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18-3 The Search for a Euro Area Safe Asset

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Abstract

This paper evaluates four approaches to creating "safe assets" or asset portfolios for the euro area: (1) a diversified portfolio of senior tranches of sovereign debt ("national tranching"); (2) a senior security backed by a diversified pool of national sovereign debt ("ESBies"); (3) debt issued by a senior financial intermediary, backed by a diversified pool of national debt ("E-bonds"); and (4) debt issued by a euro area budget or a leveraged wealth fund, based on member state contributions or dedicated direct revenue sources. None of these approaches envisages explicit guarantees by member states, and all could potentially produce safe assets in sufficient quantities to replace euro area sovereign bond holdings in euro area banks. At the same time, the four approaches differ across several important dimensions. A euro area budget or wealth fund could create the largest volume of safe assets, followed by ESBies, E-bonds, and national tranching. A euro area budget or wealth fund is also likely to have the lowest impact on the structure and liquidity of national bond markets, while national tranching would have the largest impact. ESBies and E-bonds occupy an intermediate position. ESBies and potentially bonds issued by a euro area budget would offer their holders greater protection from deep national defaults than the other two proposals. Both ESBies and national tranching would avoid cross-country redistribution by construction, whereas E-bonds and a euro area budget could have significant distributional consequences, depending on their design. E-bonds are unique in that they would raise the marginal cost of sovereign debt issuance at higher levels of debt, thereby exerting fiscal discipline, without necessarily raising average debt costs for lower-rated borrowers.

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I. INTRODUCTION

Proposals to create a public "safe asset" for the euro area are as old as euro area financial stability problems. Initially, the idea was to pool euro area debt into a "Eurobond" guaranteed by member states (De Grauwe and Moesen 2009, Bonnevay 2010), which fiscal conservatives swiftly rejected (Issing 2009). Since then, a large number of alternative proposals have been put forward that seek to reduce or even completely avoid the need for member state guarantees (Monti 2010; Juncker and Tremonti 2010; Delpla and Weizsäcker 2010, 2011; Beck, Wagner, and Uhlig 2011; Brunnermeier et al. 2011, 2017; Hellwig and Philippon 2011; Ubide 2015). The motivation of proposals also evolved. Earlier proposals were interested in creating either a large, liquid euro area bond market to support financial integration and the single market or a mechanism that would help euro crisis countries maintain a stable source of funding. More recent proposals primarily aim to increase the supply of euro-denominated safe assets, both to reduce a perceived shortage of such assets and to replace national sovereign bonds on bank balance sheets (Brunnermeier et al. 2017). The latter would eliminate an important channel through which sovereign debt problems damage the economy, in turn enhancing the solvency of sovereigns.

Euro area policymakers have recently been paying close attention to these proposals—perhaps because the ideas have improved or because the problems that they are meant to address, such as the high exposure of banks to their own sovereigns, continue unabated. A high-level task force of the European Systemic Risk Board (ESRB HLTF 2018) has just completed an extensive review of Brunnermeier et al.'s (2011, 2017) proposal to create a senior security backed by a diversified pool of sovereign bonds. The European Commission, for its part, has supported safe asset ideas. Its May 2017 reflection paper on the deepening of the economic and monetary union (EMU) lists "the development of a so-called safe asset for the euro area and the regulatory treatment of government bonds" first among possible steps to strengthen EMU over the medium term (European Commission 2017a). In its December 2017 "Communication on further steps toward completing the EMU," the Commission stated that it is "supportive of the current work in the European Systemic Risk Board on European Sovereign Bond-backed Securities and will present an enabling framework for such securities in spring 2018" (European Commission 2017b).

While the idea has regained momentum, consensus is lacking on *how* to create a safe asset for the euro area and on whether plans to do so might end up doing more harm than good. Fiscal conservatives remain worried that safe asset schemes could become a source of moral hazard and redistribution. Others are worried that safe asset ideas—particularly if they accompany changes in the regulatory treatment of sovereign bond holdings by banks—may raise sovereign borrowing costs and become a source of financial instability. As such, proposals to introduce safe assets in the euro area face continued resistance. Whether one of them will succeed depends on whether it can convincingly address concerns about moral hazard and borrowing costs, as well as a plethora of practical questions and objections raised by debt managers and investors.

This paper aims to compare and evaluate proposals on how to create safe assets for the euro area that we believe are most relevant to today's debate. It is not intended to be a historically comprehensive survey. We suggest a simple framework to organize thinking about euro area safe assets—in essence, combinations of ingredients that can jointly create "safety"—and describe and analyze four proposals that correspond to various logical possibilities

within our framework. One of these—the proposal to create sovereign bond–backed securities in several tranches, of which the most senior one could serve as a safe asset—has already been elaborated in great detail (Brunnermeier et al. 2017, ESRB HLTF 2018). The others are our interpretation of ideas that have been around for a while but have hardly been elaborated. They include: a diversified pool of senior tranches of national sovereign debt; debt issued by a legally senior financial intermediary backed by a diversified pool of euro area sovereign debt; debt issued by a euro area budget or leveraged wealth fund based on member state contributions or dedicated direct revenue sources.

Prima facie, all proposals meet a set of minimal conditions for qualifying as useful in the context of today's debate. First, they would give rise to assets that can be designed to be safe in the sense that expected losses, over a given period, are sufficiently low. Second, safe assets can be produced in sufficient volume to replace the sovereign debt held by euro area banks. Third, they do not rely on joint and several guarantees by the member states of the euro area, which would render the idea unfeasible politically or at least require an extensive institutional apparatus to mitigate the associated moral hazard.

Beyond meeting these minimal requirements, however, there are significant differences among the proposals. These refer to how well they perform with respect to both their intended benefits and potential drawbacks ("unintended consequences"). Apart from the potential to create safe assets in large volumes, their benefits include their role in helping to safeguard financial stability during a transition period in which banks reduce their sovereign exposures and their impact on fiscal discipline (the latter is not the main purpose of most proposals but may be a desirable side-effect). The unintended consequences include the impact of proposals on national bond market liquidity, redistributive effects, and mutualization risks as well as the impact on average borrowing costs.

The paper has two main results. First, most proposals do well along the most important dimensions. All could produce safe assets in sufficient volumes to largely replace the sovereign exposures of banks. Unintended consequences are possible, but they are far less ominous than is sometimes argued and could be mitigated by designing the proposed safe assets in specific ways. Second, there are clear winners and losers among the four proposals along each of the dimensions considered. However, no proposal dominates all others, and none is entirely dominated by any other one. As a result, it is difficult to crown an overall winner. While a case for a specific ranking can be made (and will be made in the conclusion), such a ranking can be overturned depending on the weights given to the various criteria.

Section II briefly explains the four proposals. Section III evaluates the intended benefits of the proposals, and section IV the unintended consequences. Section V concludes.

II. OVERVIEW OF PROPOSALS

Suppose one wishes to create a euro-denominated asset, or a portfolio of euro-denominated assets, that is virtually riskless with respect to both economic shocks and sovereign distress. German bunds and other AAA (or close to AAA) rated euro area government bonds arguably meet this description.[1] However, the outstanding stock of

1. A simulation model by Brunnermeier et al. (2017, see box 1) puts the five-year expected loss of the German bund at 0.13 percent in the model's benchmark calibration and at 0.5 percent in its adverse calibration. This cor-

these bonds is small: Only about €1.5 trillion in euro area central government debt securities are rated AA+/Aa1 or higher (€3.2 trillion if AA/Aa2 rated French bonds are included), compared to almost US$15 trillion in US treasuries. Furthermore, any regulatory change that maintains the current regulatory privileges for highly rated sovereigns but reduces them for others would have large redistributive implications benefiting banks that already hold the "safe asset" (such as German banks) at the expense of banks that need to purchase it. It could also sharply raise the borrowing costs of countries whose bonds are regulated more strictly, with ensuing short-term financial stability risks.

A potential way around this problem is to induce banks to diversify their sovereign exposures across issuers (Matthes and Rocholl 2017, Véron 2017)—or equivalently, to create a financial intermediary that issues bonds backed by a diversified portfolio of sovereign bonds, as proposed by Beck, Wagner, and Uhlig (2011). This would avoid the redistributive implications of withdrawing regulatory privileges of lower-rated bonds but maintaining them for the rest. However, a diversified portfolio of euro area sovereign bonds—or an asset backed by it—would not be "safe" by the standards of a AAA-rated or even a AA-rated bond. Using a stochastic default model for the euro area calibrated to be consistent with the market prices of European sovereign bonds (see box 1), Brunnermeier et al. (2017) show that in an adverse calibration that assumes a high correlation of default probabilities across countries, the five-year expected loss rate of a German bund would be less than 0.5 percent, of a French bond less than 2 percent, of a Belgian bond less than 3 percent, and of an Italian bond about 7 percent. A pooled portfolio of all euro area bonds (based on ECB capital key weights) would have an expected loss rate of just under 4 percent. Making the asset or portfolio as "safe" as a AAA bond hence requires an ingredient in addition to diversification. Assuming that member state guarantees are ruled out for political and moral hazard reasons, the main ingredient that has been suggested by the literature is legal seniority that directly or indirectly benefits the holder of the asset. Starting from the pure diversification benchmark, this could be achieved in several ways.

National Tranching Followed by Pooling

Sovereign issuers could issue national bonds in two (or more) tranches: one senior and the other junior (Wendorff and Mahle 2015). The bond contracts would specify that payments to the junior tranche holders are legally subordinated to payments to the senior holders, that is, at each contractual payment date junior tranche holders would get paid only after the contracted payments to senior tranche holders have been made in full. In a second step, the risk remaining in the senior tranches would be diversified, in two possible ways: (1) by creating a financial intermediary (or many intermediaries) that buys diversified pools of senior bond tranches at market prices and goes on to issue tradable securities whose payoffs would be the joint payoffs of the bonds in its portfolio or (2) simply by imposing a diversification requirement on banks (in other words, only diversified pools of senior tranches would be free from capital charges).

It is then possible to pick a "subordination level" (that is, the face value of the junior tranche as a share of the total face value of each bond) that makes the diversified portfolio ("pool") of senior tranches as safe as a AAA-rated

responds to an annualized spread of 2.6 or 10 basis points, respectively, not far from the current annualized five-year credit default swaps (CDS) spread of about 9 basis points. In other words, the yield of a totally risk-free asset should be about 3 to 10 basis points below the German yield.

bond. As we show below, if one wishes to choose a *uniform* subordination level for all euro area members states, the minimum level required to keep the five-year expected loss rate of a diversified portfolio of senior tranches below 0.5 percent is about 70 percent. That is, each euro area country would assign senior status to 30 percent of its bond issuance, and junior status to the remainder.

E-Bonds

A related approach is to dispense with tranching but instead give the financial intermediary purchasing sovereign debt preferred creditor status (like the European Stability Mechanism [ESM] or the International Monetary Fund [IMF]), so that the intermediary faces lower default risk than private creditors. Following Monti (2010) and Juncker and Tremonti (2010), we refer to the (untranched) bonds issued by this senior intermediary as "E-bonds." We study two variants of this proposal, which have different distributional implications (see section IV).

- In the first, the intermediary would buy sovereign bonds at market prices. Since market prices reflect the higher probability of losses faced by "normal" bondholders, this variant would lead to the accumulation of profits over time, which could be either redistributed back to the participating sovereigns or used to finance common expenditures (e.g., flow into the EU budget).
- In the second, the intermediary would buy debt at face value directly from national issuers, passing on the cost of its own issuance to its debtors. In that case, the debt contract would take the form of a loan rather than a tradable bond and specify that the interest paid by national issuers equals the intermediary's funding costs (plus a small markup to cover administrative costs). This is how the ESM operates today (except that it lends only to crisis countries, subject to conditionality).

The preferred creditor status of the ESM and the IMF is established informally (the IMF Articles of Agreement do not mention preferred creditor status at all, while the preferred creditor status of the ESM is mentioned in the preamble of the ESM treaty, rather than in the treaty itself). As far as we are aware, private creditors do not seem to have challenged the preferred creditor status of either of these organizations in court. Nonetheless, one cannot assume that the preferred creditor status of an official financial intermediary undertaking large-scale loans in noncrisis times would be respected unless it has a firm legal basis.[2] Formal preferred creditor status could be established contractually, by writing into every sovereign bond contract that the bond is subordinated to any past and future claims held by the intermediary, or through statute. The latter could be an intergovernmental treaty such as the ESM treaty, an EU regulation, or a coordinated set of domestic laws that establish that all future sovereign bonds issued in the euro area would be subordinated to claims held by the E-bond intermediary.[3] The main advantage of the contractual approach is that it would cover bonds issued both inside and outside the euro area, while the statutory approach may cover only the former.

2. The lack of legal challenge may relate to the status of the IMF and ESM as crisis lenders, which is regularly used by economists (and the institutions themselves, see, for example, IMF 2009) to justify their preferred creditor status. This argument would not apply to the financial intermediaries issuing E-bonds.

3. To avoid fear of dilution leading to a large risk premium—over and above the direct impact of subordination on the price of sovereign bonds, which is analyzed in detail below—there would need to be well-anchored expectations on the maximum volume of claims that the E-bond intermediary will purchase from each country. The intergovernmental treaty or EU regulation establishing the E-bond intermediary could serve as such an anchor.

ESBies

A third variant is to apply a combination of tranching and pooling as in the national tranching approach, except that the order is reversed (Brunnermeier et al. 2011, 2017; ESRB HLTF 2018). A financial intermediary (or many private intermediaries) would buy diversified pools of sovereign bonds at market prices, financed by the issuance of tradable securities whose payoffs would be the joint payoffs of the bonds in its portfolio. Unlike in Beck, Wagner, and Uhlig (2011), these securities—referred to as sovereign bond–backed securities (SBBS) by ESRB HLTF (2018)—would be issued in several tranches: a senior tranche, which Brunnermeier et al. (2017) call "European Senior Bonds" (ESBs, or "ESBies"), and one or several subordinated tranches, referred to as "European Junior Bonds" (EJBs, or "EJBies").[4] Default by a national issuer would reduce payments to junior tranche holders but leave payments to the senior tranche holders unaffected, unless many countries default at the same time and the losses-given-default are large enough to wipe out junior bondholders. In simulations of sovereign defaults, Brunnermeier et al. (2017) show that the subordination level required to keep the five-year expected loss rate of ESBies below 0.5 percent is about 30 percent. In other words, "safe" senior tranches can constitute up to 70 percent of the total face value of the security issued by the intermediary.

The Brunnermeier et al. (2011, 2017) proposal has recently been the subject of an extensive review by a High-Level Task Force of the ESRB (ESRB HLTF 2018), which focused on the feasibility of developing a market for privately issued SBBS. Its main finding is that "a gradual development of a demand-led market for SBBS may be feasible under certain conditions," particularly creating an "enabling product regulation," which, at a minimum, would align the regulatory treatment of ESBies with that of the underlying sovereign bonds. The report also notes that any reform of the regulatory treatment of sovereign bonds that is sensitive to concentration or credit risk would substantially enhance demand for ESBies.

Debt Issued by a Eurozone Budget

Finally, safe assets could be created as supranational bonds issued by either a eurozone budget (Ubide 2015, Zettelmeyer 2017) or a leveraged euro area sovereign wealth fund. Debt service could be financed either by assigning tax income to the budget or fund (e.g., a small European value-added tax [VAT] or a corporate tax) or through contributions from member states. In this setting, "seniority" would mean that the budget or fund would have first pick at these revenues (for example, contributing member states would need to pay into the eurozone budget before they can service their national debts). Debt would be issued either to finance a (temporary) deficit (in the case of a budget), or to invest the proceeds in assets with an expected return in excess of its funding costs (in the case of a wealth fund), or a combination of both.

The four approaches are summarized in the matrix below. The rows describe how seniority is achieved—either through tranching or by making the financial intermediary that issues safe assets senior relative to other

4. Brunnermeier et al. (2011, 2017) envisaged just one subordinated tranche. ESRB HLTF (2018) suggests that this tranche could be split into two: a mezzanine tranche (20 percent), subordinated to the senior tranche, and a junior tranche (10 percent), subordinated to both the senior and mezzanine tranches. Since this paper focuses on the properties of the senior tranche, it is mostly irrelevant whether we think of the subordinated tranches as consisting of two tranches or just one junior tranche (the only exception arises in the last section of the paper, when we discuss "local supply" effects of safe asset proposals on similarly rated national bonds). For simplicity, we hence generally maintain Brunnermeier et al.'s (2017) terminology and refer to the subordinated tranches as "EJBies."

claim-holders (and hence more likely to meet its obligations). The columns describe the order of diversification and seniority. All arrangements involving a senior intermediary issuing plain vanilla debt a fortiori involve "first seniority, then diversification," i.e., belong in the left column, this is why the bottom right cell is empty. In these proposals, risk diversification is applied to a basket of claims whose risk is already reduced because of the intermediary's seniority. In contrast, in the ESBies approach, diversification is achieved by pooling a basket of claims that do not benefit from seniority. In a second step, risk is reduced further for the holders of the senior tranche issued by the intermediary or intermediaries.

Summary of proposals for creating safe assets

		Order of seniority and diversification	
		Seniority first, then diversification	**Diversification first, then seniority**
Seniority	**...at the level of the debt instrument (tranching)**	> Safe assets as senior tranche of national sovereign debt (Wendorff and Mahle 2015). Subsequently, diversification of senior tranches on bank balance sheets.	> "ESBies": Safe assets as a senior security backed by a diversified portfolio of sovereign debt bought at market prices (Brunnermeier et al. 2011, 2017; ESRB HLTF 2018).
	... at the level of the issuer (no tranching)	> "E-bonds" issued by a senior intermediary that buys national sovereign bonds at face value and passes on funding costs (Monti 2010). > Debt issued by a euro area budget authority (e.g., Ubide 2015).	

III. INTENDED BENEFITS

Proposals to create euro-denominated safe assets without relying on member state guarantees mention four main aims: first, to create a large, homogenous, and hence liquid euro area-level bond market; second, to mitigate the "sudden stop" experienced by crisis countries; third, to replace sovereign bonds—particularly concentrated exposures to the domestic sovereign—with "safe assets" on the balance sheets of euro area banks; and fourth, to increase total European and global supply of safe assets.[5]

All these aims imply that the volume of safe assets is an important consideration when comparing competing proposals. In the first motivation, proposals should seek to maximize the pool of euro area–level safe assets that are regularly traded (i.e., not just stashed away in banks). In the second motivation, volume matters because it determines the share of euro area sovereign debt issuance that would be held by issuers of safe assets, who would not sell in a crisis. In the third motivation, volume matters from the perspective of reaching a minimum scale. For example, replacing *all* exposure of banks to the domestic government (including loans and other illiquid exposures) would require a safe asset volume of 20 percent of euro area GDP, while about 11 percent of GDP would be required if the objective is to replace only tradable debt securities, i.e., bonds and bills (see table 1). Finally, in

5. The first argument is emphasized by Brunnermeier et al. (2011, 2017) and Ubide (2015); the second by Monti (2010) and Brunnermeier et al. (2011, 2017); the third by Beck, Wagner, and Uhlig (2011) and Brunnermeier et al. (2011, 2017); and the fourth by Brunnermeier (2017), citing Caballero, Farhi, and Gourinchas (2016).

the fourth motivation, the objective is to maximize not the "gross" size of the euro area safe asset pool produced but rather the "net" increase in the volume of safe assets, after subtracting national safe assets that went into the production of the euro area safe asset and are hence no longer directly available to be traded and held directly by investors.

A related potential benefit has to do with the process by which safe assets replace bank holdings of sovereign debt. This process entails a risk that changes in the regulatory treatment of sovereign exposures lead to a disruptive rise in yields of bonds that are presently concentrated on bank balance sheets. Some proposals might be better suited to mitigating this risk than others.

Finally, a euro area-level safe asset might help to strengthen fiscal discipline in the euro area, through two channels: by lowering the economic costs of sovereign debt restructuring (Bénassy-Quéré et al. 2018) and by increasing marginal borrowing costs when issuance exceeds certain levels (Delpla and Weizsäcker 2010, 2011). Strengthening fiscal discipline is not the main intention of most proposals but could be a desirable side-effect. Increasing marginal borrowing costs at higher debt levels could also, of course, have unintended consequences—namely increased financial instability, even if the transition to the new steady state is managed without accidents—which will be taken up in section IV.

Volume

This section first presents simulation-based estimates of the size of the safe asset pool that each proposal could create and concludes with a summary of differences in terms of both the gross volume and net increase in safe assets that various proposals can generate.

National Tranching Followed by Pooling

National-level tranching requires a subordination level (that is, a decision on the size of the junior tranche or tranches). In principle, this level could vary from country to country. For example, the subordination level could be set to equalize the credit risk of senior tranches across issuers. Given the wide range of credit ratings in the euro area, subordination levels would vary greatly. For example, using Brunnermeier et al.'s (2017) default risk model (see box 1), a senior tranche that attains AAA safety levels (a five-year expected loss rate of 0.5 percent or less in the adverse calibration of the model) would require a subordination level of 77 percent for Italy and Spain, 40 percent for France, and 0 percent for Germany (since the German bund is already AAA, without any tranching). In other words, the senior tranche would make up 23 percent of Italy's and Spain's nominal issuance, 60 percent of France's issuance, and 100 percent of German issues.

Such an approach would likely be difficult to implement practically and politically. First, the precise subordination levels will depend on the simulation model used. Agreeing on a specific model is likely to be contentious, since the choice of one model over another will create winners and losers (most countries will want their subordination level to be set as low as possible to allow their banks to retain the largest possible fraction of national sovereign debt). Second, regardless of which model is used, attempting to set country-specific subordination levels in relation to sovereign credit risk will result in a senior tranche pool that is disproportionately composed of

German bunds, since it would contain the entire German debt stock but only a portion of the debt stock of most remaining countries.

For this reason, in the remainder of the paper, we assume that national tranching would be implemented using a subordination level that is uniform across countries. This approach will lead to senior tranches of widely varying risk, although each of them is of course safer than the nontranched bond issued by the same country. For comparability with Brunnermeier et al. (2017), we assume that this uniform subordination level would be set such that the five-year expected loss rate of a diversified pool of senior tranches does not exceed 0.5 percent, exactly as safe as Brunnermeier et al.'s ESBie under the adverse calibration of their simulation model. The volume of the safe asset pool can then be computed by multiplying the uniform subordination level with the outstanding stock of euro area debt securities. The result of this calculation is sensitive to the composition of the diversified portfolio: The higher the share of countries with low five-year expected loss rates in the portfolio, the lower the risk of the entire portfolio, and the lower the subordination level consistent with the 0.5 percent five-year expected loss rate target.

The next question is how to determine the portfolio weights of each country. One approach could be to choose them in proportion to each country's outstanding sovereign debt. However, if the future regulatory treatment of the safe asset (or safe asset pool) inherits some of the current regulatory treatment of sovereign bonds on bank balance sheets, it might create an incentive to accumulate large debt stocks. One way to avoid this is to define portfolio weights that depend on each country's level of GDP rather than its level of debt. Specifically, the volume of senior tranches of country that may enter the safe asset pool could be capped by the amount that the country would generate if it had debt of 60 percent of GDP. If the debt of a country is below 60 percent of GDP, all senior tranches are included in the pool. Alternatively, the volume of the senior tranches of each country in the portfolio could be capped by each country's GDP share times the total volume of debt in the euro area. Denoting the uniform subordination level by (the "thickness" of the junior tranche), and country 's outstanding debt and GDP by and , respectively, the volume of country 's senior tranches included in the safe asset pool, denoted by , is given by either

$$P_i = (1 - s) * \min\{0.6Y_i, D_i\} \quad (1)$$

or

$$P_i = (1 - s) * \min\left\{\frac{Y_i}{Y} * D, D_i\right\} = (1 - s) * \min\left\{\frac{D}{Y} * Y_i, D_i\right\} \quad (2)$$

where D and Y stand for total euro area debt and GDP, respectively. Equations (1) and (2) look much the same, except that the factor 0.6 used to multiply Y_i in equation (1) is replaced by the factor $\frac{D}{Y}$ in equation (2), the overall euro area debt-to-GDP ratio, which turns out to be just under 0.71. (According to European Central Bank [ECB] data, the face value of general government debt securities in the euro area was €7.63 trillion in 2016 while euro area GDP was €10.77 trillion.)

Table 2 shows the portfolio weights resulting from these two equations, assuming that D_i is defined to include all general government debt securities; appendix table C.2 reproduces an analogous table based on central government debt securities only. Both tables show that equations (1) and (2) lead to portfolio weights that are very close

to GDP weights (the correlations are 0.99 and 0.98, respectively), except for countries that have very small debts compared with their GDPs. As one would expect, euro area countries whose share of euro area debt securities is smaller than their share in euro area GDP (for example, Germany) end up with a higher portfolio weight than corresponds to their share in total euro area debt, while the opposite is true for countries with a higher euro area debt share than GDP share (for example, Italy).

