these are more likely to be resolved, thus limiting the possible contribution to loss coverage needed from the deposit insurance fund.

Third, our analysis indicates that smaller and larger banks would not excessively contribute to EDIS relative to the amount of covered deposits in their balance sheet, suggesting that measures to reduce contributions for the smallest and/or largest banks, as had been proposed by some Member States, would be unwarranted. Regarding the distribution of contributions across different banks, the 10% smallest banks in the sample would pay € 0.08bn, or 0.16% of the €39.3bn target size of EDIS. In contrast, the 10% largest banks would pay € 29.5bn or 59% of the overall EDIS target. However, when comparing the contributions to the level of covered deposits, the smallest and the largest banks' contribution per covered deposits on their balance sheet is relatively low with approximately 0.9 cent and 0.74 cent per euro of covered deposit respectively, while the banks in the intermediate deciles range pay slightly more ranging from 1 to 1.13 cents per euro of covered deposits.

Finally, we find that there would be no unwarranted systematic cross-subsidisation within EDIS, in the sense of some banking systems systematically contributing less than they would benefit from the deposit insurance fund. At country level, a comparison of banks' risk-based contributions to the DIF exposure shows that, while there are some cases in which the contributions of a banking system are lower than the amounts which would be received from EDIS, this is only true for very high loss rates that have a low probability of occurring and for crises which would be much more severe than the 2007-2009 global financial crisis. This result holds also when considering random bank-level shocks, country-specific shocks or shocks affecting the largest banks in the system. We also note that, even though we observe evidence of cross-subsidisation in the most severe simulated scenarios, this cannot be considered as unwarranted systematic cross-subsidisation according to our definition since it affects only a very limited number of banking systems, and only for extremely high loss rates.

Overall, we expect that EDIS will offer substantial benefits in terms of depositor protection while posing limited risks in terms of EDIS exposure, since our results show that the probability and magnitude of interventions are likely to be low. In addition, the possible adverse impact of introducing EDIS in terms of moral hazard could be

addressed through an appropriate calibration of the banks' risk based contributions to EDIS to reflect banks' (and banking systems') relative riskiness.

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ONLINE APPENDIX

Bank sample

Table IA1: bank sample by country (year-end 2017)

Country	No Banks	*of which: SIs*	*LSIs*	TA (EUR bn)	Sample coverage (%TA)
AT	333	*3*	*330*	391.9	41.3%
BE	13	*4*	*9*	541.5	54.5%
CY	5	*2*	*3*	17.9	26.4%
DE	1,375	*15*	*1,360*	5,946.8	86.6%
EE	6	*0*	*6*	8.6	33.8%
ES	19	*10*	*9*	3,205.1	90.6%
FI	5	*0*	*5*	24.5	5.9%
FR	34	*5*	*29*	4,543.4	65.4%
GR	7	*4*	*3*	255.7	97.4%
IE	7	*5*	*2*	294.0	68.7%
IT	242	*9*	*233*	2,420.3	91.9%
LT	5	*3*	*2*	24.7	90.3%
LU	31	*3*	*28*	192.1	23.4%
LV	15	*3*	*12*	27.3	95.5%
MT	9	*2*	*7*	12.9	27.1%
NL	16	*4*	*12*	2,085.2	84.7%
PT	17	*3*	*14*	243.0	63.7%
SI	7	*2*	*5*	20.2	48.3%
SK	2	*0*	*2*	6.6	8.4%
Total	**2148**	*77*	*2,071*	**20,261.5**	75.0%

Source: ECB staff calculations based on Fitch Connect and ECB Statistical Data Warehouse, 2017:Q4.

PD estimation: summary statistics of the variables and out-of-sample tests

Table IA2: Summary statistics for the variables in the early warning models

	(1) N	(2) Mean	(3) SD	(4) P25	(5) P50	(6) P75
Bank-specific variables						
Bank in Pre-Default/Distress State	55,418	0.014	0.117	0.000	0.000	0.000
Interest Expenses / Total Liabilities	55,418	2.168	1.258	1.293	2.065	2.833
Provisions for NPLs / Total Assets	55,418	0.796	1.618	0.000	0.000	0.961
Tangible Equity / Total Assets	55,418	8.772	6.753	5.245	7.174	10.06
ln Total Assets	55,418	6.480	2.538	5.360	6.518	7.830
Return on Equity	55,418	4.672	8.264	2.300	4.280	7.143
Deposits / Total Assets	55,418	61.57	22.69	50.19	68.69	78.19
Cost to Income Ratio	55,418	69.07	18.85	60.78	68.80	76.33
Banking-sector variables						
Financial Assets / GDP	55,418	323.8	409.5	230.7	275.7	291.1
Loans / Deposits (1-year change)	55,418	-3.892	14.01	-8.662	-2.896	0.380
Mortgages / Loans (1-year change)	55,418	0.275	0.829	-0.139	0.228	0.761
Issued debt / Total liabilities (1-year change)	55,418	-0.316	1.134	-0.932	-0.203	0.221
Bank Concentration	55,418	0.364	0.0965	0.284	0.363	0.392
Macro-financial variables						
Total credit / GDP (3-year change)	55,418	2.873	12.71	-4.531	0.217	7.802
10-year yield (1-year change)	55,418	-0.283	1.052	-0.627	-0.334	0.196
Unemployment	55,418	8.001	3.068	5.500	7.770	9.420
ln GDP per capita	55,418	10.33	0.219	10.26	10.34	10.42
Inflation	55,418	90.43	7.705	83.40	91.00	98.60

Source: ECB staff calculations based on Fitch Connect, ECB Statistical Data Warehouse, Orbis Bank Focus and European Commission dataset on state aid measures.

Table IA3: Performance of the model used to estimate default probabilities

Diagnostic	(i) 97th percentile as threshold	(ii) 90th percentile as threshold
TP rate	0.8%	1.4%
TN rate	95.4%	89.1%
FP rate	2.1%	8.4%
FN rate	1.4%	0.8%
Accuracy	96.2%	90.5%
Sensitivity	36.3%	62.5%

Notes: TP abbreviates True Positive (default events correctly estimated as defaults); TN abbreviates True Negative (non-default events correctly estimated as non-defaults); FP abbreviates False Positive (or false alarms, non-default events estimated as defaults); FN abbreviates False Negative (or II type errors, default events estimated as non-defaults). True positives, false positives, true negatives, and false negatives are expressed as a share of the total number of observations. Accuracy is calculated as the ratio between TP+TN and the overall population; Sensitivity is calculated as the ratio between TP and TP+FN.
Source: ECB staff calculations based on Fitch Connect, ECB Statistical Data Warehouse, Orbis Bank Focus and European Commission dataset on state aid measures