The columns to the right show five-year expected loss rates, based on the adverse calibration of the simulation model summarized in box 1, of the senior tranches of each country for various subordination levels. The column corresponding to a subordination level of 0 shows the five-year expected loss rate of each country's sovereign bonds in the absence of tranching. For example, for the German bund, this is 0.5 percent of face value. As the subordination level—the "buffer" of junior debt protecting the senior tranche—rises, the five-year expected loss rate associated with each country's senior tranche falls. The two bold rows at the bottom show the five-year expected loss rates of the portfolios based on equations (1) and (2), respectively. The higher the subordination level, the smaller the volume of national senior tranches, and the safer they become.

The main result of the table is that in order to obtain a five-year expected loss rate of 0.5 percent or less, one needs to apply a uniform subordination level of about 69 percent for equation (1) and 70 percent for equation (2). This subordination level means that for each euro of sovereign debt issued, the senior tranche would amount to just 30 cents. The corresponding volume of the safe portfolio is €1.82 trillion based on the first portfolio selection rule and €1.95 trillion based on the second one, which represents 17 and 18 percent of euro area GDP, respectively. The second rule produces a higher volume because it allows the inclusion of a larger portion of the debt of countries with debt securities in excess of 60 percent of GDP (Austria, Belgium, Cyprus, France, Italy, Portugal, Slovenia, and Spain). Appendix table C.2 shows that if only central government debt is used for tranching, these volumes drop to €1.65 trillion–€1.69 trillion, or 15–16 percent of euro area GDP, respectively, just enough to replace the volume of euro area sovereign debt securities in euro area banks (see table 1).

E-Bonds

The E-bond approach is similar to national tranching in the sense that senior securities are created by subordinating national instruments (rather than European instruments, as is the case for ESBies). Unlike national tranching, sovereign bonds would continue to be issued as a single tranche. However, they are subordinated to claims (bonds or loans) by the public financial intermediary on the same sovereign. The subordination level—that is, the "cushion" of subordinated national instruments protecting the senior claim from sovereign risk—is determined by the share of national debt held by entities other than the intermediary.

We assume that, as in the case of national tranching, the intermediary cannot fine-tune the subordination level (for example, to equalize the risk of its claims across issuers) by buying shares of the sovereign debt markets that vary according to the fundamentals of the borrower. Instead, it must buy according to a purchasing rule that limits both the total share of sovereign debt and the share of GDP that the intermediary can hold of each country's sovereign debt. Specifically, we assume that the E-bond issuer's total portfolio holdings of country i, denoted by P_i^E, satisfy:

$$P_i^E = \min\{yY_i, cD_i\} \tag{3}$$

where Y_i and D_i denote i's outstanding GDP and debt, as before, while y and c are parameters, namely uniform shares of annual GDP and outstanding debt, respectively, for each country. For example, assume that y and c are both 0.5. Then, for countries whose debt-to-GDP ratio is above 100 percent, the first constraint binds, and the intermediary would hold 50 percent of GDP worth of debt. For countries with debt-to-GDP below 100 percent, the second constraint binds, and the intermediary would hold 50 percent of the country's debt stock.

How would the intermediary (or the euro area countries sponsoring it) choose y and c? Each choice of y and c will result in a portfolio of a certain volume, country composition, and riskiness (see appendix B for details). We assume that the intermediary would choose y and c to maximize the volume of the portfolio subject to remaining at or below a 0.5 percent five-year expected loss rate—i.e., the risk level corresponding to that of the German bund. Using the five-year expected loss rates generated by Brunnermeier et al.'s (2017) adverse calibration, it is possible to search the space of $\{y, c\}$ combinations that solves this constrained maximization problem. The optimal combination turns out to be y=0.252, c=0.495. That is, the intermediary would buy up to 49.5 percent of a country's debt and up to 25.2 percent worth of GDP, whichever is smaller.

Table 3 presents the implications of this purchase rule. The first column shows the country-by-country portfolio volume. The second and third columns show that volume as a share of country GDP and country debt securities outstanding, respectively. These columns show whether the GDP constraint or the debt constraint is binding. The results are intuitive: Germany, for example, has relatively little debt to GDP, and so the debt constraint is binding; the intermediary purchases debt claims of 49.5 percent of the current stock of Germany's outstanding debt securities. Italy has a relatively high debt-to-GDP ratio, so the GDP constraint is binding. The intermediary purchases 25.2 percent of Italian debt to GDP. In the end, the volume of German debt in the intermediary's portfolio (€768.4 billion) will exceed that of Italian debt (€420.9 billion). As the fourth column shows, German debt ends up with the highest portfolio share (29.2 percent, just above its share of euro area GDP) followed by French debt (21.3 percent) and Italian debt (16 percent).

The last column of the table shows the five-year expected loss rate associated with the portfolio holdings listed in the first column. For the eight highest rated euro area sovereigns—Germany, Netherlands, Luxembourg, Austria, Finland, France, and Belgium—the expected losses are zero, from the perspective of the intermediary. These borrowers are already low-risk, in addition to the fact that the intermediary enjoys added protection due to the subordinated national bonds. The "thickness" of the subordinated cushion (the subordination level) is 100 percent minus the purchase volume in percent of total debt listed in the third column. For example, for Germany the subordination level is 50.5 percent, but for Belgium it is 71 percent. The thicker subordination cushion offsets Belgium's higher risk: Holding about €106 billion of Belgian bonds is therefore as riskless, for the E-bond intermediary, as holding €768 billion of German bonds.

Further down the column, the five-year expected loss rates turn positive as credit ratings decline. Interestingly, however, the five-year expected loss rate associated with holdings of Italian sovereign bonds is also virtually risk-less from the perspective of the E-bond intermediary (the five-year expected loss rate is 0.32 percent, as safe as a AAA-rated bond). The reason is that the intermediary buys a small share of Italian debt—just 22.5 percent. Hence, the intermediary is protected by a subordination level of almost 78 percent. It would suffer a loss only if

(1) there is an Italian debt restructuring, and (2) it leads to a loss given default on Italian debt of over 78 percent. This event is extremely unlikely even under the assumptions of Brunnermeier et al.'s (2017) adverse calibration (box 1).

The last row of the table shows the total portfolio holdings of the intermediary as well as the five-year expected loss rate associated with that portfolio, which, by construction, is almost exactly 0.5 percent. The total portfolio holdings are over €2.6 trillion. Hence, the main result is that the E-bond approach would deliver a safe asset volume that exceeds the maximum amount that can be created through the combination of national tranching and pooling by over €600 billion, or over 30 percent. The results are very similar when only central government debt securities are considered (see appendix table C.3). In this case the maximum safe asset volume that can be created with E-bonds is about €2.3 trillion, which again exceeds the maximum that can be created in the national tranching approach by about €600 billion.

ESBies

In the Brunnermeier et al. (2011, 2017) proposal, a public intermediary (or private intermediaries) would purchase a diversified pool of sovereign bonds, financed by issuing tradable securities divided into two (or possibly three) tranches. The senior tranche, called ESBies for "European Senior Bonds," would be protected from default by the subordinated tranche(s). As before, the subordination level needed to maintain the five-year expected loss rate of the senior tranche below 0.5 percent—Brunnermeier et al.'s "safe" level—will depend on the composition of the collateral pool purchased by the intermediary or intermediaries. The higher the proportion of riskier sovereign debt in the collateral pool, the higher the subordination level required to make the senior tranche "safe."

Continuing with the approach of the two previous proposals, we assume a purchase limit of either 60 percent of each country's GDP or the country's share in euro area GDP times total euro area debt (equivalent to setting a limit at 71 percent of GDP, the overall euro area debt-to-GDP ratio).[6] This approach raises the question of how to treat countries whose total outstanding debt is below these maximum volumes. Purchasing all outstanding debt in such cases would eliminate the secondary sovereign debt market in these countries, as SBBS intermediaries would hold these bonds until maturity, making them unavailable for trading. However, maintaining liquid sovereign bond markets is important to generate prices of both sovereign bonds and other financial assets, including corporate bonds, on an ongoing basis.[7] This motivates two alternative additional caps to preserve secondary bond market liquidity, one more restrictive and one less so.

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6. This approach differs slightly from that in Brunnermeier et al. (2017) and ESRB HLTF (2018). Brunnermeier et al. (2017) determine each country's weight in the pooled portfolio according to each country's relative GDP, with the constraint that the pooled portfolio cannot include more than 100 percent of countries' outstanding debt (assuming that the total collateral pool is 60 percent of euro area GDP). ESRB HLTF (2018), when calculating indicative portfolio weights, assume that the face value of the total SBBS cover pool amounts to €1.5 trillion. In contrast, in our approach, the total size of the collateral pool is not an assumption but an implication of the portfolio purchase rules defined above.

7. Among the beneficiaries of such price signals are of course the SBBS intermediaries themselves, who may want to use the secondary market to purchase sovereign bonds at market prices. However, the existence of a liquid secondary market is probably less important for this purpose than for other reasons, since the SBBS cover pool could also be purchased in the primary market, particularly if SBBS intermediaries are competitive private entities. See ESRB HLTF (2018) for details (Volume I, Sections 3.1 and 3.3).

The more restrictive approach follows ESRB HLTF (2018) in using the purchase limits of the European Central Bank's Public Sector Purchase Programme (PSPP) as a guidepost. The maximum shares of outstanding debt purchased by the PSPP are 33 percent of each member state's eligible debt and 50 percent of the debt of supranational institutions such as the ESM. According to the ECB, these limits were imposed as "a means to safeguard market functioning and price formation as well as to mitigate the risk of the ECB becoming a dominant creditor of euro area governments."[8] The latter concern does not apply in the case of ESBies, since, in the event of a debt restructuring, the SBBS issuers that technically own the sovereign debt being restructured are intended to be "robotic" intermediaries acting on instructions from the holders of the SBBS (ESRB HLTF 2018). We therefore assume that the 50 percent purchase limit would be the relevant one from the perspective of maintaining market functioning and price formation.

However, even a 50 percent upper limit could be too restrictive when it comes to the large debt markets such as those of Italy, Germany, or France. 50 percent of a very large market is still large. From the perspective of maintaining liquidity and price discovery, what likely matters in such cases is the residual *nominal* amount of debt that remains unpurchased. Following McCauley and Remolona (2000), we set the minimum such amount at €200 billion. Below this, sustaining a very liquid government bond market may begin to become more difficult: Figure 1 suggests that bid-ask spreads in euro area debt markets tend to be higher for markets with a volume of less than €100 billion to €200 billion. We hence experiment with purchase rules that raise the maximum country purchase limit from $0.5D_i$ to $\max[0.5D_i, D_i - €200\text{bn}]$. For countries with debt stocks below €400 billion, half the debt stock is purchased, while for countries above €400 billion, all debt except for a residual €200 billion is purchased.

To summarize, we operate with two alternative upper bounds based on country GDP and two alternative upper bounds based on the principle that enough debt must remain in the market to ensure liquidity, for a total of four alternative purchase rules, as follows (using the same notation as in the previous two sections):

$$P_i = \min\{0.6Y_i, 0.5D_i\} \tag{4}$$

$$P_i = \min\{0.6Y_i, \max[0.5D_i, D_i - €200\text{bn}]\} \tag{5}$$

$$P_i = \min\left\{\frac{D}{Y} * Y_i, 0.5D_i\right\} \tag{6}$$

$$P_i = \min\left\{\frac{D}{Y} * Y_i, \max[0.5D_i, D_i - €200\text{bn}]\right\} \tag{7}$$

Table 4 shows the purchase volumes by country according to these equations based on the assumption that D_i includes all general government debt securities; appendix table C.4 is the analogous table based only on central government debt securities. The tables are divided into four groups of columns, each of which corresponds to one of the four equations (4) to (7). The first column within each group shows purchase volumes in nominal terms, while the second and third columns show purchase volumes in percent of outstanding government debt securities

8. The quote is from a Q&A published on the ECB's website, www.ecb.europa.eu/mopo/implement/omt/html/pspp-qa.en.html.

and in percent of the total underlying portfolio, respectively. Subordination levels and safe asset volumes associated with each portfolio are shown in the last two rows.

The first set of columns of table 4 show the purchase volumes by country according to equation (4). It turns out that the $0.5D_i$ limit is binding for all countries, because $\frac{D_i}{Y_i}$ is less than 120 percent for all countries if D_i is defined as debt securities and excludes other types of debt such as loans. The same is true for equation (6), represented in the third set of columns. Hence, the GDP-based constraints that differ across the two equations are not binding, and both equations result in identical portfolios, which imply a subordination level of about 34.5 percent, and hence a senior tranche consisting of 65.5 percent of the total portfolio of €3.8 trillion, i.e., €2.5 trillion. If only central government debt securities are used (table C.4), the corresponding subordination level would be 37 percent, resulting in a €2.2 trillion volume of ESBies.

Equations (5) and (7) replace the $0.5D_i$ purchase ceiling with the constraint that intermediary purchases need to leave either $0.5D_i$ or €200 billion in the market, whichever is smaller. Volumes in excess of half of the debt market may now be bought for the four countries with the largest outstanding nominal debt volumes: Italy, Germany, France, and Spain. In the case of Germany, which has a relatively small share of general government debt securities outstanding as a share of GDP, the requirement to leave €200 billion of general government debt securities unpurchased allows purchases of 87 percent of its sovereign debt stock, well below 60 percent of German GDP (since general government debt securities are only 50 percent of GDP in Germany; see table 1). For Germany, the requirement to leave €200 billion in the market is the binding constraint in both equations (5) and (7). In contrast, in France, Italy, and Spain, general government debt securities are much higher as a share of GDP, namely, 81, 112, and 83 percent of GDP, respectively (see table 1). Hence, the binding constraint for these countries is the 60 percent of GDP ceiling in equation (5) and 71 percent of GDP ($\{\frac{D}{Y} * Y_i\}$) in equation (7). Hence, equation (7) allows the purchase of higher volumes of French, Italian, and Spanish debt than equation (5), while purchases of German debt remain unchanged, increasing the portfolio weights of France and Italy and slightly pushing up the expected loss rate of the total portfolio. Achieving the assumed maximum of 0.5 percent consequently requires a slightly higher subordination level than under equation (5): 33 percent instead of 31.5 percent. However, since the underlying pool of assets is larger, the resulting volume of ESBies that can be created under rule (7) rises slightly, from €3.5 trillion to around €3.7 trillion. If only central government debt securities are purchased, the corresponding amounts are €3.07 trillion and €3.15 trillion (see table C.4).

Debt Issued by a Euro Area Budget or a Euro Area Leveraged Wealth Fund

A straightforward approach to creating a safe asset would be for a European authority to issue securities long term at fixed interest rates—say, with maturities between 10 and 30 years—and invest them in a diversified portfolio of risky assets, as a sovereign wealth fund would do. If the authority can borrow near the risk-free rate, which is currently around zero, this scheme is almost certain to return a profit, allowing the production of a safe asset without cost to—indeed, generating a dividend for—the European taxpayer.

The snag, of course, is that the relevant authority needs to be able to borrow at a near-risk-free interest rate. Ruling out member state guarantees, this would require either an upfront capitalization, or a dedicated stream

of revenues or member state contributions that would be available for interest payment even if the fund does not produce any returns. In the following, we assume such a stream. It can be interpreted either as a committed stream of savings flowing into a euro area wealth fund or as the primary surplus (surplus of revenue over noninterest expenditure) generated by a euro area budget. The question is how much debt could be supported by such a dedicated surplus, assuming that these constitute the only income source to support such debt service.

The answer is given by the standard static debt sustainability formula, based on assumptions about the primary surplus, long-run growth, and long-run real interest rates.[9] For the primary surplus, either 0.2 percent or 0.5 percent of euro area GDP is assumed. This can be rationalized as representing either 10 or 25 percent, respectively, of euro area budget revenue comprising 2 percent of GDP. This share is much smaller than federal budgets in countries such as Germany or Switzerland, which represent about 10 percent of GDP.

With respect to long-run real growth, our benchmark assumption is based on the IMF *World Economic Outlook*, which projects medium-term euro area growth to be just under 1.5 percent. Since uncertainty around this projection is relatively low (growth for the euro area as a whole is not very volatile, in part because it depends on slow-moving demographics), we limit the sensitivity analysis around this benchmark to a band ranging from 1.2 to 1.6 percent, interpreted to represent uncertainty in productivity growth. With respect to real interest rates, there is more uncertainty. To err on the side of prudence, interest rates are assumed to "snap back" to historical levels in all scenarios in table 5. According to Bundesbank estimates, the average five-year German bund real interest rate over the period 1989 to 2017—which includes a long period of low interest rates beginning around 2010—was 1.7 percent, while the precrisis average, i.e., 1989–2008, was 2.9 percent. We take these two values to define lower and upper bounds of the sensitivity analysis. In addition, we look at 2.2 percent as an intermediate benchmark.

Table 5 shows that sustainable debt levels vary widely across these scenarios. In the most adverse case—i.e., a return to precrisis real interest rates of almost 3 percent, combined with slow growth of just 1.2 percent, which is not very plausible since such persistent low growth would be expected to go along with much lower real interest rates—a 0.2 percent primary surplus can support debt of about 12 percent of GDP, while a 0.5 percent primary surplus could support debt of close to 30 percent of GDP. In the more plausible central scenario—growth at 1.4 percent and real interest rates at 2.2 percent—sustainable debt levels rise to over 20 percent of euro area GDP based on a 0.2 percent primary surplus and over 50 percent of euro area GDP if a 0.5 percent surplus is assumed.

The main conclusion is that the debt levels needed to replace home-country sovereign debt on bank balance sheets could be sustained by a modest euro area primary surplus of just 0.2 percent, even under very adverse

9. Starting from the debt accumulation equation, $D_t = (1 + i_t)D_{t-1} - P_t$, where D_t represents nominal debt in euros, P_t the primary surplus, and i_t the interest rate, divide both sides by nominal output Y_t and use the definitions $(1 + y_t) \equiv Y_t/Y_{t-1}$, $d_t \equiv D_t/Y_t$, and $p_t \equiv P_t/Y_t$ to obtain: $d_t = \frac{(1+i_t)}{(1+y_t)} d_{t-1} + p_t$. Defining real growth g_t and the real interest rates r_t as $(1 + g_t) \equiv \frac{(1+y_t)}{(1+\pi_t)}$ and $(1 + r_t) \equiv \frac{(1+i_t)}{(1+\pi_t)}$, this can be rewritten as $d_t = \frac{(1+r_t)}{(1+g_t)} d_{t-1} - p_t$. Now impose the condition that the debt ratio d_t is stable: $d_t = d_{t-1}$. Dropping the time subscript, this gives $d = p * \frac{1+g}{r-g}$ (for $r > g$), a steady-state relationship between the stable debt-to-GDP ratio, the primary surplus as a share of GDP, real growth and real interest rates. This formula is used in table 5.

assumptions about growth and real interest rates. Significantly larger amounts can be rationalized by assumptions involving a higher primary surplus, continued low real interest rates, or a combination of both.

Comparison

Table 6 pulls together the relevant results. The "gross volume" columns show the euro area–level safe asset volumes that can be produced, under various assumptions, by the four proposals discussed above. For national tranching, E-bonds, or ESBies, results are shown both under the assumptions that these schemes can purchase or include general government debt securities and for the case that they are based only on central government debt securities. The "net increase" columns indicate how the proposals change the *total* outstanding stock of euro area safe bonds, defined to include any other remaining assets with five-year expected losses of 0.5 percent or less. Note that this is an exceedingly narrow definition of "safety", which excludes all present euro area government bonds other than the German bund,[10] all junior tranches in the national tranching proposal, and all government bonds held outside the E-bond intermediary in the E-bond proposal (including German bunds, whose expected loss rate would rise to about 1 percent in the E-bond proposal in the adverse calibration of the Brunnermeier et al. (2017) default risk model, about in line with current expected loss rates of Finnish and Austrian sovereign bonds). In addition, the "net increase" column excludes the volume of German securities held in the pool of senior tranches in the national tranching proposal, or purchased by E-bond or ESBie intermediaries, since these securities are no longer available for purchase by other investors.[11]

The potentially largest volumes of euro area–level safe assets could clearly be produced by a euro area budget (or equivalently, a euro area sovereign wealth fund) with a borrowing capacity. The disadvantage is that it would require committing relative large resources for debt service, which may be politically viable only if it is part of a structure that has additional purposes beyond just creating a safe asset—for example, to fund public goods that member states agree are best provided at the supranational level.

In the absence of a euro area budget (or a euro area sovereign wealth fund), either ESBies or E-bonds could generate the largest gross volumes of euro area–level safe assets:

- If one is prepared to allow the intermediary that produces ESBies to dip deeply into national debt markets—50 percent of the small markets, and over 80 percent in the large markets, subject to leaving a market volume of at least €200 billion to ensure liquidity—up to €3.7 trillion (35 percent of euro area GDP) of ESBies could be generated, more than by any other approach except possibly a euro area budget.
- If one imposes a purchase limit of a maximum 50 percent of any debt market—including the large ones—the E-bond proposal comes out on top, generating up to €2.3 trillion (22 percent of GDP) based on central

10. Although governments bonds issued by the Netherlands and Luxembourg are also AAA-rated, their five-year expected loss rates are somewhat higher than 0.5 percent in Brunnermeier et al.'s adverse scenario (box 1), due to the fact that the CDS spreads used to calibrate Brunnermeier et al.'s default risk model are slightly higher for these countries than for Germany.

11. Debt issued by the euro area budget does not "use up" debt securities issued by member countries in the same way as the other proposals. At the same time, we did not want to assume that issuing such debt is a "free" way of creating euro area safe assets, because euro area debt ultimately competes for revenues that could otherwise be used to sustain national debt. Table 6 hence assumes that issuing euro area debt would be offset by proportionally less issuance of national sovereign debt. To get from "gross volumes" to "net increase," we subtract the reduction in the German debt stock that follows from this assumption.

government debt securities and €2.6 trillion (24.4 percent of GDP) based on general government debt securities. The ESBies are a close second, at €2.2 trillion and €2.5 trillion, respectively

Importantly, however, ESBies do much better than E-bonds when it comes to the *net* increase in safe asset volumes. This is 15–22 percent for ESBies, but only 10–11 percent for E-bonds. The reason is that in the E-bond proposal, the total outstanding stock of euro area safe assets excludes the entire currently outstanding stock of German bonds, since these are either held in the collateral pool of the E-bond intermediary or subordinated to these claims.

Finally, national tranching is dominated by the other proposals both in terms of the gross safe asset pools that it can produce (17 to 18 percent of euro area GDP), and the resulting net increase in safe assets (just 2–5 percent of euro area GDP). After replacing national bond holdings on bank balance sheets, almost no senior tranches would be left over for nonbank investors—nor would, strictly speaking, any other euro-denominated safe assets, since German bunds would have ceased to exist: Only junior tranches of bunds would be available for purchase by nonbanks. Although some of these, such as the junior tranche of the German bund, would likely still be AAA or close to AAA rated, none of them are considered entirely safe in the definition used throughout this paper.

Before concluding, it is worth checking to what extent these differences in safe asset volumes are driven by the fact that the portfolio selection rules used in some of these approaches imply large deviations from GDP weights (or similarly, the ECB capital key). In particular, portfolios that give higher weights to higher-rated bonds from countries such as Germany, the Netherlands, and France allow lower subordination levels: Since the portfolio composition is skewed towards "safer" bonds, the safe asset or asset portfolio requires less protection from subordinated bonds, implying a higher share of safe assets. Is this one reason why the E-bond approach produces higher safe asset volumes than the national tranching approach, for example, or why the ESBie portfolio rules (5) and (7) lead to much higher safe asset volumes than rules (4) and (6)?

To answer this question, we repeat the portfolio selection steps for national senior tranches, E-bonds, and ESBies using the same purchase rules as before (i.e., equations 1 through 7) except that an additional constraint is imposed, namely, that the deviation of the resulting portfolios from the ECB capital key cannot exceed a given maximum. Specifically, we take the deviation of the portfolio shares of the ECB's PSPP from the ECB capital key at the end of 2017, measured by the root mean squared error (RMSE), as indicative of the deviation that might be acceptable for a portfolio that is meant to be representative for the euro area.[12] As it turns out (see appendix table

12. Specifically, we proceeded as follows: In the ESBies and national tranching approaches, we follow ESRB HLTF (2018) in applying a method of successive reweighting. In all cases (i.e., equations 1 or 2 for national tranching, or 4, 5, 6, or 7 for ESBies) we take the ECB's capital key as a starting point. Once a country reaches one of the limits implied by the portfolio rule that is being considered (e.g., for equation 1, either 60 percent of GDP or the exhaustion of the debt stock), then this country's portfolio weight is set to zero for the purpose of the following purchases, and all other countries' portfolio weights are reweighted proportionally. This process continues until the deviation of portfolio weights from the ECB's capital keys reaches RMSE=0.93, which is the root mean squared error of the end-2017 PSPP shares with respect to the ECB capital key. The implication is that the purchases of some countries' debt may not reach either the GDP limit or the total debt limit set by the rules, as the reweighting process ends when RMSE=0.93. In the E-bond approach, we extend the approach described in appendix A so that the uniform parameters y (share of GDP that debt purchases may not exceed) and c (maximum share of debt that can be purchased) are now picked to maximize the volume of safe assets subject to the constraint that the RMSE of the resulting portfolio shares relative to the ECB capital key cannot exceed 0.93 (in addition to the constraint that the expected loss rate from the portfolio cannot exceed 0.5 percent).

C.5), six out of the seven portfolios described in tables 2 to 4 and summarized in table 6 involve higher deviations from the ECB capital key than the PSPP (the only exception is national tranching using equation 1).

Table 7 is analogous to table 6 except that it shows the maximum safe asset volumes associated with a set of modified portfolio shares, shown in appendix table C.6, whose deviations from the ECB capital key are no higher than those of the PSPP. As can be seen by comparing tables 7 and 6, this exercise lowers the maximum safe asset volumes in all cases except for the first portfolio in the national tranching approach, which already satisfied the maximum deviation constraint. The changes are particularly large in the cases of purchase rules (5) and (7), for which the maximum ESBie volume is lower by around €1 trillion (from €3.5 and €3.7 trillion, respectively, to €2.6 trillion). This decline is driven mainly by a large reduction in the portfolio share of French bonds, which in purchase rules (5) and (7) turned out to be above France's ECB capital share by a large margin (see appendix tables C.5 and C.6).

As a result, the maximum gross volume of safe assets that can now be produced under both the ESBies and the E-bonds approaches is about the same, namely €2.6 trillion, compared with about €1.9 trillion in the national tranching approach. The overall ranking of the four approaches when it comes to safe asset volumes does not change, however: A euro area or EU budget or leveraged sovereign wealth fund would have the highest potential, followed by E-bonds and ESBies, and finally national tranching.

Fiscal Discipline

The four proposals could potentially enhance fiscal discipline through two channels.

First, to the extent that safe assets would replace banks' exposures to their own sovereigns, it would reduce the economic costs (or increase the net fiscal transfers[13]) associated with sovereign debt restructuring, as the banking sector would be less hard hit. This raises the probability that countries whose debts are unsustainable will restructure, rather than "gambling for redemption" through fiscal adjustment supported by official crisis lending (Benassy-Quéré et al. 2018). All else equal, the higher probability of debt restructuring would raise the costs of borrowing for countries with high and increasing debt burdens, perhaps inducing these countries to take corrective measures earlier than would otherwise be the case. Even if it does not, the higher credibility of the no-bailout rule may lead to countries with unsustainable debts losing market access earlier, increasing market discipline in this sense. This effect would arise regardless of how the safe asset is created (in fact, the effect arises from any measure that reduces concentrated bank exposures to specific sovereigns, particularly their own).

This said, unless the replacement of sovereign exposures on bank balance sheets is accompanied by a substantial "hardening" of European rules or institutions governing crisis lending, one would not expect this effect to be very strong. The reason is that sovereign debt restructurings are likely to remain economically and politically costly, even if banks are not directly exposed to the sovereign. For example, there is evidence that sovereign defaults reduce private access to international capital, which could curtail investment (Das, Papaioannou, and Trebesch 2010). Defaults could also have domestic "reputational spillovers" (Cole and Kehoe 1996): Firms may

13. In the sense that resources needed to recapitalize the domestic banking system after a debt restructuring would be lower.

interpret a default as revealing bad information about the government, which increases policy uncertainty and depresses investment, creating a recession. In anticipation, banks may reduce their lending, which deepens the recession. Hence, debt restructuring is likely to remain unattractive to domestic policymakers, even if banks are not directly exposed to sovereign debt.

Second, in the E-bond proposal, the loss given default expected by private creditors may increase,[14] raising the cost of borrowing from the private sector. Without subordination, a given loss $l * D$ (where D is the outstanding debt and l is the loss given default rate) would have been distributed among the entire creditor mass D, so that each creditor suffers the same loss rate l. With subordination, there are two possibilities. If the losses are larger than the claims of the private creditors, $s * D$ (where s is the subordination level), i.e., if $l \geq s$, private claims would be written down to zero. If not, i.e., $l < s$, claims of private creditors would be written down in the proportion l/s, i.e., each junior creditor suffers a loss rate of l/s, which is smaller than 1 but bigger than l. The lower the subordination level s (i.e., the smaller the mass of junior creditors), the higher the loss rate for private creditors.

Denoting π as the default probability, r^* as the risk-free interest rate, and r_s as the risky interest rate with subordination s (i.e., after the introduction of E-bonds), the standard interest parity condition can be written as:

$$(1 + r_s)(1 - \pi) = \begin{cases} (1 + r^*) & \text{for } l \geq s \\ (1 + r^*) - \pi(1 - l/s) & \text{for } l < s \end{cases} \quad (8)$$

Equation (8) implies that for any $l < s$, r_s, is decreasing in s. The status quo (no subordination) corresponds to the special case in which $s = 1$. Using the country-specific subordination levels for the E-bond proposal shown in table 3, the equation can be used for back-of-the-envelope estimates, based on an assumed loss given default rate, of how much the marginal cost of borrowing from the debt market would increase if the proposal were adopted. For example, at end-October 2017, the 10-year German benchmark bond yield was about 0.36 percent, the 10-year Italian benchmark bond yield was 1.82 percent, and the 10-year Portuguese yield was 2.06 percent. Since the German bond yield is not quite risk-free, the risk-free 10-year rate, r^*, should be slightly below 0.36 percent. Brunnermeier et al.'s "benchmark" simulations lead to a five-year expected loss rate of 0.13 percent, which implies $r^* = 0.33$ percent.[15] Taking $l = 0.5$ (which is on the high side of long-run historic average loss rates, see Cruces and Trebesch 2013 and Meyer, Reinhart, and Trebesch 2018), setting $s = 1$ and solving for π yields an implicit default probability of $\pi = (r_s - r^*)/(l + r) = 2.9$ percent for Italy and 3.3 percent for Portugal. Substituting these probabilities back into equation (8), and using the country-specific subordination levels of $s = 0.78$ for Italy and $s = 0.65$ for Portugal, respectively, leads to $r_s = 2.24$ *percent* for Italy and $r_s = 2.97$ *percent* for Portugal. Compared with current levels, this is an increase of 42 basis points for Italy and 91 basis points for Portugal. The bigger impact on Portugal mainly reflects the smaller subordination level for Portugal (0.65) than for Italy (0.78),[16] which implies that in a Portuguese credit event, a given loss would need to be shared among a smaller pool of creditors.

14. In this section, the term "private creditors" is used to refer to all creditors other than the (senior) E-bond issuer.

15. A five-year expected loss rate of 0.13 percent implies a spread between the risk-free rate and the German rate on the order of 3 basis points ($100*(1 - (1 - 0.0013)^{1/5}) = 0.026$).

16. This in turn reflects the fact that the outstanding general government debt securities volume as a share of GDP is smaller for Portugal than for Italy. As a result, purchasing a constant 25 percent of national GDP worth of debt securities in both countries under the E-bond proposal leaves a larger pool of subordinated debt in Italy than in Portugal (see table 3).

As will be shown in more detail in the last section of the paper, this rise in the costs of borrowing from the market does not necessarily translate into a rise in overall borrowing costs. The reason is that a share $1 - s$ of the debt, i.e., 22 percent for Italy and 35 percent for Portugal, is now being borrowed from the E-bond intermediary at the much lower German cost of borrowing (since the E-bond was designed to exactly match the expected loss rate of the German bund, and the E-bond issuer is assumed to pass on its funding costs to its borrowers). The new average cost of borrowing would hence be $0.22 * 0.36\% + 0.78 * 2.24\% = 1.82\%$ for Italy and $0.35 * 0.36\% + 0.65 * 2.97\% = 2.06\%$ for Portugal, unchanged from their previous levels. Importantly, however, the *marginal* borrowing costs of these countries would still go up by the full increase of borrowing costs from the market, since the 25 percent of GDP borrowing limit from the E-bond issuer would be binding for both countries. Any additional borrowing would hence happen at the—more expensive—market rates.

The only other proposal that might have a conceptually similar subordination characteristic as the E- bonds, and hence might raise the cost of debt issued to the market, is the euro area budget. If the revenues feeding the euro area budget consist of member state contributions that must be prioritized over national debt service, it could create a subordination effect that leads to a faster increase in the borrowing costs of countries with imprudent fiscal policies than would otherwise be the case. The circumstances under which this might occur are quite narrow, however. For example, there would be no subordination effect if the euro area budget is fed by a direct revenue stream, such as a euro area or EU corporate tax: Although national tax bases might shrink, fluctuations in economic activity would affect the euro area budget and national budgets *pari passu*. Furthermore, the euro area budget could weaken fiscal discipline through its spending side, if it acts as an insurance mechanism that protects countries from the consequences of fiscal crises. Hence, the incentive effects of a euro area budget are ambiguous and would depend on how both the revenue and the expenditure sides are designed.

The remaining proposals, national tranching and ESBies, involve subordination at the level of the issuer, rather than the subordination of national debt or national debt service. As such, they would not raise the marginal costs of national borrowing through a subordination effect. This said, the rules according to which safe assets or safe asset pools are created in these proposals—given by equations (1) or (2) for national tranching and (4), (5), (6), or (7) for ESBies—imply that once a country's total stock of debt securities exceeds either 60 or 71 percent of GDP (depending on the rule), national debt no longer enters the pool that comprises or backs the safe asset, which may enjoy a more favorable regulatory treatment (to induce banks to hold safe assets). They would hence need to be sold to investors that enjoy no direct or indirect regulatory advantage from holding them and hence require somewhat higher returns. This could imply an increase in the costs of debt issuance after these limits have been reached.

Protecting Financial Stability during the Process of Lowering Bank Holdings of Sovereign Bonds

The previous section implicitly compared two steady states: the status quo and a state in which safe assets have been created in large volumes, replacing current holdings of sovereign bonds by banks. While the new steady state would imply higher marginal costs of sovereign borrowing in at least one of the four proposals (E-bonds), it would

not affect the average costs of sovereign borrowing. However, this argument disregarded the transition from the status quo to the new steady state. Persuading banks to replace their current sovereign bond holdings with a safe asset (or asset portfolio) will require tightening the regulatory treatment of sovereign exposures. Depending on the form of the new regulation, euro area banks may reduce aggregate holdings of sovereign bonds,[17] which could in turn raise the cost of debt issued by member states during the transition period, reduce fiscal space, and create adverse debt dynamics.

Consider first how ESBies and E-bonds might be used to mitigate this problem. Producing these assets requires the purchase of a collateral pool of sovereign debt, which can be used to neutralize any decline in demand by banks. For example, issuing €100 of E-bonds requires purchasing €16 from Italy, since Italy's share in the E-bonds collateral pool is 16 percent. Issuing €100 of ESBies requires issuing sovereign bond–backed securities of about €150, which—given an Italian share in the ESBies collateral pool of about 20 percent—would create a demand for €30 in Italian bonds in terms of face value.

Sovereign exposures of banks could be gradually reduced by synchronizing the issuance of ESBies or E-bonds with redemptions of sovereign bonds held by banks, as follows. After getting the infrastructure for issuing ESBies or E-bonds up and running, the regulatory treatment of euro area bank holdings of *newly issued* sovereign debt would change in a way that makes it more expensive for banks to hold sovereign debt. The capital charge would apply neither to the safe asset nor to previously issued sovereign debt—hence avoiding a "fire sale" of existing bond holdings. As national bond holdings of euro area banks mature, banks may have an incentive to replace these holdings with euro area safe assets rather than freshly issued national bonds. ESBies or E-bonds would have to be issued at a level that (a) meets that demand in the aggregate; (b) for all euro area countries, at least offsets the redemptions of sovereign debt held by euro area banks.[18]

For example, a back-of-the-envelope calculation suggests that in 2018 the amount of maturing Greek debt on euro area bank balance sheets might be on the order of €11 billion, much smaller than the amount of maturing Italian debt (€289 billion). However, the SBBS or E-bond portfolio required to purchase €11 billion of Greek debt would lead to demand for Italian debt in excess of €289 billion, because Greece's weight in the portfolios is much smaller than Italy's. The same is true for all other countries. Hence, calibrating the 2018 level of ESBies or E-bond issuance to equal redemptions of Greek bonds held by banks implies that the ESBie or E-bond intermediaries' demand for the sovereign bonds of all other countries will exceed the redemptions of bank-held bonds for these countries.

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17. Véron (2017) proposes regulation that would require euro area banks to hold capital only against *concentrated* sovereign exposures. This could conceivably leave the *aggregate* demand for euro area debt by euro area banks unchanged, as banks that were previously unexposed to some sovereigns purchase bonds from banks previously overexposed to these sovereigns. However, it is also possible that some banks will need to sell some of their exposures to nonbanks, putting pressure on the yields of these sovereigns.

18. More precisely, the two conditions are as follows. Let p_i denote the portfolio weight of country i, $R^B_{i,t}$, the total redemptions of country bonds held by euro area banks coming due at time t, and V_t the volume of either E-bonds or sovereign bond–backed securities issued by the ESBie intermediaries (i.e., the volume of ESBies plus the associated junior tranches) at time t. Then, (a) $\sigma * V_t \geq \sum_i R^B_{i,t}$ and (b) $V_t = \max_i\{R^B_{i,t}/p_i\}$, where σ equals 1 in the case of E-bonds and the subordination level (e.g., 0.33) in the case of ESBies.

Satisfying condition (b) would deal with the worst case in which the change in regulation implies that *no* maturing redemptions are rolled over. This is clearly an extreme case: For example, following a change in regulation that penalizes sovereign exposures beyond a particular concentration level, banks would presumably roll over maturing exposures up to that level. It is nonetheless useful to check whether the creation of ESBies and E-bonds could be calibrated to meet this condition. This is explored in table 8. Using Bloomberg data on the maturity structure of each country's sovereign debt, we determine, for each year, the "binding country": that is, the country whose maturing quantity of debt requires the highest amount of ESBies or E-bonds to offset the redemption of its debt held by banks.[19] Issuing ESBies or E-bonds, respectively, in the amounts indicated in the columns entitled "Flow (1)" and "Flow (2)" would ensure sufficient demand to offset the redemption of bank-held sovereign debt of all other countries and to meet the maximum aggregate demand for safe assets from banks (shown in the column "redemptions of euro area sovereign bonds held by euro area banks") by a significant margin.

Table 8 also shows that after 12 years, the total *stock* of ESBies and E-bonds outstanding would remain below the maximum market sizes shown in tables 6 and 7. The pace of issuance of ESBies described in the column "Flow (1)" would therefore be feasible. With respect to the issuance of E-bonds, however, one has to worry about an additional feasibility constraint: the volume of E-bonds that can be issued in any given year is capped by the need to attain a specific subordination level for each country (see table 3), which requires leaving a sufficient volume of national debt outside the E-bond collateral pool.[20] The column "Flow (3)" shows the maximum volume of E-bonds that can be generated within that constraint in each year. As is clear by comparing this column with "Flow (2)", the maximum feasible flow of E-bonds fluctuates between about 52 percent and about 72 percent of the flow needed to absorb potential excess net supply of euro area government bonds in the first 10 years. In a setting in which a large proportion of maturing debt held by banks is not rolled over, ESBies are a more powerful and flexible instrument than E-bonds to offset large shifts in bank portfolio holdings of sovereign bonds.

E-bonds and ESBies also differ in another important respect. E-bonds consist of a single, "safe" tranche. Issued into a world in which such assets are in short supply, they would presumably be absorbed easily without putting pressure on the yields of similarly rated sovereign bonds, such as those issued by Germany or the Netherlands. In contrast, ESBies are the senior component of a set of sovereign bond–backed securities. Issuing ESBies in the way described by table 8 requires issuing subordinated securities corresponding to about 50 percent of the ESBie flows indicated in the table.[21] According to the Brunnermeier et al. (2017) benchmark model, five-year expected loss rates of these junior securities would be about 9 percent, similar to the five-year expected loss rate of a Portuguese sovereign bond. Hence, it is possible that junior bonds would compete with similarly rated country issues, possibly

19. We assume, as an illustration, that bank holdings of each country's debt have the same maturity structure as its total outstanding debt securities.

20. Suppose the targeted subordination level for country i is s_i. Since it is not legally feasible to retroactively subordinate the outstanding stock of debt to debt held by a newly created E-bond issuer, achieving this subordination level requires that the E-bond issuer purchase no more than a share $1 - s_i$ of the newly issued sovereign debt of country i. Column "Flow (3)" shows the sum of these purchases across all countries.

21. With a subordination level between 30 and 35 percent (see table 4), EJBies make up 30 to 35 percent of total debt issuance, while ESBies make up 65 to 70 percent. Hence, EJBies constitute 43 to 54 percent of ESBie issuance.

putting pressure on yields of lower-rated countries through this channel. We return to this question in the last section of the paper.

Under national tranching, assembling safe asset portfolios requires only national senior tranches as an input. Hence, synchronizing bond redemptions by banks with the creation of these portfolios creates demand for only 30 percent of the face value of the debt. Since euro area banks hold only 22 percent of euro area debt, this is not a problem in the aggregate. However, euro area banks hold more than 30 percent of sovereign debt securities in countries such as Spain (32 percent), Portugal (36 percent), Slovakia (41 percent) and Cyprus (45 percent; see table 1). In these countries, redemptions of bank-held debt may hence exceed the share of new issues that banks demand to create safe asset pools, putting some pressure on yields.

Finally, issuing a safe asset in the form of the debt of a euro area budget or wealth fund would normally be neither based on purchases of national debt nor expected to reduce the need to issue national debt, since it should have no first-order impact on the national fiscal position (creating the budget requires assigning both some revenues and some expenditure functions to the euro area level, of about equal magnitude). Hence, of the four proposals considered, it would normally offer the least flexibility in offsetting the decline in demand for sovereign debt associated with the reduction of sovereign exposures of banks. However, this conclusion can be overturned by allowing the euro area budget to pay a deficit-financed transfer (over and above its normal expenditures) to euro area countries during the transition phase, calibrated to equal the expected decline in demand for national debt by banks. Alternatively, it could provide countries with a loan of the same magnitude or purchase the bonds that would normally have been rolled over by banks. Hence, the euro area budget might work at least as well in managing the transition phase as ESBies—provided it is given a mandate to do so.

IV. UNINTENDED CONSEQUENCES

Less Liquid National Bond Markets

Sovereign issuers, and particularly their debt managers, attach great importance to sovereign debt market liquidity (Gelpern, Gulati, and Zettelmeyer 2017), in part because the flexibility of public funding depends on liquidity and in part because sovereign bond prices act as benchmarks for other asset prices (for example, corporate debt). Hence, the potential impact of safe asset proposals on the liquidity of sovereign bond markets is a relevant consideration for comparing such proposals.

Debt issued by a euro area budget or sovereign wealth fund would likely be the least "invasive" from the vantage point of national debt managers. It would add a source of competition, but debt managers already operate in competitive markets. The size of national debt markets could shrink in equilibrium (as both national tax bases and spending responsibilities might be reduced), but maintaining stable market access should not be a problem, and debt markets would otherwise remain unaffected.

ESBies and E-bonds are likely the next best option. Depending on how purchase limits are set, they may affect market liquidity. However, because the functioning of ESBies depends on the presence of meaningful market prices, the incentives of ESBie regulators and national debt managers are largely aligned. Preservation of the liquidity of the underlying market is essential for both, and purchase limits would hence likely be set accord-

ingly. ESRB HLTF (2018) show that evidence of a decrease in liquidity following the start of the PSPP in March 2015 is limited and argue that a steady-state SBBS market size comparable to the PSPP could have similarly minor effects on national bond market liquidity. This finding is consistent with the arguments and evidence on the link between market liquidity and market size cited earlier. As the comparison between tables 3 and 4 shows, E-bonds would have similar or tighter purchase limits compared with ESBies, leading to similar or higher liquidity of the residual market.[22]

National tranching would do no worse and perhaps better than E-bonds or ESBies with respect to the liquidity of the junior tranche, since it would amount to around 70 percent of total issuance and be held outside banks. Senior tranches could be mostly illiquid, however. For countries whose share of euro area GDP exceeds their share of euro area debt securities markets—Germany, the Netherlands, Luxembourg, Finland, Estonia Slovakia, Ireland, Latvia, Lithuania, Malta, Cyprus, and (since 2012) Greece—senior sovereign debt tranches would be held entirely by euro area banks. Even for the remaining countries, the volume of trading senior tranches would be small—less than €100 billion, except in the case of Italy.

Redistributive Effects

By design, neither national tranching nor ESBies can have redistributive effects as long as they work as intended (the possibility that they may not is discussed in the next section). National tranching is just a different way of selling national debt. ESBies are created by intermediaries buying and selling at market prices. They would pay highly rated borrowers more, for the same face value, than lower-rated borrowers. Assuming that yields in secondary or primary markets adequately reflect the risk of default and expected loss given default, borrowers would be remunerated in line with their credit risk, making redistribution impossible.

Whether a euro area budget or a debt-financed euro area sovereign wealth fund would have redistributive effects depends on the design. Consider two examples for designs that would not lead to redistribution.

- A euro area budget that is fed by dedicated tax revenues (for example, a corporate tax or a small percent of VAT) and allocates spending across member countries in the same proportion as the revenues it receives from those countries when they are in a cyclically neutral position. When the budget incurs a deficit, spending would be raised (or revenues reduced) in fixed proportions across all member states (see Zettelmeyer 2017).
- A euro area sovereign wealth fund based on a small stream of contributions ("savings") from all member states. Member states do not guarantee the debt of the fund, only their own contributions. Contribution shares would equal ownership shares, which in turn equal the shares according to which profits are distributed.

While these designs rule out redistribution, plenty of other designs would not—for example, if the euro area budget spends disproportionally on infrastructure or services in specific countries, or if fiscally stronger countries are expected to implicitly guarantee debt issued at the euro area level. For the purposes of this section, however,

22. Furthermore, Dunne (2018) argues that ESBies would induce positive liquidity spillovers that offset any negative effects, as dealers could use sovereign bond–backed securities as instruments to hedge inventory risk. The existence of low-cost hedging and diversification opportunities would limit the divergence of bid-ask spreads between national and SBBS markets. The same argument would extend to E-bonds.

the important insight is that a euro budget or a leveraged euro area sovereign wealth fund could issue euro area debt using rules that exclude redistribution.

As in the section on fiscal discipline, the E-bond proposal is the outlier here. In this proposal, redistribution can arise in either of the two variants briefly described in section II of the paper, albeit in opposite directions. To recall, in the first variant the E-bond intermediary would purchase bonds at market prices, while in the second it would extend loans, repaid at face value, with the interest on the loan set in a way that distributes the funding costs of the intermediary to all borrowers in proportion to the face value borrowed. Table 9 explores the distributional implications of both variants, using the benchmark calibration of the Brunnermeier et al. (2017) simulation model (analogous results using the adverse calibration are presented in appendix table C.7).

In the first variant, the E-bond intermediary would purchase debt at market prices and earn a corresponding return. We assume a competitive secondary market, in which the expected return equals the expected loss, bearing in mind that the latter reflects the subordinated status of private borrowers. Using the subordination levels of table 3, these five-year expected losses are recorded in the third column of the table. Not surprisingly, they are much larger than the five-year expected loss of the senior intermediary itself (column 4). Multiplying the difference between the two with the intermediary's debt holdings of each country leads to an expected profit that the intermediary can expect to earn from those holdings (column 5). The sum of these expected profits, over five years, is €79 billion, off a €2.63 trillion total stock of debt holdings. €29 billion of these are attributable to Italian debt holdings, reflecting the fact that the assumed return on Italian debt is much higher than the risk faced by the senior investor. These profits are then assumed to be distributed among the euro area countries according to their portfolio shares (column 6). Column (7) records the difference between these expected profit distributions and the expected profits attributable to the country. This yields large transfers to Germany (€21 billion) and to a lesser extent France (€8 billion) and the Netherlands (€4 billion) and large transfers from Italy (€16 billion), Greece (€10 billion), and Spain (€7 billion). In other words, an E-bond issuer purchasing sovereign debt at market prices would be redistribute from the lower-rated to the higher-rated countries of the euro area.

What if the E-bond issuer purchases debt at face value? This would make a big difference in two respects: First, the direction of the redistribution would be reversed, and second, the overall magnitude of the redistribution would be much smaller. In this variant, the E-bond issuer would make zero profits, because its funding costs are assumed to be passed on to its borrowers by setting the interest it charges—assumed to be the same for all countries—accordingly. The E-bond issuer's funding costs reflect the expected losses of the issuer vis-à-vis each borrower, multiplied with its portfolio holdings (see column 8). Because of the issuer's preferred creditor status, these funding costs would be relatively modest—about €10 billion over 5 years, again assuming a €2.63 trillion total portfolio, €4 billion of which reflect holdings of Greek debt, which are risky even from the perspective of a senior debt holder (expected loss rate of 14 percent over 5 years). When these funding costs are distributed according to the portfolio shares (column 9), the largest countries shoulder the biggest burden (Germany €3 billion, France €2.2 billion). At the same time, these countries do not contribute to the funding costs at all, because they are virtually riskless from the perspective of the E-bond intermediary. Greece is in the opposite posi-

tion: In this simulation, it would be responsible for about 40 percent of the funding cost—over €4 billion—but pay only about €110 million toward it due to its small portfolio share.

Italy is a special case. It contributes to the expected losses of the portfolio, but only very little, with an expected loss rate of around 0.3 percent. The reason is that its subordination level is extremely high (0.78, see table 3). In other words, any Italian debt restructuring would cause losses to the E-bond issuer only if it led to a write-down of more than 78 percent of Italian debt, which is almost inconceivable. At this level of subordination, Italy is a safe country—not quite as safe as Belgium or France, but almost—from the perspective of the intermediary. At the same time, Italy, as a large country, has a sizeable portfolio weight, of almost 16 percent. As such, it shoulders 16 percent of the aggregate expected portfolio loss of €10 billion. As a result, Italy is an expected net contributor, to the tune of about €540 million over 5 years, in spite of its relatively low credit rating. But this amount is of course much lower than the €29 billion that it would be expected to contribute, over the same period, in the variant in which the E-bond intermediary purchases debt at market prices.

In sum, in the second variant of the proposal, the "safer" countries, from the perspective of the intermediary, would in general be subsidizing the less safe ones. Importantly, however, the level of redistribution—with net contributors paying about €7 billion over 5 years (i.e., the sum of the negative entries in column 10)—would be modest compared with the sum of net contributions in the first variant of the proposal (€38 billion). Moreover, €7 billion represents a fraction of the redistribution that already takes place within the EU budget. For example, when the E-bond issuer purchases debt at face value, the net expected annual contribution of Germany would be about €600 million, which is about 38 percent of its average annual *net* contribution to the EU budget during the 2007–13 period.

Is there a version of the E-bond proposal that would avoid redistribution in either direction? Conceptually, the way to do this would be to extend loans to each country at interest rates that are higher than the intermediary's funding costs but lower than market yields, at a mark-up over funding costs that reflects the risk *to the public intermediary* (rather than private investors). In other words, each sovereign issuer should be charged a country-specific fair risk premium, taking into account the intermediary's seniority and portfolio holdings relative to the outstanding market size (since these determine the subordination level).

Unfortunately, this approach is likely to be difficult to implement in practice, because of the lack of an objective benchmark that would help decide the fair premium that each issuer should be charged. To illustrate this point, consider the case of the International Monetary Fund, a preferred creditor. The interest rates that the IMF charges its borrowers are not based on market rates; rather, it sets a "rate of charge" that covers its risks and leads to roughly zero profits over time. This approach sounds close to the "fair risk premium" approach described above, but with a crucial difference: The IMF makes zero profits *across* all its nonconcessional borrowers, not for each and every borrower. While it differentiates its rate of charge according to some criteria—in particular, how much the country borrows—it does not adapt its rate of charge to the perceived credit risk of specific borrowers. As a result, some countries borrow from the IMF at rates below the fair risk premium, and others above, just like in the second variant of the E-bond proposal discussed above. This approach has never been a problem politically, perhaps because the majority of IMF shares are held by rich countries that do not expect to ever borrow from the

fund, so they are neither winners nor losers. But if the IMF were to attempt to differentiate borrowing rates across countries, it would surely result in acrimony.

There is hence no "clean" solution to the redistribution problem associated with the E-bond approach. There may be politically feasible ways of reducing redistribution, however. One such way would be to opt for a version of the first variant, i.e., purchases at market prices, and use the accumulating seniority rents to finance a euro area or EU budget whose expenditures disproportionately benefit the countries that contribute to the profits of the intermediary. Another would be a version of the second variant, which involves capitalizing the intermediary in a way that would absorb any expected losses over a particular period and negotiate a capital key that puts a larger burden on countries with higher contributions to expected loss rates. The consequence would be to reduce aggregate funding costs to zero or near zero and hence eliminate any redistribution arising from distributing these funding costs across members in line with portfolio weights. Of course, this merely shifts the problem from a negotiation over "fair risk premiums" to a negotiation over the capital key. But this negotiation would need to happen, say, only once every five years; and it could be informed by several risk models as well as political considerations.

"Mutualization Through the Back Door"

As we have seen, none of the proposals discussed in this paper involves any explicit guarantee. Critics nonetheless worry that some of the proposals discussed here might give rise to *implicit* guarantees, or "mutualization through the back door," and hence become a source of moral hazard.[23] In particular, moral hazard could arise through the expectation of some form of publicly financed bailout triggered either by the failure of the supposedly safe asset or by the failure of the *system* that was put in place to create the asset. Such expectations might arise because the asset is viewed as state-sponsored, or simply because the consequences of allowing the safe asset to fail are so catastrophic that they are sure to trigger public intervention.[24] Similarly, if the failure of the *system* that was put in place to create the safe asset threatens fiscal or financial stability (for example, because governments may have come to depend on it as a channel for issuing sovereign debt), it might be viewed as implicitly guaranteed. We now briefly examine the plausibility of these potential sources of moral hazard under the various proposals.

Public Sponsorship?

The impression of "public sponsorship" of the safe asset could arise, most obviously, if the safe asset is formally the liability of a public intermediary. According to this argument, E-bonds or bonds issued by a euro area budget might give rise to implicit guarantees because both involve public institutions created by these members. National tranching and ESBies do not have this problem: The latter could be created by private intermediaries (see ESRB

23. See, for example, Academic Advisory Council to the German Federal Ministry of Finance (2017).

24. Examples of the former include an exchange rate peg that fails notwithstanding earlier government protestations to the contrary. Even if they could stomach the losses, households that had borrowed in foreign currency may expect a bailout because they feel that the government should take responsibility for misleading them. Examples of the latter include a natural disaster such as a flood. Even if the government bears no responsibility for the flood, and even if homeowners building in the flood plane were warned not to do so, those homeowners may expect a bailout purely on the grounds that the human and ultimately political cost for refusing it would be too high.

HLTF 2018) while the former does not require any intermediary at all ("safe" portfolios could be created by banks and other investors simply by purchasing the senior tranche of multi-tranche sovereign debt).

However, a sense of public sponsorship may extend even to safe assets that are not created by public entities, so long as the system that created them was publicly organized or is publicly recognized—for example, by EU regulation—as one that is *meant* to generate safe assets. Both ESBies and national tranching would be included here, since safe assets or asset portfolios based on these approaches would come with a regulatory signal to both banks and the broader public that it is safe to hold these assets. Indeed, the fact that a high-level task force comprising members of the Eurosystem, the European Commission, and European supervisory institutions spent 18 months scrutinizing the ESBie proposal and producing a practical blueprint (ESRB HLTF 2018) may be enough to generate the impression that ESBies created according to that blueprint are publicly sponsored, whether or not they are issued by a public entity.

Hence, it may not be possible to avoid the appearance of implicit guarantees merely by entrusting the production of the safe asset to private entities. Because any of the four approaches to creating sovereign debt–based safe assets in the euro area would ultimately have to be publicly sponsored in some form—if only via public regulation that is intended to allow such assets to develop—the argument that any of them could give rise to implicit guarantees is impossible to refute.

Unexpected Losses

Given that any of the proposals discussed could arguably give rise to implicit guarantees, the question is whether—and if so, with what likelihood—the members of the euro area might be called to make good on these guarantees. What are the chances that the supposedly safe assets suffer losses that are sufficiently large and systemic to create pressures to bail out the holders of the assets?

By construction, expected loss rates associated with each proposal are very low and equal for all proposals (namely, 0.5 percent of the face value of the asset over a five-year period). The *distribution* of losses, however, can differ and can be simulated with the same tools that were used to compute the expected loss rate (namely the Brunnermeier et al. 2017 model described in box 1). Based on these distributions, one can compute the loss rates associated with catastrophic tail-events—i.e., losses happening with a specific, low probability. Following ESRB HLTF (2018), we focus on two standard measures for such unexpected losses, the value at risk (VaR) and the expected shortfall (ES), at various probability levels p. The VaR at probability p measures the loss such that the probability of losses at or exceeding this level is p%, while ES measures expected losses in the worst p% of outcomes. By construction, the ES is always higher than the VaR.

Table 10 compares VaRs and ES across three of the four main proposals—national tranching, E-bonds, and ESBies at various probability levels, beginning at 5 percent and declining to 1 percent, for both the benchmark and adverse calibrations. Consider first the benchmark calibration. The main result is that VaRs and ES are generally significantly higher in the national tranching and E-bond approaches than in the ESBie approach—the only exception is the 1 percent ES, in which the expected loss rates across the three proposals are about the same (namely, between 8 and 12 percent). Thus, for this calibration and the range of tail-events considered, ESBies dominate the alternatives in terms of the protection that they afford.

The flavor of the results is a bit different in the adverse calibration. In the somewhat more likely tail-events (occurring with probabilities of 5, 4, 3, and even just 2 percent) the VaRs of ESBies continue to be smaller than those of the other two proposals. At the 1 percent level, however, the opposite is true: In this case, 20 to 30 percent of the value of the ESBies would be wiped out, while the VaRs of the other two proposals are only around 9 to 13 percent. For the same reason, the ES of ESBies is generally higher than those of the other proposals in the adverse calibration: The extreme losses borne by ESBies in the tail of the loss distribution raise the ES, which is an average measure. Hence, the overall result of table 10 is that ESBies would suffer bigger losses in very rare, systemic crises in which many countries default at the same time, but otherwise do a better job at protecting their holders than E-bonds or a diversified portfolio of national senior tranches.

This difference between ESBies on one side and national tranching and E-bonds on the other is due to the difference in the sequence of pooling and tranching. ESBies, as senior tranches of sovereign bond–backed securities, do not bear any losses until all junior tranches have been entirely wiped out. As appendix table C.8 illustrates, this is the case only in catastrophic systemic crises, in which even euro area countries rated AA and better default (in other words, ESBies are safe as long as France and higher-rated countries do not default). Once the junior tranches are wiped out, however, any additional default comes fully at the expense of the senior bondholders, and ESBies loss rates rise very steeply.

In the cases of national tranching and E-bonds, however, the pool of senior tranches or the E-bond bear a loss as soon as the loss in any *one* country exceeds the value of the junior bonds of that country (table C.9). For example, table C.9 shows that the 5 percent VaR loss of 0.2 percent in the national tranching case is generated by losses in Greece and Cyprus that exceeded the loss-absorption capacity of the junior holders of Greek and Cypriot bonds and caused further losses to the senior holders of 23 and 3 percent of their value, respectively. Even a default in just one country could trigger a loss in the supposedly "safe" diversified portfolio of senior tranches, or a loss by the E-bond intermediary that would have to be passed on to the holders of the E-bonds, provided the default is large enough to wipe out the junior claim holders.[25] As more countries default, loss rates in the "safe" asset or asset portfolio rise more slowly than in the case of ESBies, since for each new default a portion of the losses (or perhaps even the entire loss, depending on its extent) is absorbed by the junior claim holders.

These results have a surprisingly clear implication for the question of whether losses suffered by supposedly safe assets might trigger implicit guarantees by member states. In the case of national tranching and E-bonds, this appears conceivable: Consider, for example, the 3 percent VaR case for national tranching, which is enough to inflict moderately severe losses—almost 9 percent—on banks and other holders of a supposedly safe diversified portfolio of senior tranches due to defaults by Greece, Ireland, Italy, Portugal, and some smaller members. Germany, France, the Netherlands, Austria, Finland, Belgium, and Spain do not default in this scenario, so they may come under pressure to bail out their banks and perhaps other countries. ESBies, however, remain safe until the debt crisis becomes so systemic that even France defaults. ESBie losses rise above 10 percent only after Germany and the Netherlands default. In other words, ESBies are largely safe until there is no fiscally strong

25. In the case of E-bonds, this could be avoided by capitalizing the E-bond intermediary.

country left in the euro area. Hence, the possibility that any euro area country, even Germany, might feel called upon to bail out the ESBie holders seems remote.

Loss of Market Access

Both national tranching and ESBies are "structured products" that require selling a junior tranche. If no one buys this tranche, senior tranches cannot be issued either, and new issuance stops. Would junior tranches lose market access in a future debt crisis because they are viewed as too risky? In the case of national tranching, individual countries would be cut off from debt markets even when they remain solvent. In the case of ESBies, the failure to issue junior tranches could be even more ominous, since it would affect all euro area member states rather than just countries in crises—since all would be financing a substantial part of their debt issuance through sovereign bond–backed securities. One might worry that this would trigger a bailout—for example, in the form of a purchase of junior tranches by public institutions to stabilize the market.

However, this worry seems unfounded, for two reasons.

First, even if the market for junior tranches were to freeze, it seems very unlikely that this would give rise to "backdoor mutualization." In the case of national tranching, loss of market access would simply trigger ESM crisis lending. This might not be pleasant for the countries involved, but it does not pose significant mutualization risks so long as the loss in market access reflects the new debt structure, as we have assumed, rather than deep solvency problems. In the case of ESBies, countries would continue to issue plain vanilla sovereign debt to the markets. As a result, it seems unlikely that a freezing of the EJB market would in fact trigger a bailout: It is far more likely that sovereign bond–backed securities would not be issued for a while, and debt that is normally sold to SBBS intermediaries would instead be sold directly into the market. While this is not ideal, "backdoor mutualization" would have been avoided.

Furthermore, the possibility that ESBies might trigger "backdoor mutualization" through either channel—a failure of private intermediaries or a "freeze" of the junior market—can be minimized through the way in which the system is designed. ESBie-issuing intermediaries can be regulated in a way that rules out "warehousing" risk—specifically, by requiring them to fill an "order book" before they purchase any bonds (see ESRB HLTF 2018). The risk of a "freeze" of the junior market can be minimized by prohibiting intermediaries from purchasing bonds of countries that have lost access to debt markets and prohibiting sovereigns from discriminating against intermediaries in the event of a default. By a simple no-arbitrage argument, it can be shown that if (1) all countries in the SBBS cover pool have market access; (2) SBBS intermediaries are not themselves risky, and (3) sovereigns treat SBBS issuers the same as any other creditors in a restructuring, then EJBies will always retain market access.[26]

To conclude, the main result of this section is that—perhaps surprisingly—ESBies win the contest when it comes minimizing the risk of "backdoor mutualization." The reason is not so much that they can be issued by

26. Suppose that these conditions are satisfied, and EJB markets nonetheless "freeze," implying that EJBies can be purchased at a zero price. In that case, buying an ESB/EJB "pair" would be a cheaper way of buying a claim on the income stream promised by the bonds in the ESB/EJB collateral pool than buying the bonds directly, despite identical risk. This should increase demand for ESBies/EJBies, contradicting the assumption that the EJB markets are "frozen."

private intermediaries but the fact that ESBies can be designed in a way that makes it impossible for them to suffer losses except in extreme crises in which the potential financiers of a bailout—the large, highly rated European sovereigns—would themselves not be in a position to bail anyone out.

"Backdoor mutualization" is a bit more plausible in national tranching, E-bonds, and a euro area budget (or euro area wealth fund), as these approaches are more susceptible to tail risks that would induce high losses but fall short of a systemic catastrophe. Whether this is an issue in the last two cases will depend on the strength of "front-door" mechanisms protecting the solvency of these intermediaries. In the case of E-bonds, one such mechanism could be sufficiently strong ex-ante capitalization, as suggested in the last section. In the case of a euro area budget or euro area wealth fund, it will depend on the strength of the internal governance and revenue streams on which these vehicles are based.

Higher Costs of Borrowing

As argued earlier, a possible *intended* consequence of some safe asset proposals is to increase the marginal cost of borrowing at higher debt levels, sending a market signal that might contribute to fiscal discipline. This is not the same, however, as saying that the *average* costs of borrowing will or should go up, even in high-debt countries, because these depend on how much the country paid to issue the "inframarginal" units. In principle, average borrowing costs might be unaffected (or even lower). None of the proposals *aim* to raise average borrowing costs, so if they did, it would be an unintended (and undesirable) consequence and a source of worry particularly for countries with higher debts and less fiscal space.

To see whether this concern is justified, consider the channels through which the introduction of a safe asset could affect borrowing costs. As already argued, one such channel could operate through the expectation that the creation of a euro area safe asset would lower the costs of debt restructuring and hence make private sector bail-ins more likely. However, as argued in the section on fiscal discipline, even with a safe asset the economic and political costs of debt restructuring are likely to remain high. Furthermore, the costs may be offset by the (beneficial) impact of safe assets on financial stability, via reduced sovereign exposure of banks. In other words, replacing the sovereign bond holdings of banks with a safe asset might increase the chance that a sovereign debt crisis will be resolved using private sector involvement, but the likelihood of such a crisis should decline. We thus abstract from this effect.

This leaves three direct channels through which proposals could conceivably increase average debt costs:

- First, by reducing bond market liquidity, they may raise liquidity premia. This possibility arises mainly for the "national tranching" proposal (see discussion of liquidity above).
- Second, the cost of borrowing from the market will rise if issuing the safe asset goes along with the subordination of sovereign bonds. This effect is relevant for E-bonds, which rely on a public intermediary that is also a preferred creditor of sovereign issuers. In the first variant of the E-bond proposal—purchases at market prices—borrowing costs would unambiguously rise. In the second variant, however, the E-bond intermediary lends to sovereigns at face value, which will tend to lower borrowing costs for all countries whose funding costs in bond markets are higher than those of the E-bond intermediary. The question is which of these effects dominates.

- Third, safe asset proposals could change the supply of sovereign debt within specific risk buckets. If investors prefer a particular risk bucket—that is, do not view bonds across buckets as perfect substitutes—increasing "local supply" could have a negative or positive impact on bond yields.[27] Since the intended purpose of safe asset proposals is to increase the supply of debt in the lowest risk bucket, it may contribute to higher yields in this bucket, but in the context of a shortage of safe assets in Europe and globally, one would expect this effect to be small. Of greater concern is the possibility that some proposals may raise the debt supply in some of the riskier buckets, for example, through subordination of existing bonds or through the issuance of junior bonds. If so, this could put additional pressure on bond prices, and upward pressure on borrowing costs, of countries that already face relatively high spreads.

In the remainder of this section, we look at the second and third channels in more detail.

Average Cost of Borrowing in the E-bond Proposal

Suppose the E-bond intermediary lends to sovereigns at face value and passes on its funding costs. Sovereign borrowing costs will be a weighted average of the cost of debt issuance to the private sector, which should go up, and the funding costs of the E-bond intermediary. German average borrowing costs should thus slightly rise: Since the expected loss rate of E-bonds is identical to that of Germany, the interest rate that Germany pays to the E-bond intermediary will be equal to the rate that it previously paid to the market. At the same time, the yield on German bonds sold to the market will rise, because German bonds are now subordinated to the German debt held by the E-bond intermediary.

For other countries, the net effect could go in either direction, depending on the creditworthiness of the country. To see this, compare a situation before and after the introduction of E-bonds, assuming that both the risk-free rate and country fundamentals are unchanged. Hence, sovereign risk associated with holding sovereign debt and any sovereign debt-based securities is unchanged. Consequently, a portfolio consisting of all outstanding E-bonds plus all outstanding national bonds should receive the same interest payments as the portfolio of national bonds before the introduction of the safe asset. For the reasons explained, the interest costs of Germany will be slightly higher after the introduction of E-bonds. The same might be true for high-rated countries with borrowing costs very slightly above those of Germany, such as the Netherlands. However, because total interest payments are unchanged, there must be *some* countries (at least one) whose borrowing costs fall if E-bonds are introduced.

Appendix B shows more formally that (1) in general, the impact of E-bonds on the cost of borrowing for a given country is ambiguous; (2) for $l < s$ (where l refers to loss given default and s to the subordination level), the higher the probability of default π, the more likely that E-bonds will lower borrowing costs. Hence, E-bonds will tend to lower the average borrowing costs of the lower-rated countries (although their marginal borrowing costs would increase).

Table 11 illustrates what this might imply for selected individual euro area countries, based on euro area interest rates from two dates: July 2014, which precedes the ECB's PSPP, and October 2017. For each point in time, the table shows actual 10-year government bond rates r as well as the 10-year government bond rates r_s

27. This is analogous to "local supply" or "preferred habitat" effect identified by Vayanos and Vila (2009) and Greenwood and Vayanos (2014), except that in our case the "habitat" refers to a risk bucket rather than a maturity segment.

expected after the introduction of E-bonds, based on the portfolio shares s shown in table 3 and assuming interest parity holds (i.e., using equation 8, see above). r_s is computed for two alternative assumptions about loss given default rates—one in which loss given default would be equal to 50 percent ($l = 0.5$) for all countries, labeled L_1, and one that uses Brunnermeier et al.'s (2017) assumptions, in which loss given default ranges from $l = 0.4$ for Germany to $l = 0.85$ for Portugal and $l = 0.95$ for Greece (L_2). As is clear from comparing columns labeled r_s for the same date across L_1 and L_2, L_2 leads to a smaller increase in bond rates, i.e., a smaller difference between r and r_s. To see why, consider the case of Portuguese government debt in July 2014, assuming that 35 percent is purchased by the E-bond intermediary, implying $s = 0.65$ (table 3). Assuming $l = 0.5$ implies a higher default probability, conditional on the observed bond rate, than if $l = 0.85$ is assumed—namely 4 percent rather than 3.6 percent. Notwithstanding the higher loss given default in the $l = 0.85$ case, expected return would be lower, unless the bond rate is higher in the $l = 0.05$ case than in the $l = 0.85$ case.

The columns "overall change" show the weighted average change in borrowing cost attributable to borrowing from the E-bond intermediary (that is, $r_g - r$, where r_g, the German market rate, is 1.15 percent in July 2014 and 0.36 percent in October 2017, with weight $1 - s$) and the rise in the cost of borrowing from the market ($r_s - r$, with weight s). Average borrowing costs would go up in all four cases considered for a higher-rated borrower group that includes Germany, the Netherlands, Austria, Finland, France, and Belgium. However, the increases are tiny: The maximum increase would be 1.3 basis points for Germany. At the same time, for a group of lower-rated borrowers, which include Spain, Italy, Portugal, and Greece, borrowing rates decline in three out of the four examples given (except Greece, whose borrowing costs always decline). The exception, for these four countries, is the October 2017 setting combined with a flat 0.5 loss given default assumption (L_1), because the October 2017 interest rate environment implies that the decline in yields through $r_g - r$ would be relatively small (spreads are historically compressed) while the flat 0.5 loss given default assumption implies a relatively high $r_s - r$. The overall change varies with the loss given default assumption. This is a consequence of the fact that the cost advantage of borrowing from the E-bond intermediary ($r_g - r$) is independent of the assumed loss given default, while expected market rates depend on the assumed loss given default, for reasons explained in the last paragraph.

"Local Supply" Changes in Higher Risk Debt Categories

We next consider whether "safe asset" proposals could increase the borrowing costs of lower-rated borrowers by creating a large supply of junior or subordinated bonds that competes with the issuance of such borrowers. Table 12 shows the volume of sovereign debt securities trading in European debt markets today (first row) and conditional on implementation of the national tranching, E-bond, and ESBies proposals (second, third and fourth rows, respectively) for three risk categories. For comparison purposes, the last row of the table shows the volume of non–euro area sovereign debt in the same risk categories. Risk classifications were based on five-year expected losses computed using the benchmark calibration of the Brunnermeier et al. (2017) model. These correspond roughly to the sovereign ratings buckets BBB+ and BBB (first category), BBB–, BB+ and BB (second category), and BB– and lower (third category).[28]

28. This follows Standard and Poor's taxonomy. The results would be similar if Moody's ratings had been used to classify the buckets.

The table yields two main insights. First, the sum of debt across the three risk buckets (see last column) is lower in all three proposals than in the status quo. While the national tranching proposal, for example, would add the junior tranches of sovereign debt of three countries with currently lower expected losses to the 4 to 8 percent loss category (Latvia, Lithuania, and Malta), the total volume would still decline because the debts of these countries are small and junior tranches make up only 70 percent of the outstanding volume for each country. A similar argument applies for the E-bond proposal: While the number of countries populating the 4 to 8 percent expected loss category would rise due to the subordination effect, debt issued to the market would decline, as 22 to 50 percent of the debt of countries in this category would take the form of borrowing from the E-bond intermediary (see table 3).

In the case of ESBies, the intermediaries would remove at least 50 percent of debt from the markets of the countries shown (equation (5) is assumed, implying that for Spain 73 percent would be removed and for Italy 54 percent, see table 4). At the same time, junior sovereign bond–backed securities would be added to the market. The table shows two variants, one with just one subordinated tranche (EJBies, comprising 31.5 percent of the collateral pool) and the other in which this tranche is divided 2:1 into a mezzanine tranche and a junior (equity) tranche (following ESRB HLTF 2018). Issuing just one subordinated tranche would add about €1.5 trillion to the 8 to 14 percent expected loss bucket, resulting in a slightly lower number of risky sovereign debt–based assets, across the three categories, than is the case now (€2.8 trillion rather than €3 trillion). Issuing two subordinated tranches would result in a mezzanine tranche of about €1.1 trillion whose five-year expected loss rate, 3.9 percent, would place it just outside the three risk buckets shown in the table. This would reduce the total volume of sovereign debt–based assets across the three categories to just under €1.8 trillion (or about €2.8 trillion if one slightly expands the 4 to 8 percent bucket to include the mezzanine tranche). In either case, the conclusion is that none of the proposals would be expected to put pressure on higher-risk European sovereign debt, defined broadly to include five-year expected losses of about 4 percent and higher.

This conclusion changes slightly if one looks *within* risk buckets. In the ESBies proposal with just one subordinated tranche, there would be a very large increase in the supply of sovereign debt–based securities in the 4 to 8 percent bucket, competing with Portuguese sovereign bonds. In the case of two subordinated tranches, there would be a large increase in the above-14 percent bucket, competing with Greek sovereign bonds, as well as in the proximity of the 4 to 8 percent bucket, since the mezzanine bond would have an expected loss rating that is a bit higher than, but close to that of Spanish and Italian bonds. To what extent this increase would hit the prices of the bonds in these buckets is not clear: It depends on exactly how local "local supply" effects are in this risk category and on whether regulatory changes that might precede the creation of a market in sovereign bond–backed securities would have an impact on the demand for the subordinated tranches that partly offsets the supply effect.[29] Furthermore, the 8 to 14 percent expected loss category is quite a lot larger if one were to include non–euro area sovereign debt in this category (see last row of table 12).

29. Specifically, the European Commission has announced a regulatory change that would put sovereign bond–based securities on a par with the current regulatory treatment of sovereign exposures, which are not subject to capital charges (European Commission 2017b). As a result, sovereign bond–backed securities may attract demand from investors, such as households, that seek a diversified exposure to all European sovereigns at a low cost. That demand may not necessarily subtract from that for individual sovereigns but could subtract from other investments such as exchange-traded funds or other structured products that banks have been offering to households.

V. CONCLUSION

This paper evaluated the intended benefits and unintended drawbacks of four proposals for generating a debt-based euro area safe asset that—unlike early (2009–10) ideas to create "Eurobonds"—do not rely on member state guarantees to achieve "safety." Intended benefits include the capacity to produce safe assets in high-enough volumes to replace sovereign debt on bank balance sheets and reduce a perceived shortage of safe assets in Europe and internationally, to supply safe assets in a way that would neutralize any disruptive effects of a potential change in the regulation of sovereign exposures of banks, and to strengthen fiscal discipline. Possible drawbacks include reduced liquidity of national bond markets, redistribution across euro area members, the possibility of "backdoor" mutualization of risk (notwithstanding the absence of explicit mutualization), and increases in the average cost of borrowing for some countries.

All four proposals share several characteristics. All would be able to produce safe assets or asset portfolios in sufficient quantities to replace euro area sovereign bond holdings in euro area banks. All could be introduced in a way that would help maintain financial stability—in particular, to avoid a sharp rise in sovereign yields—during the transition from high to low levels of bank exposures to sovereign risk. All but one proposal would avoid redistribution. Even the case that does not—E-bonds—could be structured so that redistribution would be tightly limited (and could be reduced further by capitalizing the E-bond issuer in a way that asks the potential beneficiaries to contribute a larger share). All proposals can be designed to limit, if not eliminate entirely, the risk of "backdoor mutualization." None of the proposals would raise the average cost of borrowing of the fiscally weaker euro area countries (and one proposal, E-bonds, may lower it), except by making the debts of insolvent countries less costly to restructure. But this effect may be more than offset by the reduced risk of twin sovereign/banking crises associated with the greater use of safe assets.

These proposals also have significant differences. One way of summarizing them is to first discuss E-bonds and ESBies as a pair, and then briefly the remaining two proposals.

In both the ESBies and E-bond proposals, safe assets would be created as securities issued by a financial intermediary (or possibly several financial intermediaries, in the case of ESBies) backed by a collateral pool of diversified euro area sovereign debt. Also common to both proposals is the fact that (1) the sovereign debt holdings of the intermediaries cannot exceed a maximum (defined as a share of outstanding debt and/or country GDP), and (2) "safety" is generated through a combination of diversification and seniority. These commonalities imply that the two proposals perform similarly in some important respects. Both could generate safe assets—that is, assets calibrated to achieve a given, low expected loss rate—in large volumes, on the order of 25 percent of euro area GDP, amply exceeding the volume of euro area sovereign debt that is currently held by euro area banks (the ESBie approach could go even further, but only if intermediaries were allowed to buy most German and French sovereign debt). Both would preserve liquid (albeit smaller) national debt markets.

At the same time, there are important conceptual and practical differences between E-bonds and ESBies. First, while ESBie issuers rank equally with other creditors in terms of seniority and issue securities in several tranches, the E-bond issuer would have preferred creditor status and issue a single-tranche bond (the E-bond). As a result, sovereign bonds would become subordinated. One consequence is that the E-bond approach would raise the *net*

volume of euro area safe assets—with "safety" defined by the *current* riskiness of German bunds – by a significantly smaller amount than ESBies, since German bunds held outside the E-bond intermediary would now be somewhat riskier. Another consequence is that E-bonds would raise the cost of sovereign borrowing on the bond market. If the E-bond issuer purchases sovereign debt at face value, however, this would be approximately offset by the lower cost of borrowing via the E-bond issuer, resulting in a small net increase in *average* borrowing costs in higher-rated countries and a net decrease in others. The *marginal* cost of borrowing, however, would rise for countries that have reached the maximum level, as a share of GDP, beyond which the E-bond intermediary will no longer purchase debt. In this sense, E-bonds have a disciplining effect. This effect is absent in the ESBies proposal, because purchases of bonds by the ESBie intermediary do not lead to the subordination of bonds held by other creditors.

Second, while ESBies rule out redistribution across euro area members by design, redistributive implications are hard to avoid in the E-bond proposal. Depending on how the proposal is structured, redistribution could go either way. If the E-bond issuer were to purchase sovereign debt at market prices, it would earn a "seniority rent," which—if disbursed to its borrowers in proportion to their shares in the collateral pool—would lead to massive redistribution from the riskier to the safer countries. If the E-bond issuer were to purchase sovereign debt at face value and proportionally distribute its funding costs to its borrowers, redistribution would be in the other direction—from more to less creditworthy countries—albeit in more modest amounts. There is an intermediate case between these two models in which no redistribution would happen, but it would be hard to calibrate in practice. One option would be to conduct E-bond purchases at face value while capitalizing the E-bond issuer in a way that most of the capital is contributed by the less creditworthy countries, covering the risk that emanates from them.

Third, although ESBies and E-bonds can be calibrated to be identically risky in terms of expected losses, ESBies are much better than E-bonds at protecting their holders from deep sovereign defaults. Any loss given default in any given country that exceeds its share of sovereign bonds held outside the E-bond collateral pool will reduce the value of the pool and therefore reduce the value of E-bonds. In contrast, the value of ESBies will be unaffected unless the entire subordinated tranche (i.e., EJBies) is wiped out. This requires a massive debt crisis in which not only the "periphery" countries default but also France and/or countries presently rated higher than France. Achieving the same level of protection in the E-bond proposal would require capitalizing the E-bond intermediary.

Finally, consider the remaining two proposals—a euro area budget or leveraged wealth fund issuing euro area debt and issuing multi-tranche debt at the national level, enabling "safe" diversified pools of senior tranches.

The most flexible way of producing euro area-level safe assets in the desired volume would clearly be a euro area budget—or equivalently, a euro area sovereign wealth fund—with a borrowing capacity. If given the mandate, the budget or fund could also be used to neutralize any undesirable spike in bond yields during the transition period in which banks are reducing their sovereign debt holdings. It could also be structured to rule out redistribution. And while the risk of "backdoor" mutualization clearly exists, it could be limited by defining an appropriate legal framework and a strong governance structure.

The disadvantage of a euro area budget or fund as a generator of safe assets is that it would require committing relatively large resources for debt service—perhaps up to 0.5 percent of annual GDP (over €500 billion). "Committing" does not necessarily mean "paying," however, as the money raised by issuing European debt could

be profitably invested, as a sovereign wealth fund would do. The returns from these investments would normally exceed the committed revenue streams, because the latter is based on low "safe" interest rates. If these returns are distributed to euro area members in the same proportion as the revenue commitments, the scheme would hence normally produce a net payout for each member. This said, members bear risk in proportion to their committed revenue streams, and large and fiscally strong members may worry that the risk they bear implicitly—namely, to help rescue the fund or budget in the event of several successive years of very poor returns—may be larger than their explicit risk. For this reason, this type of scheme may not be politically viable, unless it is embedded in a budget that has additional purposes beyond just creating a safe asset—for example, to fund public goods that member states agree are best provided at the supranational level.

National tranching in many ways occupies the opposite end of the spectrum. It need not involve any new financial commitment or financial intermediary. It would simply constitute a different form of issuing national debt, ruling out redistribution by design. But these advantages come at a cost. Among all proposals considered, national tranching would produce the lowest volume of safe assets, barely enough to replace aggregate euro area sovereign debt holdings in euro area banks. Because the bulk of euro area sovereign debt would consist of subordinated and hence riskier tranches, the *net* volume of safe assets would barely increase. For some issuers, the decline of banks' sovereign debt holdings during the transition phase may exceed the volume of senior tranches that are required to replace them, which could raise the interest costs for these countries. And multi-tranche debt would lead to more fragmented sovereign debt markets, with low trading volumes particularly among the senior tranches, since most or all of these would be held by euro area banks.

Table 13 summarizes the pros and cons of the various proposals along seven dimensions. Based on their rankings along these dimensions, ESBies and the euro area budget come out in front: Both rank "first" in three categories. Furthermore, ESBies stand out as the only proposal not to rank last in any category. National tranching does least well overall, scoring "first" in only one case and last in four. At the same time, no proposal dominates or is dominated entirely.

Taken together, the four proposals offer something for everyone. Conservatives wishing for no new euro area institutions, no cross-country redistribution, and low risk of backdoor mutualization will prefer national tranching. ESBies are for those who wish to create a potentially large volume of euro area safe assets with minimal interference in the structure or pricing of national debt, while also avoiding cross-country redistribution and minimizing mutualization risk. Debt management offices and policymakers who wish to minimize disruptions to the volume and liquidity of European sovereign debt will opt for a euro area budget or wealth fund. And E-bonds will be attractive to those who want an alternative to ESBies that does not rely on tranched securities. E-bonds are also unique in generating both fiscal discipline and (in one variant) disproportionately benefiting lower-rated issuers.

To summarize, although no single proposal will be attractive to all constituencies, all proposals analyzed in this paper have attractive features. And while they also have drawbacks—some more than others—these can be clearly articulated and compared. As a result, these proposals can no longer be dismissed as academic ideas whose potential unintended consequences have not been properly explored. They deserve serious consideration, particularly in the context of a broader package of euro area reform.

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Box 1 Probability of default and expected loss calculations

For all calculations relating to the national tranching, E-bond, and ESBies proposals, this paper relies on a two-level hierarchical simulation model described in Brunnermeier et al. (2017), the code of which is publicly available (link). The two main inputs are a stochastic model of default and a distribution of loss-given default (LGD) rates for each euro area country.

In the **first level**, the authors simulate 2,000 five-year periods, in each of which the economy can be in one of three states: (1) a severe recession, in which default probabilities and LGD rates are very high for all countries, particularly those with worse credit ratings; (2) a mild recession, in which default probabilities and LGD rates are elevated (LGD rates are 80 percent of those in state (1)); (3) expansion, in which default risk is low for most countries, and LGD rates are 50 percent of those in state (1). In the simulation, the euro area economy is in state (3) 70 percent of the time, in state (2) 25 percent of the time, and in state (1) 5 percent of the time (table B.1).

Table B.1 Assumed default probabilities and loss-given default (percent)

Country	Rating	pd1	pd2	pd3	lgd1
Germany	1	5	0.5	0	40
Netherlands	1	10	1	0	40
Luxembourg	1	10	1	0	40
Austria	1.5	15	2	0	45
Finland	1.5	15	2	0	45
France	3	25	3	0.05	60
Belgium	3.5	30	4	0.1	62.5
Estonia	4.5	35	5	0.1	67.5
Slovakia	5	35	6	0.1	70
Ireland	6.5	40	6	0.12	75
Latvia	7	50	10	0.3	75
Lithuania	7	50	10	0.3	75
Malta	7.5	55	11	0.4	78
Slovenia	9	60	15	0.4	80
Spain	9	60	15	0.4	80
Italy	9.5	65	18	0.5	80
Portugal	12	70	30	2.5	85
Cyprus	13.5	75	40	10	87.5
Greece	19	95	75	45	95

Note: This table shows the assumptions in Brunnermeier et al.'s (2017) benchmark calibration of their simulation. Countries are ordered in terms of their sovereign ratings as of December 2015. Letter grades are converted into a numerical score (1 is AAA, 19 is CCC–) and averaged across S&P and Moody's. "pd1", "pd2", and "pd3" describe the five-year default probabilities in states 1, 2, and 3 of their simulation, respectively. "lgd1" describes the five-year loss given default rates in state 1; in state 2, loss given default rates are 80 percent of those in state 1, and in state 3 they are 50 percent of those in state 1.

Source: Brunnermeier et al. (2017).

The simulation model's **second level** determines sovereign defaults. A random variable, which is assumed to have a fat-tailed distribution (Student-t with 4 degrees of freedom), determines whether a given country defaults, conditional on the aggregate state, in that period that is determined in level 1. 5,000 draws are taken of the sovereigns' stochastic default processes, which brings the total amount of draws to 10 million. The model can be used to compute five-year expected loss rates, calculated as average loss rates over the simulations of the default process. Brunnermeier et al. (2017) report expected loss rates for two calibrations of their simulation model:

- A benchmark calibration based on probability of default and loss-given default parameters that imply average default rates consistent with bond yields and credit default swap (CDS) spreads at the end of 2015, and loss-given default rates that are consistent with historical averages. This calibration delivers the default probabilities and LGD rates reported in table B.1 and the cross-country correlations in default probabilities shown in panel A of table B.2.

- An adverse calibration with much higher cross-country correlations in default probabilities, as summarized in panel B of table B.2. These are due to four additional contagion assumptions, which stipulate that when Germany, France, Italy, or Spain defaults, default probabilities will be raised particularly in lower-rated countries (see Brunnermeier et al. 2017 for details).

(box continues)

Box 1 Probability of default and expected loss calculations *(continued)*

Table B.2 Correlations between countries' default probabilities in Brunnermeier et al.'s (2017) simulation

Panel A: Benchmark calibration	Panel B: Adverse calibration																	
DE	0.77	0.77	0.72	0.72	0.37	0.31	0.30	0.31	0.31	0.30	0.30	0.30	0.29	0.33	0.33	0.24	0.20	0.11
0.04	**NL**	0.68	0.64	0.64	0.37	0.34	0.34	0.35	0.35	0.34	0.34	0.34	0.33	0.37	0.36	0.29	0.23	0.13
0.04	0.06	**LU**	0.64	0.64	0.37	0.34	0.34	0.35	0.35	0.34	0.34	0.34	0.33	0.37	0.37	0.29	0.23	0.13
0.05	0.07	0.07	**AT**	0.61	0.36	0.34	0.34	0.35	0.36	0.35	0.35	0.34	0.34	0.37	0.37	0.29	0.24	0.13
0.05	0.07	0.07	0.08	**FI**	0.36	0.34	0.34	0.35	0.35	0.35	0.35	0.34	0.34	0.37	0.37	0.39	0.24	0.13
0.06	0.09	0.09	0.11	0.11	**FR**	0.81	0.79	0.51	0.51	0.49	0.49	0.48	0.47	0.56	0.56	0.40	0.33	0.18
0.07	0.10	0.10	0.11	0.11	0.15	**BE**	0.73	0.51	0.51	0.49	0.49	0.49	0.48	0.55	0.55	0.42	0.34	0.19
0.07	0.10	0.10	0.12	0.12	0.16	0.17	**EE**	0.51	0.51	0.49	0.49	0.49	0.48	0.55	0.55	0.42	0.34	0.19
0.07	0.10	0.10	0.12	0.12	0.15	0.16	0.18	**SK**	0.81	0.77	0.77	0.76	0.73	0.79	0.77	0.62	0.50	0.26
0.08	0.11	0.11	0.13	0.13	0.17	0.18	0.19	0.19	**IE**	0.77	0.77	0.76	0.73	0.79	0.77	0.62	0.50	0.26
0.08	0.11	0.12	0.14	0.14	0.18	0.19	0.20	0.20	0.22	**LV**	0.74	0.73	0.71	0.75	0.74	0.61	0.49	0.27
0.08	0.11	0.11	0.14	0.14	0.18	0.19	0.20	0.20	0.22	0.23	**LT**	0.73	0.71	0.75	0.74	0.61	0.49	0.27
0.09	0.12	0.12	0.14	0.14	0.18	0.20	0.21	0.21	0.23	0.24	0.24	**MT**	0.70	0.74	0.73	0.6	0.49	0.27
0.09	0.12	0.12	0.14	0.14	0.19	0.20	0.21	0.21	0.23	0.25	0.25	0.26	**SI**	0.72	0.71	0.59	0.49	0.27
0.09	0.12	0.12	0.14	0.14	0.18	0.20	0.22	0.21	0.23	0.25	0.25	0.26	0.27	**ES**	0.75	0.61	0.5	0.26
0.09	0.12	0.12	0.15	0.15	0.19	0.20	0.22	0.22	0.23	0.25	0.25	0.27	0.27	0.27	**IT**	0.61	0.49	0.27
0.08	0.11	0.11	0.13	0.13	0.17	0.18	0.20	0.20	0.21	0.23	0.23	0.24	0.26	0.26	0.27	**PT**	0.45	0.26
0.06	0.09	0.09	0.10	0.10	0.13	0.15	0.16	0.16	0.17	0.19	0.19	0.20	0.21	0.21	0.22	0.22	**CY**	0.22
0.04	0.05	0.06	0.07	0.07	0.09	0.10	0.11	0.11	0.11	0.13	0.13	0.13	0.14	0.14	0.15	0.16	0.14	**GR**

Note: The lower left triangle of the matrix (panel A) shows the correlations between nation states' probabilities of default in Brunnermeier et al.'s (2017) benchmark calibration. For example, the correlation between Italian and Spanish default probabilities is 0.27. The upper right triangle (panel B) shows the same correlations for the adverse calibration. For example, the correlation between Italian and Spanish default probabilities is 0.75. Correlations are higher in the adverse calibration owing to additional contagion assumptions.

Source: Brunnermeier et al. (2017).

Table 1 General government debt in the euro area, by issuer (end-2016 stocks)

	General government debt			General government debt securities					
	Total	Held by banks in issuing country		Total		Held by euro area banks		Held by banks in issuing country	
Country	% of GDP	% of GDP	% of GG debt	% of GDP	% of GG debt	% of GDP	% of debt securities	% of GDP	% of debt securities
Austria	84.6	13.5	15.9	70.3	83.1	19.0	27.0	9.6	13.6
Belgium	105.9	19.4	18.3	86.8	82.0	20.0	23.0	10.6	12.2
Cyprus	107.8	9.4	8.7	35.2	32.7	15.8	44.9	13.6	38.6
Estonia	9.5	2.8	29.6	1.1	11.1	0.4	37.0	0.6	54.9
Finland	63.6	8.9	14.1	49.0	77.0	8.2	16.8	2.3	4.7
France	96.0	17.4	18.1	81.2	84.6	11.4	14.1	7.5	9.3
Germany	68.3	18.3	26.7	49.6	72.6	9.3	18.8	7.2	14.6
Greece	179.0	...	...	32.5	18.2	7.1	21.7	6.6	20.4
Ireland	75.4	...	...	46.7	61.8	9.7	20.7	6.7	14.3
Italy	132.6	38.0	28.7	112.0	84.4	30.4	27.1	23.1	20.6
Latvia	40.1	4.4	11.1	29.4	73.3	6.4	21.9	3.9	13.3
Lithuania	40.2	5.1	12.6	31.8	79.0	6.5	20.4	3.1	9.8
Luxembourg	20.0	...	...	11.5	57.6	4.2	36.4	2.1	18.2
Malta	58.3	...	...	54.3	93.3	18.4	33.8	17.5	32.2
Netherlands	62.3	15.2	24.4	48.9	78.5	9.2	18.8	5.9	12.1
Portugal	130.4	20.4	15.6	71.9	55.1	25.8	35.9	16.5	22.9
Slovakia	51.9	16.1	30.9	44.3	85.3	18.0	40.6	11.7	26.4
Slovenia	79.7	15.8	19.8	67.0	84.1	15.8	23.5	12.0	17.9
Spain	99.4	20.7	20.8	82.6	83.1	26.4	32.0	19.6	23.8
Euro area	**89.2**	**20.3**	**22.8**	**71.0**	**79.6**	**15.8**	**22.3**	**11.2**	**15.8**

Note: "Debt securities" refer to bonds, treasury bills, and other short-term government debt securities. "GG" denotes "general government."

Source: European Central Bank.

Table 2 Portfolio shares and five-year expected loss rates of national and pooled senior sovereign bond tranches (based on general government debt securities, in percent)

	Share in euro area		Portfolio weights using		Subordination level								
Country	GDP	Debt securities	Eq. (1)	Eq. (2)	0	10	20	30	40	50	60	70	80
Germany	29.2	20.3	26.5	23.9	0.50	0.40	0.27	0.11	0.00	0.00	0.00	0.00	0.00
Netherlands	6.5	4.5	5.8	5.2	0.69	0.55	0.38	0.16	0.00	0.00	0.00	0.00	0.00
Luxembourg	0.5	0.1	0.1	0.1	0.69	0.55	0.38	0.16	0.00	0.00	0.00	0.00	0.00
Austria	3.2	3.2	3.6	3.8	0.96	0.80	0.60	0.35	0.09	0.00	0.00	0.00	0.00
Finland	2.0	1.4	1.8	1.6	0.96	0.80	0.60	0.35	0.09	0.00	0.00	0.00	0.00
France	20.7	23.8	22.8	24.3	1.94	1.75	1.51	1.20	0.81	0.33	0.00	0.00	0.00
Belgium	3.9	4.8	4.3	4.6	2.64	2.40	2.10	1.71	1.22	0.54	0.13	0.00	0.00
Estonia	0.2	0.0	0.0	0.0	3.10	2.87	2.57	2.19	1.70	1.03	0.43	0.00	0.00
Slovakia	0.8	0.5	0.6	0.6	5.58	5.16	4.65	3.98	3.13	1.97	0.80	0.00	0.00
Ireland	2.6	1.6	2.1	1.9	6.05	5.68	5.21	4.62	3.83	2.80	1.24	0.55	0.00
Latvia	0.2	0.1	0.1	0.1	6.81	6.38	5.85	5.16	4.26	3.09	1.32	0.59	0.00
Lithuania	0.4	0.2	0.2	0.2	6.80	6.37	5.84	5.15	4.26	3.08	1.32	0.58	0.00
Malta	0.1	0.1	0.1	0.1	7.32	6.91	6.39	5.73	4.85	3.72	2.04	0.96	0.00
Slovenia	0.4	0.3	0.4	0.4	8.17	7.74	7.20	6.51	5.59	4.41	2.64	1.24	0.00
Spain	10.3	12.0	11.4	12.1	6.80	6.45	6.02	5.46	4.71	3.75	2.31	1.13	0.00
Italy	15.5	24.5	17.1	18.2	7.22	6.85	6.38	5.78	4.98	3.96	2.42	1.17	0.00
Portugal	1.7	1.7	1.9	2.0	11.80	11.21	10.47	9.52	8.25	6.78	4.69	1.96	0.98
Cyprus	0.2	0.1	0.1	0.1	16.07	15.12	13.93	12.41	10.37	8.41	6.14	2.35	1.51
Greece	1.6	0.7	1.0	0.9	35.19	32.79	29.79	25.94	20.80	15.15	12.46	7.99	3.33
Pooled using portfolio shares (1)					**3.60**	**3.35**	**3.04**	**2.64**	**2.14**	**1.59**	**0.95**	**0.47**	**0.05**
Pooled using portfolio shares (2)					**3.71**	**3.45**	**3.13**	**2.73**	**2.22**	**1.65**	**0.98**	**0.48**	**0.05**
Memorandum items:													
Portfolio volume based on shares (1) (€ billion)					5,861	5,275	4,688	4,102	3,516	2,930	2,344	1,758	1,172
Portfolio volume based on shares (2) (€ billion)					6,510	5,859	5,208	4,557	3,906	3,255	2,604	1,953	1,302

Note: The first two columns of the table show the share of 2016 euro area GDP and the end-2016 stock of euro area general government debt securities attributable to the country. The third and fourth columns show the portfolio weights of each country in a pool of senior tranches based on the following rules: (1) when debt is less than 60 percent of GDP, include all available senior tranches in the pool, otherwise include senior tranches corresponding to a nominal value of debt equal to 60 percent of GDP; (2) when the country's share in euro area GDP exceeds its share in euro area debt securities, include all available senior tranches in the pool, otherwise include the senior tranches corresponding to the product of the country's share of euro area GDP and the nominal value of euro area debt (see equations (1) and (2) in the text). The remaining columns of the table shows five-year expected loss rates (in percent) in the adverse calibration described in Brunnermeier et al. (2017) for various subordination levels (i.e. face value of junior tranche as a percent of face value of debt issued). The two rows at the bottom show five-year expected loss rates for a portfolio of senior securities with uniform subordination levels across countries, pooled according to portfolio weights (1) and (2), respectively. The memorandum item shows the aggregate volume (in € billion) of senior tranches in portfolios (1) or (2) for various subordination levels. The subordination levels corresponding to an expected loss rate of 0.5 percent are 69 and 70 percent, respectively, which implies an aggregate volume of €1,817 billion for portfolio (1) and €1,953 billion for portfolio (2).

Source: Eurostat and authors' calculations using simulation model of Brunnermeier et al. (2017) (adverse calibration, see box 1).

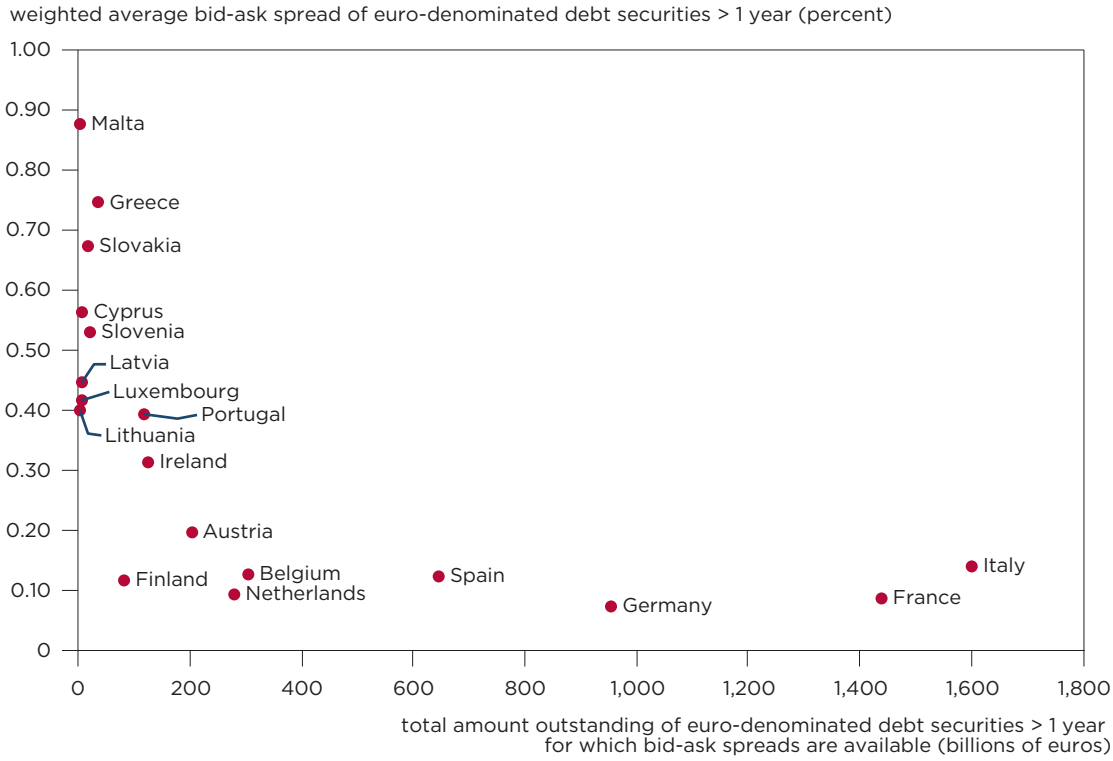
Table 3 E-bond purchase portfolio and expected losses
(purchase volumes = minimum of {49.5% of national debt securities and 25.2% of national GDP})

Country	Purchase volume (in € billion)	Purchase volume in % of			Implicit subordination level (%)	5-year exp. loss rate (%)
		GDP	debt	Portfolio		
Germany	768.4	24.4	49.5	29.2	50.5	0.00
Netherlands	168.6	24.0	49.5	6.4	50.5	0.00
Luxembourg	3.1	5.7	49.5	0.1	50.5	0.00
Austria	87.9	25.2	35.8	3.3	64.2	0.00
Finland	51.8	24.0	49.5	2.0	50.5	0.00
France	560.9	25.2	30.9	21.3	69.1	0.00
Belgium	106.1	25.2	29.0	4.0	71.0	0.00
Estonia	0.1	0.5	49.5	0.0	50.5	0.95
Slovakia	17.8	21.9	49.5	0.7	50.5	1.83
Ireland	61.4	22.3	49.5	2.3	50.5	2.67
Latvia	3.6	14.5	49.5	0.1	50.5	2.94
Lithuania	6.1	15.7	49.5	0.2	50.5	2.94
Malta	2.5	25.2	46.5	0.1	53.5	3.29
Slovenia	10.2	25.2	38.2	0.4	61.8	2.17
Spain	280.3	25.2	30.5	10.7	69.5	1.13
Italy	420.9	25.2	22.5	16.0	77.5	0.32
Portugal	46.5	25.2	35.0	1.8	65.0	3.20
Cyprus	3.1	17.4	49.5	0.1	50.5	8.23
Greece	28.3	16.1	49.5	1.1	50.5	14.93
Total portfolio	**2,627.6**				**62.4**	**0.50**

Note: The table shows the purchases and 5-year expected loss rates, from the perspective of the E-bond issuer buying national debt, arising from a purchase rule in which the issuer buys either 49.5 percent of national general government debt securities or 25.2 percent of GDP worth of debt, whichever is smaller. For example, for Germany, 49.5 percent of national debt is bought, for Italy, 25.2 percent of GDP. The parameters 49.5 percent of national debt and 25.2 percent of GDP were chosen to maximize the size of the portfolio (and hence the volume of E-bonds backed by the portfolio) subject to keeping the portfolio 5-year expected loss at or below 0.5 percent. In the last row of the table, the total portfolio purchase volume is computed as the sum of the country purchase volumes, while the total portfolio 5-year expected loss of 0.5 percent is computed as the weighted average of the country 5-year expected losses shown in the final column, using the portfolio purchase shares as weights.

Sources: Eurostat and authors' calculations based on simulation model of Brunnermeier et al. (2017) (adverse calibration, see box 1).

Figure 1 Sovereign bond bid-ask spreads and market size



Note: Weighted average bid-ask spreads were constructed using bonds for which both bid-ask spreads and outstanding amounts were available on Bloomberg. Each bond's bid-ask spread is weighted by its outstanding amount to construct the country weighted average.

Source: Bloomberg.

Table 4 SBBS purchase portfolios consistent with 0.5 percent expected loss of the senior tranche (ESBies)

	Purchase volume = min {0.6*Y_i, Φ(D_i)}, where						Purchase volume = min {Y_i/Y*D, Φ(D_i)}, where					
	Φ(D_i) = 0.5*D_i			Φ(D_i) = max {D_i–€200bn, 0.5D_i}			Φ(D_i) = 0.5*D_i			Φ(D_i) = max {D_i–€200bn, 0.5D_i}		
Country	€ bn	% debt	% portfolio	€ bn	% debt	% portfolio	€ bn	% debt	% portfolio	€ bn	% debt	% portfolio
Germany	776.7	50.0	20.35	1,353.3	87.1	26.54	776.7	50.0	20.35	1,353.3	87.1	24.28
Netherlands	170.4	50.0	4.46	170.4	50.0	3.34	170.4	50.0	4.46	170.4	50.0	3.06
Luxembourg	3.1	50.0	0.08	3.1	50.0	0.06	3.1	50.0	0.08	3.1	50.0	0.06
Austria	122.9	50.0	3.22	122.9	50.0	2.41	122.9	50.0	3.22	122.9	50.0	2.20
Finland	52.4	50.0	1.37	52.4	50.0	1.03	52.4	50.0	1.37	52.4	50.0	0.94
France	908.7	50.0	23.80	1,337.3	73.6	26.23	908.7	50.0	23.8	1,579.5	86.9	28.34
Belgium	183.1	50.0	4.80	183.1	50.0	3.59	183.1	50.0	4.80	183.1	50.0	3.28
Estonia	0.1	50.0	0.00	0.1	50.0	0.00	0.1	50.0	0.00	0.1	50.0	0.00
Slovakia	17.9	50.0	0.47	17.9	50.0	0.35	17.9	50.0	0.47	17.9	50.0	0.32
Ireland	62.0	50.0	1.62	62.0	50.0	1.22	62.0	50.0	1.62	62.0	50.0	1.11
Latvia	3.7	50.0	0.10	3.7	50.0	0.07	3.7	50.0	0.10	3.7	50.0	0.07
Lithuania	6.1	50.0	0.16	6.1	50.0	0.12	6.1	50.0	0.16	6.1	50.0	0.11
Malta	2.7	50.0	0.07	2.7	50.0	0.05	2.7	50.0	0.07	2.7	50.0	0.05
Slovenia	13.3	50.0	0.35	13.3	50.0	0.26	13.3	50.0	0.35	13.3	50.0	0.24
Spain	459.8	50.0	12.05	668.3	72.7	13.11	459.8	50.0	12.05	719.6	78.3	12.91
Italy	936.2	50.0	24.52	1,003.5	53.6	19.68	936.2	50.0	24.52	1,185.2	63.3	21.26
Portugal	66.5	50.0	1.74	66.5	50.0	1.30	66.5	50.0	1.74	66.5	50.0	1.19
Cyprus	3.2	50.0	0.08	3.2	50.0	0.06	3.2	50.0	0.08	3.2	50.0	0.06
Greece	28.6	50.0	0.75	28.6	50.0	0.56	28.6	50.0	0.75	28.6	50.0	0.51
Total	**3,817.3**	**50.0**	**100.0**	**5,098.4**	**66.8**	**100.0**	**3,817.3**	**50.0**	**100.0**	**5,573.7**	**73.0**	**100.0**
Memorandum items:												
Subordination level (percent)			34.5			31.5			34.5			33.0
ESBies volume (€ bn)			2,500.30			3,492.4			2,500.3			3,734.4

SBBS = sovereign bond–backed securities

Note: The table shows purchases of general government debt securities in nominal terms, as a percentage of the debt stock, and as a percentage of the resulting underlying portfolio of bonds, for the four purchase rules set out in the ESBies part of section III-1 (equations 4, 5, 6, and 7, respectively). For each rule, the memorandum items show the subordination level required to achieve an expected loss rate of 0.5 percent or less for the senior bond, and the corresponding volume of senior tranches or ESBies created, in billions of euro. Y_i and D_i denote country *i*'s GDP and debt, respectively, and *Y* and *D* denote the euro area's overall GDP and debt.

Source: Eurostat and authors' calculations based on simulation model of Brunnermeier et al. (2017) (adverse calibration, see box 1).

Table 5 Examples of sustainable euro area debt levels (assuming maximum primary balances of 0.2 or 0.5 percent, in percent)

Primary balance	Long-run real growth	Long-run real yield of euro area debt		
		1.7	2.2	2.9
0.2	1.2	40.5	20.2	11.9
	1.4	67.6	25.4	13.5
	1.6	n.a.	33.9	15.6
0.5	1.2	101.2	50.6	29.8
	1.4	169	63.4	33.8
	1.6	n.a.	84.7	39.1

Note: The numbers in the medium-blue shaded area (last 3 columns) represent maximum sustainable debt as a share of GDP under various primary balance, long-run real growth, and long-run real yield assumptions, computed using the static debt sustainability formula: $D = p(1+r)/(r-g)$, where D is the maximum sustainable debt, p is the primary balance (both expressed in percent of annual GDP), r is the real interest rate, and g is the real growth rate. For a derivation, see Sturzenegger and Zettelmeyer (2007, appendix).

Source: Authors' calculations.

Table 6 Maximum volume of safe assets consistent with 5-year expected loss rate of 0.5 percent (summary)

Approach	Assumptions	Gross volume		Net increase	
		€ billion	% of GDP	€ billion	% of GDP
Euro area budget	primary surplus = 0.2%, g= 1.2%, r = 2.9%	1,283	11.9	1,098	10.2
	primary surplus = 0.2%, g= 1.4%, r = 2.2%	2,731	25.4	2,337	21.7
	primary surplus = 0.5%, g= 1.2%, r = 2.9%	3,207	29.8	2,744	25.5
	primary surplus = 0.5%, g= 1.4%, r = 2.2%	6,827	63.4	5,843	54.2
Based on general government debt securities					
National tranching	(1) include 0.3*min {60% of GDP, country debt stock}	1,817	16.9	1,335	12.4
	(2) include 0.3*min {GDP share*EA debt, country debt stock}	1,953	18.1	1,487	13.8
E-bonds	(3) purchase min (25% of GDP, 50% of country debt stock}	2,628	24.4	1,859	17.3
ESBies	(4) purchase min {60% of GDP, 0.5*D_i}	2,500	23.2	1,724	16.0
	(5) purchase min {60% of GDP, max {D_i–€200bn, 0.5D_i}}	3,492	32.4	2,139	19.9
	(6) purchase min {GDP share*euro area debt, 0.5*D_i}	2,500	23.2	1,724	16.0
	(7) purchase min {GDP share*euro area debt, max {D_i–€200bn, 0.5D_i}}	3,734	34.7	2,381	22.1
Based on central government debt securities					
National tranching	(1) include 0.3*min {60% of GDP, country debt stock}	1,648	15.3	1,295	12.0
	(2) include 0.3*min {GDP share*EA debt, country debt stock}	1,686	15.6	1,344	12.5
E-bonds	(3) purchase min (25% of GDP, 50% of country debt stock}	2,339	21.7	1,779	16.5
ESBies	(4) purchase min {60% of GDP, 0.5*D_i}	2,216	20.6	1,626	15.1
	(5) purchase min {60% of GDP, max {D_i–€200bn, 0.5D_i}}	3,071	28.5	2,091	19.4
	(6) purchase min {GDP share*euro area debt, 0.5*D_i}	2,216	20.6	1,626	15.1
	(7) purchase min {GDP share*euro area debt, max {D_i–€200bn, 0.5D_i}}	3,151	29.2	2,171	20.2
Memorandum items:					
Domestic general government debt held by euro area banks		2,186	20.4	…	…
Euro area general government debt securities held by euro area banks		1,699	15.8	…	…
Domestic general government debt securities held by euro area banks		1,205	15.8	…	…

Note: The table summarizes the volumes of safe assets that can be created using the four approaches. Euro area GDP in 2016 was €10,773 billion (*source:* ECB). "Gross volumes" restates the volumes shown in tables 2 to 5 under various assumptions. "Net increase" takes into account the fact that safe assets were used to create the safe asset and that previously-safe assets are no longer safe following their subordination. In the case of ESBies, we subtract the volume of German sovereign bonds that are used to create the safe asset and hence are no longer available to the public. In the cases of national tranching and E-bonds, we subtract the entire stock of German sovereign bonds, because the seniority of either the senior tranche (in the case of national tranching) or the E-bonds intermediary implies that the remaining, subordinated stock will have a higher 5-year expected loss rate than 0.5 percent. With respect to debt created by the euro area budget, the assumption is that total euro area debt is unaffected, and national debt is reduced in proportion to GDP, hence, in the "net increase" column, the proportional reduction of German sovereign debt is subtracted.

Sources: Eurostat; tables 1, 2, 3, 4, and 5; and tables C.1, C.2, C.3, and C.4 in appendix C.

Table 7 Maximum volume of safe assets consistent with 5-year expected loss rate of 0.5 percent and a maximum deviation of portfolio shares from ECB capital key equal to that of the ECB Public Sector Purchase Programme (RMSE=0.93)

		Gross volume		Net increase	
Approach	**Assumptions**	**€ billion**	**% of GDP**	**€ billion**	**% of GDP**
Based on general government debt securities					
National tranching	(1) include 0.3*min {60% of GDP, country debt stock}	1,817	16.9	1,335	12.4
	(2) include 0.3*min {GDP share*EA debt, country debt stock}	1,885	17.5	1,419	13.2
E-bonds	(3) purchase min (25% of GDP, 50% of country debt stock}	2,587	24	1,881	17.5
ESBies	(4) purchase min {60% of GDP, 0.5*D_i}	2,177	20.2	1,400	13
	(5) purchase min {60% of GDP, max {D_i–€200bn, 0.5D_i}}	2,585	24	1,232	11.4
	(6) purchase min {GDP share*euro area debt, 0.5*D_i}	2,177	20.2	1,400	13
	(7) purchase min {GDP share*euro area debt, max {D_i–€200bn, 0.5D_i}}	2,585	24	1,232	11.4
Based on central government debt securities					
National tranching	(1) include 0.3*min {60% of GDP, country debt stock}	1,475	13.7	1,133	10.5
	(2) include 0.3*min {GDP share*EA debt, country debt stock}	1,488	13.8	1,146	10.6
E-bonds	(3) purchase min (25% of GDP, 50% of country debt stock}	2,281	21.2	1,713	15.9
ESBies	(4) purchase min {60% of GDP, 0.5*D_i}	1,735	16.1	1,145	10.6
	(5) purchase min {60% of GDP, max {D_i–€200bn, 0.5D_i}}	2,577	23.9	1,597	14.8
	(6) purchase min {GDP share*euro area debt, 0.5*D_i}	1,735	16.1	1,145	10.6
	(7) purchase min {GDP share*euro area debt, max {D_i–€200bn, 0.5D_i}}	2,577	23.9	1,597	14.8
Memorandum items:					
Domestic general government debt held by euro area banks		2,186	20.4	…	…
Euro area general government debt securities held by euro area banks		1,699	15.8	…	…
Domestic general government debt securities held by euro area banks		1,205	15.8	…	…

Note: As in table 6, this table summarizes the volumes of safe assets that can be created using each approach, with the additional constraint that the deviation of the country portfolio weights from the ECB capital keys, expressed using the root mean squared error, is less than or equal to that of the ECB's Public Sector Purchase Programme (namely, 0.93 as of December 2017). Euro area GDP in 2016 was €10,773 billion (*source:* ECB). "Gross volumes" restates the volumes shown in tables 2 to 5 under various assumptions. "Net increase" takes into account the fact that safe assets were used to create the safe asset and that previously safe assets are no longer safe following their subordination. In the case of ESBies, we subtract the volume of German sovereign bonds that are used to create the safe asset and hence are no longer available to the public. In the cases of national tranching and E-bonds, we subtract the entire stock of German sovereign bonds, because the seniority of either the senior tranche (in the case of national tranching) or the E-bonds intermediary implies that the remaining, subordinated stock will have a higher 5-year expected loss rate than 0.5 percent.

Source: Eurostat and authors' calculations.

Table 8 ESBies and E-bond issuance required to offset redemption of bank-held sovereign bonds (in € billion)

Year	Redemptions of euro area sovereign bonds held by euro area banks	"Binding country"	ESBie issuance required to offset euro area bank redemptions of sovereign debt of "binding country"		E-bond issuance required to offset euro area bank redemptions of sovereign debt of "binding country"		Maximum feasible E-bond issuance (constrained by need to achieve targeted subordination levels)	
			Flow (1)	Stock	Flow (2)	Stock	Flow (3)	Stock
2018	270	Greece	378	378	667	667	402	402
2019	203	Ireland	328	707	466	1,133	315	717
2020	183	Ireland	458	1,108	407	1,439	289	1,006
2021	142	Portugal	214	1,273	381	1,750	210	1,216
2022	153	Ireland	265	1,469	394	2,083	223	1,439
2023	122	Italy	188	1,512	338	2,164	175	1,614
2024	127	Portugal	206	1,579	341	2,306	175	1,789
2025	87	Ireland	281	1,695	214	2,347	137	1,926
2026	96	Ireland	277	1,877	211	2,392	142	2,068
2027	73	Portugal	106	1,861	140	2,382	116	2,183
2028	32	Belgium	119	1,693	154	2,071	48	2,232
2029	23	Greece	50	1,501	72	1,786	28	2,259
2030	32	Ireland	226	1,395	172	1,667	47	2,306

Note: The table illustrates how many ESBies and E-bonds would need to be created to offset the redemption of euro area sovereign debt held by euro area banks and contrasts this with the maximum volume of E-bonds that could actually be created, given the need to achieve a specific subordination level for each country (see table 3). In the case of ESBies, we assume that purchases follow equation (5), while in the case of E-bonds we assume that they follow equation (3). For each given year we find the country for which the quantity of maturing debt implies the highest amount of ESBies or E-bonds that must be created to offset the redemption of its debt. For example, even though the amount of Greek debt maturing in 2018 (€11 billion) is much smaller than the amount of maturing Italian debt (€289 billion), the SBBS or E-bond portfolio required to purchase an amount of Greek debt equal to the maturing bank-held Greek debt would more than cover the purchase of all maturing bank-held Italian debt, since Italy's weight in the two collateral pools is much larger than Greece's weight. Hence, Greece is the "binding country" in this case. The table shows the amount of ESBies or E-bonds that would need to be created to offset the drop in demand from the banks for all countries and what this would imply for the growth of the stock of outstanding ESBies and E-bonds (assuming the following maturity structure: 15 percent of 2-year bonds, 30 percent of 5-year bonds, 50 percent of 10-year bonds, and 5 percent of 30-year bonds). However, in the case of E-bonds, issuance is constrained by the need to target a minimum subordination level (i.e., maintain a minimum volume of national bonds) in each year. As the last column shows, in the initial decade, the stock of E-bonds would increase more gradually than implied by the needed flow. Note that the last column assumes that maturing E-bonds are replaced, since replacements have no impact on the desired subordination level.

The data cover the 11 largest euro area countries: Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, and Spain. Data on sovereign debt redemptions refer to central government debt (*source:* Bloomberg), while data on euro area bank holdings of euro area sovereign debt refer to general government debt (*source:* ECB). To estimate the amount of central government debt held by banks, we assume that the proportion of central government debt to general government debt held by banks is equal to that of total central government to general government debt outstanding for each country. The maturity structure of the debt held by banks is assumed to be the same as that of total debt outstanding.

Sources: ECB Securities Holding Statistics, Bloomberg, and authors' calculations.

Table 9 Redistributive effects of both variants of the E-bond proposal (based on table 3 and distribution of expected losses according to portfolio shares, benchmark calibration; in percent unless otherwise stated)

					Debt purchased at market prices			Debt purchased at face value		
Country	**Debt volume in portfolio, € billion**	**Portfolio share**	**5-year exp. loss rate (%), subordinated private investors**	**5-year exp. loss rate (%), senior intermediary**	**5-year exp. profit caused, € billion**	**5-year exp. profit received,€ billion**	**5-year exp. transfer, € billion**	**5-year exp. profit caused, € billion**	**5-year exp. profit received,€ billion**	**5-year exp. transfer, € billion**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**
Germany	768.4	29.2	0.27	0.00	2.05	23.2	21.15	0.00	–3.02	–3.02
Netherlands	168.6	6.4	0.53	0.00	0.90	5.09	4.19	0.00	–0.66	–0.66
Luxembourg	3.1	0.1	0.53	0.00	0.02	0.09	0.08	0.00	–0.01	–0.01
Austria	87.9	3.3	0.78	0.00	0.69	2.65	1.97	0.00	–0.35	–0.35
Finland	51.8	2.0	0.99	0.00	0.52	1.57	1.05	0.00	–0.20	–0.20
France	560.9	21.3	1.57	0.00	8.81	16.94	8.12	0.00	–2.20	–2.20
Belgium	106.1	4.0	2.00	0.00	2.12	3.20	1.09	0.00	–0.42	–0.42
Estonia	0.1	0.0	3.02	0.62	0.00	0.00	0.00	0.00	0.00	0.00
Slovakia	17.8	0.7	3.30	0.78	0.45	0.54	0.09	–0.14	–0.07	0.07
Ireland	61.4	2.3	3.53	1.19	1.44	1.85	0.42	–0.73	–0.24	0.49
Latvia	3.6	0.1	5.19	1.62	0.13	0.11	–0.02	–0.06	–0.01	0.04
Lithuania	6.1	0.2	5.17	1.61	0.22	0.18	–0.03	–0.10	–0.02	0.07
Malta	2.5	0.1	5.65	1.93	0.09	0.08	–0.02	–0.05	–0.01	0.04
Slovenia	10.2	0.4	6.99	1.51	0.56	0.31	–0.25	–0.15	–0.04	0.11
Spain	280.3	10.7	6.65	0.91	16.08	8.46	–7.62	–2.55	–1.10	1.45
Italy	420.9	16.0	7.18	0.27	29.10	12.71	–16.39	–1.13	–1.65	–0.52
Portugal	46.5	1.8	12.44	2.52	4.62	1.41	–3.21	–1.17	–0.18	0.99
Cyprus	3.1	0.1	20.27	6.75	0.42	0.09	–0.33	–0.21	–0.01	0.20
Greece	28.3	1.1	53.65	14.26	11.14	0.85	–10.28	–4.03	–0.11	3.92
Total	**2,627.6**	**100.0**	**3.41**	**0.39**	**79.34**	**79.34**	**0.00**	**–10.33**	**–10.33**	**0.00**

Note: The first two columns of the table repeat information from table 3. The third and fourth columns show 5-year expected loss rates from the perspective of both private investors and the E-bond intermediary, assuming the country-specific subordination rates presented in table 3. In the first variant of the E-bond proposal, in which the intermediary buys at market rates, the intermediary would make large profits because of its preferred creditor status. Column (5) shows how these profits would be earned, and column (6) how they would be distributed, based on the portfolio shares shown in column (2). Column (7) shows the net transfers arising in this variant of the proposal (column 6 minus column 5). A positive sign means that the country is a net transfer recipient, and a negative sign that it is a net contributor. Column (8) shows each country's contribution to the funding costs of the intermediary (a negative sign means a cost/loss from the perspective of the intermediary). Column (9) shows how the funding costs would be distributed across countries in the second variant of the proposal, in which the intermediary purchases debt at face value and charges the same interest rate to all its borrowers, so as to achieve zero profits. Column (10) shows the net transfers across countries in the second variant of the proposal (column 9 minus column 8).

Source: Authors' calculations based on results of table 3.

Table 10 Unexpected losses of safe assets generated under alternative proposals
(in percent)

		Value at risk (VaR)					Expected shortfall (ES)				
		5%	4%	3%	2%	1%	5%	4%	3%	2%	1%
Benchmark calibration											
National tranching	(1)	0.2	2.4	6.5	8.4	12.0	7.5	9.1	10.3	11.5	12.3
	(2)	0.2	2.2	6.3	8.2	11.9	7.3	8.9	10.1	11.4	12.2
E-Bonds	(3)	1.1	3.0	4.9	6.5	7.8	5.4	6.3	7.1	7.8	8.4
ESBies	(4)	0.0	0.0	0.0	0.0	1.2	2.5	3.1	4.1	6.1	12.2
	(5)	0.0	0.0	0.0	0.0	0.0	2.3	2.9	3.9	5.9	11.7
	(6)	0.0	0.0	0.0	0.0	1.2	2.5	3.1	4.1	6.1	12.2
	(7)	0.0	0.0	0.0	0.0	0.0	2.5	3.1	4.1	6.2	12.4
	HLTF	0.0	0.0	0.0	0.0	0.0	1.8	2.2	2.9	4.4	8.7
Adverse calibration											
National tranching	(1)	0.2	5.4	8.6	12.5	12.6	9.0	11.0	12.2	12.6	12.6
	(2)	0.2	5.2	8.4	12.3	12.4	8.9	10.8	12.1	12.4	12.4
E-Bonds	(3)	1.4	3.9	7.3	8.9	9.3	6.8	8.0	8.8	9.2	9.3
ESBies	(4)	0.0	0.0	3.1	7.8	22.6	10.1	12.7	16.6	22.4	29.5
	(5)	0.0	0.0	1.2	8.0	21.8	9.9	12.4	16.5	22.2	28.7
	(6)	0.0	0.0	3.1	7.8	22.6	10.1	12.7	16.6	22.4	29.5
	(7)	0.0	0.0	0.0	8.5	22.8	10.0	12.5	16.6	22.5	29.4
	HLTF	0.0	0.0	1.4	5.9	18.4	8.5	10.6	14.0	19.4	25.7

Note: The table shows values at risk and expected shortfalls, for various probability levels, associated with the safe assets produced according to purchase rules (1) through (7), using the simulation model of Brunnermeier et al. (2017). The values at risk at *p%* describe the minimum loss associated with a tail-event occurring with *p%* probability. The expected shortfalls at *p%* describe the expected loss associated with a tail-event occurring with *p%* probability. The numbers in brackets in the second column denote the portfolio selection equation used; "HLTF" refers to the portfolio weights for ESBies assumed by ESRB HLTF (2018). Results are shown for both the benchmark calibration of the model and the adverse calibration (see box 1).

Source: Eurostat and authors' calculations based on the simulation model of Brunnermeier et al. (2017) (see box 1).

Table 11 Change in average borrowing costs associated with E-bond proposal
(in percent unless otherwise indicated)

	July 2014					October 2017				
		L_1		L_2			L_1		L_2	
Country	r	r_s	Overall change (bp)	r_s	Overall change (bp)	r	r_s	Overall change (bp)	r_s	Overall change (bp)
Germany	1.15	1.18	1.3	1.18	1.3	0.36	0.39	1.3	0.39	1.3
Netherlands	1.34	1.54	1.1	1.54	1.0	0.47	0.59	1.2	0.59	1.2
Austria	1.39	1.64	1.0	1.64	1.0	0.53	0.72	1.2	0.72	1.2
Finland	1.28	1.37	0.8	1.37	0.8	0.52	0.62	0.9	0.62	0.9
France	1.53	1.91	0.8	1.79	–5.3	0.75	1.16	1.1	1.03	–5.4
Belgium	1.54	1.71	0.5	1.71	0.6	0.60	0.72	0.7	0.72	0.8
Ireland	2.20	2.63	0.1	2.55	–5.3	0.57	0.66	0.7	0.65	–0.5
Spain	2.50	3.82	–0.2	2.84	–49.6	1.45	2.54	0.9	1.73	–39.9
Italy	2.69	4.19	–0.4	3.08	–56.6	1.82	3.26	0.8	2.19	–53.5
Portugal	3.60	5.97	–1.4	4.03	–99.3	2.06	3.73	0.7	2.36	–68.6
Greece	5.97	10.60	–4.0	6.22	–225.4	5.43	10.38	–0.4	5.70	–237.1

Note: This table shows the change in debt costs that countries would face if they issued part of their debt through a senior intermediary that lends to sovereigns at face value, issues E-bonds, and passes on its funding costs, which would be equal to the German yield (r_g). Columns labeled r show 10-year benchmark bond yields for two dates: end-July 2014 and end-October 2017. Columns labeled r_s show the interest rate that countries would need to pay to the market in the presence of E-bonds. They are computed using an interest parity condition (equation 8), the subordination levels given in table 3, and two different assumptions about loss rates given default. In L_1, the loss rate given default is assumed to be 0.5 for all countries; in L_2, loss rates given default are equal to those in Brunnermeier et al.'s (2017) benchmark calibration ("state 1"; Germany: 0.4, Netherlands: 0.4, Austria: 0.45, Finland: 0.45, France: 0.6, Belgium: 0.625, Ireland: 0.75, Spain: 0.8, Italy: 0.8, Portugal: 0.85, and Greece: 0.95). Columns labeled "overall change in bp" indicate the total change in borrowing costs, in basis points, after the introduction of E-bonds. They consist of the weighted average of the savings associated with issuing the debt share (1–s) to the E-bond intermediary and the borrowing cost increase due to the higher cost of issuing the debt share s to the market, where s denotes the subordination levels of table 3. That is, the overall change (in basis points) is (1–s)*(r_g –r) + s*(r_s –r).

Source: Bloomberg and authors' calculations.

Table 12 Volume of sovereign debt securities at higher risk levels

	5-year expected loss rates						Total volume in € bn
	4 to 8 percent		8 to 14 percent		Above 14 percent		
	Volume in € bn	Debt class	Volume in € bn	Debt class	Volume in € bn	Debt class	
Euro area sovereign debt today	2,819	Slovenia, Spain, Italy	139	Portugal, Cyprus	57	Greece	3,015
Euro area sovereign debt after national tranching	1,991	JrLatvia, JrLithuania, JrMalta, JrSlovenia, JrSpain, JrItaly	93	JrPortugal	44	JrCyprus, JrGreece	2,128
Euro area sovereign debt after E-Bonds	2,120	Latvia, Lithuania, Malta, Slovenia, Spain, Italy	86	Portugal	32	Cyprus, Greece	2,239
Euro area sovereign debt after ESBies (with single subordinated tranche)	1,134	Slovenia, Spain, Italy	1,676	EJBies, Portugal, Cyprus	29	Greece	2,838
Euro area sovereign debt after ESBies (with two subordinated tranches)	1,134	Slovenia, Spain, Italy	70	Portugal, Cyprus	564	Junior (equity) tranche, Greece	1,767
Memorandum item:							
World sovereign bond market excluding euro area	1,081	BBB+, BBB	2,642	BBB-, BB+, BB	806	BB- and lower	4,529

Note: The table shows the volume of euro area sovereign debt securities in three "buckets" of 5-year expected loss rates (4 to 8 percent, 8 to 14 percent, and above 14 percent) as of today, after national tranching, after E-Bonds, and after ESBies. The "debt class" columns show the securities included in each of these categories. As of today, there are about €2,819 billion of euro area debt securities with 5-year expected loss rates between 4 and 8 percent, consisting of Slovenian, Spanish, and Italian debt securities. After national tranching—assumed to follow equation (1)—the junior debt securities of Latvia, Lithuania, Malta, Slovenia, Spain, and Italy would also fall into this class. After E-bonds, the (now subordinated) debt securities of these same countries also fall into this 5-year expected loss rate class. In the case of ESBies, we show two variants, which both assume purchase levels corresponding to equation (5). The first assumes just one subordinated tranche (EJBies, size 31.5 percent). In the second, this is divided 2:1 into a mezzanine and a junior (equity) tranche (following ESRB HLTF 2018). In both cases, the debt securities of Slovenia, Spain and Italy that do not enter the collateral pool remain in the same expected loss class, as their expected loss rates are unchanged. With 5-year expected loss rates of 9, 3.9, and 15.4 percent, respectively, EJBies would fall into the 8 to 14 percent bucket, while the mezzanine tranche would fall just outside the 4 to 8 percent bucket and the junior (equity) tranche into the over-14 percent bucket. The last row shows the volume of non–euro area sovereign debt securities debt that fall into each bucket, based on matching their S&P credit ratings to those of the euro area countries in each bucket. Total volumes shown in last column differ slightly in some cases due to rounding.

Sources: Eurostat, Bloomberg, Brunnermeier et al. (2017) (benchmark calibration), and authors' calculations.

Table 13 Summary comparison of proposals

	Proposal			
Properties	**National tranching**	**E-bonds**	**ESBies**	**Euro area budget**
Supports large volume of safe assets	Last. Could support safe asset of up to 18 percent of GDP. On a *net* basis, however, safe assets would only increase by 2-4 percent due to subordination effect.	Third. Could support safe asset of up to 25 percent of euro area GDP, in line or above ESBies with purchase cap of 50 percent, but leads to significantly smaller *net* increase in safe assets due to subordination effect.	Second. Could support safe asset of up to 35 percent of euro area GDP with purchases of up to 80 percent of some debt markets. With purchase cap of 50 percent, can support only 23 percent of GDP.	First. A euro area primary surplus of 0.5 percent of GDP could support debt issuance of up to 60 percent of GDP.
Supports transition to new steady state	Third (tied). Creates demand only for senior tranches of euro area sovereign bonds.	Third (tied). Issuance constrained by the need to attain targeted subordination levels.	First (possibly tied). Can be issued in flexible volumes to absorb any shortfall in demand for sovereign bonds.	Either first (tied with ESBies) or last, depending on mandate (see discussion in main text)
Encourages fiscal discipline	Second (tied). Possible increase in cost of issuance after country's stock of debt reaches portfolio cap.	First. Higher marginal cost of borrowing after debt securities exceed 25 percent of GDP (subordination effect)	Second (tied). Possible increase in cost of issuance after country's stock of debt reaches purchase cap.	Unclear—depends on design of revenue and expenditure sides.
Maintains liquidity of national bond markets	Last. Fragments national bond markets. Low liquidity particularly of senior tranche.	Second (tied). Reduces issuance to the markets, and hence potentially liquidity, but maintains current market size at 50 percent or higher.	Second (tied). Reduces issuance to the markets, and hence potentially liquidity, but the design of the proposal depends on maintaining liquid national markets.	First. No direct interference in national debt markets except for a modest reduction in size in equilibrium.
Avoids redistribution	First (tied). No redistribution by design.	Fourth. Large redistributive effects if purchased at market prices; smaller redistributive effects if purchased at face value.	First (tied). No redistribution by design.	Third. May or may not involve redistribution, depending on design.
Avoids rise in borrowing costs of lower-rated countries	Third (tied). Small increase in costs possible due to reduced liquidity.	First (tied; if purchased at face value): Higher cost of issuing to market offset by cheaper debt issuance via E-bond intermediary. Small net reduction in borrowing cost possible for higher-rated borrowers.	Third (tied). Competition from junior tranche may raise borrowing costs of some lower-rated European issuers.	First (tied). Should not affect average cost of national debt issuance.
Avoids "backdoor mutualization"	Second (tied). A simultaneous crisis in several lower-rated countries could lead to investor losses, triggering pressures for a bailout.	Second (tied). A simultaneous crisis in several lower-rated countries could lead to investor losses, triggering pressures for a bailout (unless intermediary is capitalized upfront).	First. Design rules out losses except in extreme events that would be too severe to bail out. Could be supplied by private intermediaries.	Unclear—depends on institutional design.

APPENDIX A

CHOOSING PARAMETER VALUES IN THE "NATIONAL TRANCHING" AND "E-BOND" APPROACHES

The following notation is used. Upper-case letters indexed by i denote euro amounts pertaining to country i (e.g., D_i and Y_i are country i debt and nominal output, respectively), upper-case non-indexed letters the sum of euro amounts across euro area countries (e.g., $D \equiv \sum_i D_i$ is total euro area sovereign debt securities). Lower-case indexed letters denote shares specific to country i (e.g., $y_i \equiv \frac{Y_i}{Y}$ denotes country i's share of total euro area GDP, and $d_i \equiv \frac{D_i}{D}$ country i's share in total euro area debt securities, respectively). Nonindexed lowercase letters denote shares that are uniform across euro area countries.

National Tranching Approach

In the national-level tranching approach, the parameter that needs to be determined is the uniform subordination level s. This denotes the "thickness" of the *junior* tranche. Hence, country i's maximum available volume of *senior* tranches for pooling purposes is $(1-s)D_i$

The text motivates the following two alternative rules for determining how many of these senior tranches to include in the portfolio:

$$P_i = (1-s) * \min\{0.6Y_i, D_i\} \quad (1)$$
$$P_i = (1-s) * \min\{y_i D, D_i\} \quad (2)$$

Focusing on the first rule, denote the set of countries with $D_i/Y_i < 0.6$ with $\mathcal{A}$ and the set of remaining countries with $\mathcal{B}$. Then, the volume of senior tranches that enter the pool is given by $P = (1-s)\{\sum_{j\in\mathcal{A}} D_j + \sum_{h\in\mathcal{B}} 0.6Y_h\}$. Hence, for rule (1), portfolio shares $p_i = P_i/P$ are independent of s. The same is true for rule (2).

This makes it very easy to determine s. In a first step, use rules (1) or (2) to create a set of portfolio weights $\boldsymbol{p_i}$. In a second step, choose s as the subordination level that sets the expected loss rate of the portfolio to 0.5 percent. From the simulation model the Brunnermeier et al. simulations, we know the 5-year expected losses for all countries and subordination levels. Denote these by $\boldsymbol{\lambda_i}(s)$. Hence, s is chosen to solve:

$$\sum_i \boldsymbol{p_i}\boldsymbol{\lambda_i}(s) = 0.005$$

E-Bonds

Unlike with national tranching, a country's portfolio share and the subordination level of its bonds cannot be determined independently, because both are determined by the amount of debt purchased by the E-bond issuer.

For example, suppose that the intermediary purchases a uniform share of bonds in all bond markets: $P_i = (1-s)D_i$. This would create a uniform subordination level s for all countries. But at the same time, it would also fix the portfolio weights, which are equal to the country's share in euro area debt. (Proof: $P_i = (1-s)D_i$ implies $P = (1-s)D$. Hence, $p_i = d_i$). This means that the high-debt countries would be much more highly represented in the pool than in the case of national tranching with the purchase rule defined above.

To define the portfolio purchased by the E-bond intermediary in a way that emulates portfolio rules we used for national tranching, we hence assumed that debt worth a fixed uniform share of each country's GDP is purchased, unless this exceeds some uniform maximum ratio c of the country's total debt securities stock:

$$P_i^E = \min\{yY_i\,, cD_i\}. \tag{3}$$

Now define $\mathcal{C}$ as the set of countries for whom $yY_i > cD_i$ and $\mathcal{D}$ as the remaining countries. Then, the total purchases by the intermediary are given by $P^E \equiv \sum_{j\in\mathcal{C}} cD_j + \sum_{h\in\mathcal{D}} yY_h$. Hence, portfolio shares are given by:

$p_i^E(y,c) \equiv P_i^E/P^E = \min\{yY_i\,, cD_i\}/P^E$, with P^E defined as above.

As a result, the subordination level will now differ across countries, and depends on the choice of parameters y and c

$$\mathrm{s}_i(y,c) \equiv 1 - P_i^E/D_i = 1 - \min\{yY_i/D_i\,, c\}$$

As before, we would like to choose y and c to attain an expected portfolio loss rate. However, choosing does of the portfolio based to 0.5%. But we now have an extra degree of freedom: for a given y, c can be chosen to solve $\sum_i p_i^E(y,c)\lambda_i(s_i(y,c)) = 0.005$, and vice versa. Hence, we chose the $\{y,c\}$ pair that maximizes the size of the safe asset pool, subject to setting the expected loss rate of the portfolio to 0.5%:

$$\max_{y,c} \sum\nolimits_i \min\{yY_i\,, cD_i\}\,, \text{subject to} \sum\nolimits_i p_i^E(y,c)\lambda_i(s_i(y,c)) = 0.005$$

using the above definitions of $p_i^E(y,c)$ and $\mathrm{s}_i(y,c)$.

Solving this problem involves searching over a grid of potential pairs $\{y,c\}$ pair. This can be done either using numerical maximization or (approximatively) in a spreadsheet, using a table of 5-year expected losses for all countries and percentile subordination levels generated by the Brunnermeier et al. simulation model.

APPENDIX B

EXPECTED CHANGE IN AVERAGE DEBT COSTS DUE TO E-BONDS

In the following, country i's subordination level (a number between 0 and 1, see table 3) are denoted by s_i, the real bond yield paid by country i in the status quo as r_i, the German bond rate in the status quo as r_g, the risk-free interest rate as r^*, the real bond yield paid by country i after the introduction of E-bonds as r_i^s, and country i's default probability and loss-given-default rate as π_i and l_i, respectively.

As discussed in the text, the change in country i's average debt cost, $\Delta\bar{r}_i$ due to the adoption of E-Bonds can be written as:

$$\Delta\bar{r}_i = s_i(r_i^s - r_i) + (1 - s_i)(r_g - r_i) = s_i(r_i^s - r_i) - (1 - s_i)r_i + (1 - s_i)r_g \quad (9)$$

Using the interest parity condition

$$(1 + r_i)(1 - \pi_i) = (1 + r^*) - \pi_i(1 - l_i) \quad (10)$$

the pre-E-bonds yield can be written as:

$$r_i = \frac{r^* + \pi_i l_i}{1 - \pi_i} \quad (11)$$

To write $s_i(r_i^s - r_i)$ in terms of the underlying fundamentals, we must distinguish between the case in which $l_i \geq s_i$ and $l_i < s_i$ (see text, equation 8).

For $l_i \geq s_i$, we have $(1 + r_i^s)(1 - \pi_i) = (1 + r^*)$. Using equation (10), this implies

$$s_i(r_i^s - r_i) = s_i \frac{\pi_i(1 - l_i)}{1 - \pi_i} \quad (12)$$

For $l_i < s_i$, we have $(1 + r_i^s)(1 - \pi_i) = (1 + r^*) - \pi_i(1 - l_i/s_i)$. Using equation (10), this implies

$$s_i(r_i^s - r_i) = (1 - s_i) * \frac{\pi_i l_i}{1 - \pi_i} \quad (13)$$

Equations (12) and (13) imply that, for any, π_i l_i, and s_i with $0 \leq \pi_i < 1$, $0 < l_i < 1$, and $0 < s_i < 1$, $s_i(r_i^s - r_i) > 0$.

Assuming that π_i l_i, and s_i satisfy the above restrictions, the following results hold:

Result 1: For Germany (i.e., $i = g$) $\Delta\bar{r}_i > 0$.
Proof: follows from equation (9) and $s_i(r_i^s - r_i) > 0$.

Result 2: For $l_i \geq s_i$, $\Delta\bar{r}_i < 0$ if and only if $\frac{1}{1 - \pi_i}\{\pi_i(l_i - s_i) + (1 - s_i)r^*\} > (1 - s_i)r_g$
Proof: From equations (9), (11), and (12), we have:

$$\Delta\bar{r}_i = (1 - s_i)r_g - \frac{1}{1 - \pi_i}\{\pi_i(l_i - s_i) + (1 - s_i)r^*\} \quad (14)$$

Note that $l_i \geq s_i$ by assumption.

Result 3: For $l_i < s_i$, $\Delta\bar{r}_i < 0$ if and only if $\pi_i > 1 - \frac{r^*}{r_g}$
Proof: From equations (9), (11), and (13), we have:

$$\Delta\bar{r}_i = (1 - s_i)\left\{r_g - \frac{r^*}{1 - \pi_i}\right\} \quad (15)$$

Results 2 and 3 imply that, depending on parameter values, $\Delta\bar{r}_i$ can be positive or negative. Result 3 says that for $l_i < s_i$, $\Delta\bar{r}_i < 0$ for "sufficiently risky" countries.

Result 4. Suppose that E-Bond intermediary is capitalized to an extent that enables it to borrow at the risk-free rate, i.e., at $r^* < r_g$. Then, $\Delta\bar{r}_i < 0$ for all countries i (even for Germany).
Proof: Under the assumption made,

$$\Delta\bar{r}_i = s_i(r_i^s - r_i) + (1 - s_i)(r^* - r_i). \tag{16}$$

Assume $l_i \geq s_i$. Using equations (16), (11), and (12), $\Delta\bar{r}_i = \frac{\pi_i}{1-\pi_i}\{s_i(1 + r^*) - (r^* + l_i)\}$. Hence, $\Delta\bar{r}_i < 0$ if and only if $s_i + s_i r^* < r^* + l_i$. This always holds because $l_i \geq s_i$ and $0 < s_i < 1$.

Assume $l_i < s_i$. Using equations (16), (11), and (13), $\Delta\bar{r}_i = \frac{\pi_i}{1-\pi_i} r^*(s_i - 1)$. Since $s_i < 1$, $\Delta\bar{r}_i < 0$.

APPENDIX C

TABLES

Table C.1 Central government debt in the euro area, by issuer (end-2016 stocks, percent of GDP)

Country	Gross debt	Debt securities
Austria	77.7	68.2
Belgium	90.1	84.8
Cyprus	151.2	36.4
Estonia	10.4	0.3
Finland	53.7	47.2
France	80.5	73.1
Germany	43.5	37.5
Greece	185.9	37.5
Ireland	73.0	45.5
Italy	127.8	111.6
Latvia	40.6	29.4
Lithuania	37.8	31.8
Luxembourg	18.8	11.5
Malta	57.6	53.7
Netherlands	57.9	48.5
Portugal	131.7	75.6
Slovakia	51.9	44.3
Slovenia	77.1	66.1
Spain	87.0	79.7
Euro area	**77.6**	**65.3**

Note: "Debt securities" refer to bonds, treasury bills, and other short-term government securities.

Source: Eurostat.

Table C.2 Portfolio shares and five-year expected loss rates of national and pooled senior sovereign bond tranches (based on central government debt securities, in percent)

	Share in euro area		Portfolio weights using		Subordination level								
Country	GDP	Debt securities	Eq. (1)	Eq. (2)	0	10	20	30	40	50	60	70	80
Germany	29.2	16.4	21.3	19.9	0.50	0.40	0.27	0.11	0.00	0.0	0.00	0.00	0.00
Netherlands	6.5	4.7	6.1	5.7	0.69	0.55	0.38	0.16	0.00	0.0	0.00	0.00	0.00
Luxembourg	0.5	0.1	0.2	0.1	0.69	0.55	0.38	0.16	0.00	0.0	0.00	0.00	0.00
Austria	3.2	3.3	3.8	3.9	0.96	0.80	0.60	0.35	0.09	0.0	0.00	0.00	0.00
Finland	2.0	1.4	1.9	1.8	0.96	0.80	0.60	0.35	0.09	0.0	0.00	0.00	0.00
France	20.7	23.5	24.3	25.2	1.94	1.75	1.51	1.20	0.81	0.33	0.00	0.00	0.00
Belgium	3.9	5.1	4.6	4.8	2.64	2.40	2.10	1.71	1.22	0.54	0.13	0.00	0.00
Estonia	0.2	0.0	0.0	0.0	3.10	2.87	2.57	2.19	1.70	1.03	0.43	0.00	0.00
Slovakia	0.8	0.5	0.7	0.6	5.58	5.16	4.65	3.98	3.13	1.97	0.80	0.00	0.00
Ireland	2.6	1.9	2.4	2.3	6.05	5.68	5.21	4.62	3.83	2.80	1.24	0.55	0.00
Latvia	0.2	0.1	0.1	0.1	6.81	6.38	5.85	5.16	4.26	3.09	1.32	0.59	0.00
Lithuania	0.4	0.2	0.2	0.2	6.80	6.37	5.84	5.15	4.26	3.08	1.32	0.58	0.00
Malta	0.1	0.1	0.1	0.1	7.32	6.91	6.39	5.73	4.85	3.72	2.04	0.96	0.00
Slovenia	0.4	0.4	0.4	0.5	8.17	7.74	7.20	6.51	5.59	4.41	2.64	1.24	0.00
Spain	10.3	12.7	12.2	12.6	6.80	6.45	6.02	5.46	4.71	3.75	2.31	1.13	0.00
Italy	15.5	26.6	18.3	18.9	7.22	6.85	6.38	5.78	4.98	3.96	2.42	1.17	0.00
Portugal	1.7	2.0	2.0	2.1	11.80	11.21	10.47	9.52	8.25	6.78	4.69	1.96	0.98
Cyprus	0.2	0.1	0.1	0.1	16.07	15.12	13.93	12.41	10.37	8.41	6.14	2.35	1.51
Greece	1.6	0.9	1.2	1.1	35.19	32.79	29.79	25.94	20.80	15.15	12.46	7.99	3.33
Pooled using portfolio shares (1)					**3.87**	**3.60**	**3.27**	**2.85**	**2.32**	**1.72**	**1.03**	**0.51**	**0.06**
Pooled using portfolio shares (2)					**3.91**	**3.64**	**3.31**	**2.88**	**2.36**	**1.75**	**1.05**	**0.52**	**0.06**
Memorandum item:													
Portfolio volume based on shares (1) (€ billion)					5,495	4,945	4,396	3,846	3,297	2,747	2,198	1,648	1,099
Portfolio volume based on shares (2) (€ billion)					5,813	5,231	4,650	4,069	3,488	2,906	2,325	1,744	1,163

Note: The first two columns of the table show the share of 2016 euro area GDP and the end-2016 stock of euro area debt securities attributable to the country. The third and fourth columns show the portfolio weights of each country in a pool of senior tranches assembled according to the following rules: (1) when debt of country is less than 60 percent of country GDP, include all available senior tranches in the pool, otherwise include the senior tranches corresponding to a nominal value of debt equal to 60 percent of GDP; (2) when the country's share in euro area GDP exceeds its share in euro area debt securities, include all available senior tranches in the pool, otherwise include the senior tranches corresponding to the product of the country's share of euro area GDP and the nominal value of euro area debt (see equations (1) and (2) in the text). The remaining columns of the table show five-year expected loss rates (in percent) in the adverse calibration described in subsection 4.4 of Brunnermeier et al. (2017) for various subordination levels (i.e., face value of junior tranche as a percent of face value of debt issued). The two rows at the bottom show five-year expected loss rates for a portfolio of senior securities with uniform subordination levels across countries, pooled according to portfolio weights (1) and (2), respectively. The memorandum item shows the aggregate volume (in € billion) of senior tranches in portfolios (1) or (2) for various subordination levels. The subordination levels generating an expected loss rate of exactly 0.5 percent are 70 and 71 percent, respectively, for portfolio shares (1) and (2), and the implied aggregate volumes are €1,648 billion for portfolio shares (1) and €1,686 billion for portfolio shares (2).

Source: Eurostat and authors' calculations using simulation code for Brunnermeier et al. (2017) (adverse calibration, see box 1).

Table C.3 **E-bond purchase portfolio and expected losses** (based on central government debt securities, in percent) (purchase volumes = minimum of {47.5 percent of national debt securities and 24 percent of national GDP})

Country	Purchase volume in € billion	Purchase volume in % of			Implicit subordination level	5-year exp. loss rate, %
		GDP	Debt	Portfolio		
Germany	560	17.8	47.5	23.9	52.5	0.00
Netherlands	161.9	23.0	47.5	6.9	52.5	0.00
Luxembourg	3.0	5.5	47.5	0.1	52.5	0.00
Austria	83.8	24.0	35.1	3.6	64.9	0.00
Finland	48.4	22.4	47.5	2.1	52.5	0.00
France	534.8	24.0	32.8	22.9	67.2	0.00
Belgium	101.2	24.0	28.3	4.3	71.7	0.00
Estonia	0.0	0.1	47.5	0.0	52.5	0.77
Slovakia	17.0	21.0	47.5	0.7	52.5	1.52
Ireland	59.5	21.6	47.5	2.5	52.5	2.40
Latvia	3.5	13.9	47.5	0.1	52.5	2.64
Lithuania	5.8	15.1	47.5	0.2	52.5	2.63
Malta	2.4	24.0	44.4	0.1	55.6	2.81
Slovenia	9.7	24.0	36.3	0.4	63.7	1.65
Spain	267.3	24.0	30.1	11.4	69.9	1.13
Italy	401.3	24.0	21.5	17.2	78.5	0.17
Portugal	44.4	24.0	31.7	1.9	68.3	2.09
Cyprus	3.1	17.3	47.5	0.1	52.5	7.83
Greece	31.3	17.8	47.5	1.3	52.5	14.46
Total portfolio	**2,338.5**				**63.9**	**0.49**

Note: The table shows the purchases volumes and 5-year expected loss rates, from the perspective of the E-bond issuer buying national debt, arising from a purchase rule in which the issuer buys either 47.5 percent of national central government debt securities or 24 percent of GDP worth of debt, whichever is smaller. For example, for Germany, 47.5 percent of national debt are bought, for Italy, 24 percent of GDP. The parameters 47.5 percent of national debt and 24 percent of GDP were chosen to maximize the size of the portfolio (and hence issue volume of E-bonds backed by the portfolio) subject to keeping the portfolio 5-year expected loss equal or below 0.5 percent. In the last line of the table, the total portfolio purchase volume is computed as the sum of the country purchase volumes, while the total portfolio 5-year expected loss of 0.5 percent is computed as the weighted average of the country 5-year expected losses shown in the final column, using the portfolio purchase shares as weights.

Sources: Eurostat and author's calculations based on simulation model of Brunnermeier et al. (2017) (adverse calibration, see box 1).

Table C.4 SBBS purchase portfolios consistent with 0.5 percent expected loss of the senior tranche (ESBies) (based on central government debt securities, in percent)

	Purchase volume = min{0.6*Y_i, Φ(D_i)}, where						Purchase volume = min{Y_i/Y*D, Φ(D_i)}, where					
	Φ(D_i) = 0.5*D_i			Φ(D_i) = max {D_i–€200bn, 0.5D_i}			Φ(D_i) = 0.5*D_i			Φ(D_i) = max {D_i–€200bn, 0.5D_i}		
Country	**€ bn**	**% debt**	**% portfolio**	**€ bn**	**% debt**	**% portfolio**	**€ bn**	**% debt**	**% portfolio**	**€ bn**	**% debt**	**% portfolio**
Germany	589.8	50.0	16.77	979.7	83.0	20.74	589.8	50.0	16.77	979.7	83.0	19.9
Netherlands	170.5	50.0	4.85	170.5	50.0	3.61	170.5	50.0	4.85	170.5	50.0	3.46
Luxembourg	3.1	50.0	0.09	3.1	50.0	0.07	3.1	50.0	0.09	3.1	50.0	0.06
Austria	119.3	50.0	3.39	119.3	50.0	2.53	119.3	50.0	3.39	119.3	50.0	2.42
Finland	51.0	50.0	1.45	51.0	50.0	1.08	51.0	50.0	1.45	51.0	50.0	1.04
France	814.2	50.0	23.15	1,337.3	82.1	28.31	814.2	50.0	23.15	1,428.5	87.7	29.01
Belgium	178.7	50.0	5.08	178.7	50.0	3.78	178.7	50.0	5.08	178.7	50.0	3.63
Estonia	0.0	50.0	0.00	0.0	50.0	0.00	0.0	50.0	0.00	0.0	50.0	0.00
Slovakia	17.9	50.0	0.51	17.9	50.0	0.38	17.9	50.0	0.51	17.9	50.0	0.36
Ireland	62.7	50.0	1.78	62.7	50.0	1.33	62.7	50.0	1.78	62.7	50.0	1.27
Latvia	3.7	50.0	0.10	3.7	50.0	0.08	3.7	50.0	0.10	3.7	50.0	0.07
Lithuania	6.1	50.0	0.17	6.1	50.0	0.13	6.1	50.0	0.17	6.1	50.0	0.12
Malta	2.7	50.0	0.08	2.7	50.0	0.06	2.7	50.0	0.08	2.7	50.0	0.05
Slovenia	13.4	50.0	0.38	13.4	50.0	0.28	13.4	50.0	0.38	13.4	50.0	0.27
Spain	443.8	50.0	12.62	668.3	75.3	14.15	443.8	50.0	12.62	687.6	77.5	13.97
Italy	933.4	50.0	26.54	1,003.5	53.8	21.24	933.4	50.0	26.54	1,091.9	58.5	22.18
Portugal	70.0	50.0	1.99	70.0	50.0	1.48	70.0	50.0	1.99	70.0	50.0	1.42
Cyprus	3.3	50.0	0.09	3.3	50.0	0.07	3.3	50.0	0.09	3.3	50.0	0.07
Greece	33.0	50.0	0.94	33.0	50.0	0.70	33.0	50.0	0.94	33.0	50.0	0.67
Total	**3,516.8**	**50.0**	**100.0**	**4,724.3**	**67.2**	**100.0**	**3,516.8**	**50.0**	**100.0**	**4,923.2**	**70.0**	**100.0**
Memorandum items:												
Subordination level (percent)			37.0			35.0			37.0			36.0
ESBies volume (€ bn)			2,215.6			3,070.8			2,215.6			3,150.8

SBBS = sovereign bond–backed securities

Note: The table shows purchases of central government debt securities in nominal terms, as a percentage of the debt stock, and as a percentage of the resulting underlying portfolio of bonds, for the four purchase rules set out in the ESBies part of section III-1 (equations 4, 5, 6, and 7, respectively). For each rule, the memorandum items show the subordination level required to achieve an expected loss rate of 0.5 percent or less for the senior bond, and the corresponding volume of senior tranches or ESBies created, in billions of euro. Y_i and D_i denote country *i*'s GDP and debt, respectively, and *Y* and *D* denote the euro area's overall GDP and debt.

Source: Eurostat and author's calculations based on simulation model of Brunnermeier et al. (2017) (adverse calibration, see box 1).

Table C.5 Summary of portfolio weights from tables 2 to 4 and comparison with ECB capital key (in percent)

Country	ECB capital key	ECB PSPP	National tranching		E-Bond	ESBies			
			(1)	(2)	(3)	(4)	(5)	(6)	(7)
Germany	25.57	26.67	26.50	23.86	29.24	20.35	26.54	20.35	24.28
Netherlands	5.69	5.97	5.81	5.23	6.42	4.46	3.34	4.46	3.06
Luxembourg	0.29	0.14	0.11	0.10	0.12	0.08	0.06	0.08	0.06
Austria	2.79	3.01	3.58	3.78	3.35	3.22	2.41	3.22	2.20
Finland	1.78	1.70	1.79	1.61	1.97	1.37	1.03	1.37	0.94
France	20.14	21.79	22.82	24.26	21.35	23.8	26.23	23.80	28.34
Belgium	3.52	3.79	4.32	4.59	4.04	4.80	3.59	4.80	3.28
Estonia	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Slovakia	1.10	0.63	0.61	0.55	0.68	0.47	0.35	0.47	0.32
Ireland	1.65	1.46	2.12	1.91	2.34	1.62	1.22	1.62	1.11
Latvia	0.40	0.10	0.13	0.11	0.14	0.10	0.07	0.10	0.07
Lithuania	0.59	0.17	0.21	0.19	0.23	0.16	0.12	0.16	0.11
Malta	0.09	0.06	0.09	0.08	0.10	0.07	0.05	0.07	0.05
Slovenia	0.49	0.40	0.41	0.41	0.39	0.35	0.26	0.35	0.24
Spain	12.56	13.33	11.40	12.13	10.67	12.05	13.11	12.05	12.91
Italy	17.49	18.95	17.12	18.21	16.02	24.52	19.68	24.52	21.26
Portugal	2.48	1.82	1.89	2.01	1.77	1.74	1.30	1.74	1.19
Cyprus	0.21	0.01	0.11	0.10	0.12	0.08	0.06	0.08	0.06
Greece	2.89	0.00	0.98	0.88	1.08	0.75	0.56	0.75	0.51
Memorandum item:									
RMSE		0.93	0.91	1.84	1.18	2.29	1.74	2.29	2.29

Note: The table shows the national portfolio shares in the seven approaches to creating a safe asset portfolio or safe asset collateral pool described by equations (1) through (7) and compares them with the capital key of the European Central Bank (ECB) and the ECB's Public Sector Purchase Programme (PSPP). The last row shows the root mean squared error (square root of the average of squared deviations) of the ECB PSPP shares and the seven sets of portfolio shares with respect to the ECB capital key. A larger RMSE means larger average deviations from the ECB capital key.

Sources: European Central Bank; and tables 2, 3, and 4.

Table C.6 Portfolio weights after reweighting (in percent)

Country	ECB capital key	ECB PSPP	National tranching		E-Bond	ESBies			
			(1)	(2)	(3)	(4)	(5)	(6)	(7)
Germany	25.57	26.67	26.50	24.72	27.31	24.26	27.55	24.26	27.55
Netherlands	5.69	5.97	5.81	5.42	5.99	5.32	4.58	5.32	4.58
Luxembourg	0.29	0.14	0.11	0.10	0.11	0.10	0.08	0.10	0.08
Austria	2.79	3.01	3.58	3.20	3.51	3.08	3.01	3.08	3.01
Finland	1.78	1.70	1.79	1.67	1.84	1.64	1.41	1.64	1.41
France	20.14	21.79	22.82	23.06	22.39	22.25	21.70	22.25	21.70
Belgium	3.52	3.79	4.32	4.03	4.23	3.89	3.79	3.89	3.79
Estonia	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Slovakia	1.10	0.63	0.61	0.57	0.63	0.56	0.48	0.56	0.48
Ireland	1.65	1.46	2.12	1.89	2.18	1.82	1.67	1.82	1.67
Latvia	0.40	0.10	0.13	0.12	0.13	0.12	0.10	0.12	0.10
Lithuania	0.59	0.17	0.21	0.20	0.22	0.19	0.17	0.19	0.17
Malta	0.09	0.06	0.09	0.09	0.09	0.08	0.07	0.08	0.07
Slovenia	0.49	0.40	0.41	0.42	0.41	0.42	0.36	0.42	0.36
Spain	12.56	13.33	11.40	12.56	11.19	13.88	13.54	13.88	13.54
Italy	17.49	18.95	17.12	18.86	16.80	19.32	18.85	19.32	18.85
Portugal	2.48	1.82	1.89	2.09	1.86	2.08	1.79	2.08	1.79
Cyprus	0.21	0.01	0.11	0.10	0.11	0.10	0.08	0.10	0.08
Greece	2.89	0.00	0.98	0.91	1.00	0.89	0.77	0.89	0.77
Memorandum item:									
RMSE		0.93	0.91	0.93	0.93	0.93	0.93	0.93	0.93

Note: The table shows the national portfolio shares in the seven approaches to creating a safe asset portfolio or safe asset collateral pool described by equations (1) through (7) subject to the constraint that the root mean squared error (square root of the average of squared deviations) of the portfolio shares with respect to the European Central Bank (ECB) capital key must not exceed that of the ECB's Public Sector Purchase Programme (PSPP) shares (namely, 0.93). In the national tranching and ESBies approaches (i.e., equations 1 and 2, and 4-7, respectively), we follow ESRB HLTF (2018) in applying a method of successive reweighting: Starting from the ECB's capital key, if a country that has reached one of the limits implied by the portfolio rule that is being considered (e.g., for equation (1), either 60 percent of GDP or the exhaustion of the debt stock), then this country's portfolio weight is set to zero for the purpose of the following purchases, and all other remaining countries' portfolio weights are reweighted proportionally. This process continues until the deviation of portfolio weights from the ECB's capital keys reaches RMSE = 0.93. The implication is that the purchases of some countries' debt may not reach either the GDP limit nor the total debt limit set by the rules, as the re-weighting process ends when RMSE = 0.93. In the E-bond approach, we extend the approach described in appendix A so that the uniform parameters y (share of GDP that debt purchases may not exceed) and c (maximum share of debt that can be purchased) are now picked to maximize the volume of safe assets subject to the constraint that the RMSE of the resulting portfolio shares relative to the ECB capital key cannot exceed 0.93 (in addition to the constraint that the expected loss rate from the portfolio cannot exceed 0.5 percent).

Source: European Central Bank, and authors' calculations based on equations (1) through (7) and Brunnermeier et al. (2017) simulation model (adverse calibration).

Table C.7 Redistributive effects of both variants of the E-bond proposal (based on table 3 and distribution of expected losses according to portfolio shares, adverse calibration) (in percent unless otherwise stated)

Country	Debt volume in portfolio, € billion	Portfolio share	5-year exp. loss rate, subordinated private investors	5-year exp. loss rate, senior intermediary	1. Debt purchased at market prices			2. Debt purchased at face value		
					5-year exp. profit caused, € billion	5-year expected profit received	5-year exp. transfer, € billion	5-year exp. profit caused, € billion	5-year expected profit received	5-year exp. transfer, € billion
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Germany	768.4	29.2	1.00	0.00	7.65	34.40	26.75	0.00	–3.81	–3.81
Netherlands	168.6	6.4	1.37	0.00	2.30	7.55	5.24	0.00	–0.84	–0.84
Luxembourg	3.1	0.1	1.37	0.00	0.04	0.14	0.10	0.00	–0.02	–0.02
Austria	87.9	3.3	1.50	0.00	1.32	3.94	2.62	0.00	–0.44	–0.44
Finland	51.8	2.0	1.91	0.00	0.99	2.32	1.33	0.00	–0.26	–0.26
France	560.9	21.3	2.80	0.00	15.72	25.11	9.40	0.00	–2.78	–2.78
Belgium	106.1	4.0	3.71	0.00	3.94	4.75	0.81	0.00	–0.53	–0.53
Estonia	0.1	0.0	5.21	0.95	0.00	0.00	0.00	0.00	0.00	0.00
Slovakia	17.8	0.7	9.25	1.83	1.32	0.79	–0.52	–0.32	–0.09	0.24
Ireland	61.4	2.3	9.36	2.67	4.10	2.75	–1.36	–1.64	–0.30	1.33
Latvia	3.6	0.1	10.59	2.94	0.28	0.16	–0.12	–0.11	–0.02	0.09
Lithuania	6.1	0.2	10.58	2.94	0.46	0.27	–0.19	–0.18	–0.03	0.15
Malta	2.5	0.1	10.82	3.29	0.19	0.11	–0.08	–0.08	–0.01	0.07
Slovenia	10.2	0.4	11.88	2.17	0.99	0.46	–0.53	–0.22	–0.05	0.17
Spain	280.3	10.7	9.29	1.13	22.87	12.55	–10.32	–3.17	–1.39	1.78
Italy	420.9	16.0	9.23	0.32	37.49	18.84	–18.65	–1.34	–2.09	–0.74
Portugal	46.5	1.8	16.43	3.20	6.16	2.08	–4.07	–1.49	–0.23	1.26
Cyprus	3.1	0.1	23.75	8.23	0.48	0.14	–0.34	–0.26	–0.02	0.24
Greece	28.3	1.1	55.02	14.93	11.34	1.27	–10.07	–4.22	–0.14	4.08
Total	**2,627.6**	**100.0**	**4.97**	**0.50**	**117.64**	**117.64**	**0.00**	**–13.04**	**–13.04**	**0.00**

Note: The first two columns of the table repeat information from table 3. The third and fourth columns show 5-year expected loss rates both from the perspective of private investors and that of the E-bond intermediary, assuming the country-specific subordination rates presented in table 3. In the first variant of the E-bond proposal, in which the intermediary buys at market rates, the intermediary would make large profits on account of its preferred creditor status. Column (5) shows how these profits would be earned, and column (6) how they would be distributed, based on the portfolio shares shown in column (2). Column (7) consists of column (6) minus column (5), it represents the net transfers arising in this variant of the proposal. A positive sign means that the country is a net transfer recipient, and a negative sign that it is a net contributor. Column (8) shows each country's contribution to the funding costs of the intermediary, using the same sign convention as before (a negative sign means a cost/loss from the perspective of the intermediary). Column (9) shows how the funding costs would be distributed across countries in the second variant of the proposal, in which the intermediary purchases debt at face value and charges the same interest rate to all its borrowers, so as to achieve zero profits. Column (10) consists of column (9) minus column (10). It shows the net transfers across countries in the second variant of the proposal.

Source: Authors' calculations based on results of table 3.

Table C.8 Decomposition of values at risk and expected shortfall for the senior and junior tranches of sovereign bond–backed securities based on equation (5) (in percent)

	5% VaR	4% VaR	3% VaR	2% VaR	1% VaR	1% ES
ESBies	0.0	0.0	1.2	8.0	21.8	28.7
EJBies	81.3	94.5	100.0	100.0	100.0	100.0
Germany	0.0	0.0	0.0	0.0	32.0	37.0
Netherlands	0.0	0.0	0.0	0.0	32.0	39.5
Luxembourg	0.0	0.0	0.0	0.0	32.0	39.5
Austria	0.0	0.0	0.0	36.0	45.0	45.0
Finland	0.0	0.0	0.0	36.0	45.0	45.0
France	0.0	0.0	48.0	48.0	60.0	60.0
Belgium	0.0	50.0	50.0	62.5	62.5	62.5
Estonia	54.0	54.0	54.0	67.5	67.5	67.5
Slovakia	56.0	56.0	70.0	70.0	70.0	70.0
Ireland	60.0	60.0	75.0	75.0	75.0	75.0
Latvia	60.0	60.0	75.0	75.0	75.0	75.0
Lithuania	60.0	60.0	75.0	75.0	75.0	75.0
Malta	62.4	62.4	78.0	78.0	78.0	78.0
Slovenia	64.0	64.0	80.0	80.0	80.0	80.0
Spain	64.0	64.0	80.0	80.0	80.0	80.0
Italy	64.0	64.0	80.0	80.0	80.0	80.0
Portugal	68.0	68.0	85.0	85.0	85.0	85.0
Cyprus	70.0	87.5	87.5	87.5	87.5	87.5
Greece	76.0	95.0	95.0	95.0	95.0	95.0

Note: The table shows the loss rates of sovereign bonds in a collateral pool of sovereign bond–backed securities compiled using purchase rule (5) in the text. It corresponds to line (5) of the "adverse calibration" panel in table 10. The five columns to the left show values at risk. The final column shows the expected shortfall.

Source: Eurostat and authors' calculations based on simulation model of Brunnermeier et al. (2017) (adverse calibration, see box 1).

Table C.9 Decomposition of values at risk and expected shortfall for the national tranching and E-bonds cases shown in table 10 (in percent)

		National tranching				E-bond			
		5% VaR	3% VaR	1% VaR	1% ES	5% VaR	3% VaR	1% VaR	1% ES
	Safe asset	**0.2**	**8.6**	**12.6**	**12.6**	**1.4**	**7.3**	**9.3**	**9.3**
Senior national tranche (national tranching) or debt held by E-bond issuer (E-bond)	Germany	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Netherlands	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Luxembourg	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Austria	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Finland	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	France	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Belgium	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Estonia	0.0	0.0	0.0	0.0	0.0	34.3	34.3	21.0
	Slovakia	0.0	3.2	0.0	2.7	11.1	39.4	39.4	39.4
	Ireland	0.0	19.4	19.4	19.4	19.1	49.5	49.5	49.5
	Latvia	0.0	19.4	19.4	19.4	0.0	49.5	0.0	47.3
	Lithuania	0.0	19.4	19.4	19.4	19.1	0.0	49.5	49.5
	Malta	0.0	0.0	29.0	29.0	19.2	52.7	52.7	46.2
	Slovenia	0.0	35.5	35.5	35.5	5.7	0.0	47.6	47.6
	Spain	0.0	0.0	35.5	35.5	0.0	34.4	34.4	34.4
	Italy	0.0	35.5	35.5	35.5	0.0	0.0	11.0	11.0
	Portugal	0.0	51.6	51.6	51.6	8.6	57.2	57.2	57.2
	Cyprus	3.2	59.7	59.7	59.7	39.4	74.7	74.7	74.7
	Greece	22.6	83.9	83.9	83.9	51.5	89.9	89.9	89.9
Junior tranche (national tranching) or debt held by private investors (E-bond)	Germany	0.0	0.0	0.0	14.0	63.3	0.0	0.0	19.2
	Netherlands	0.0	0.0	0.0	15.7	0.0	0.0	0.0	21.5
	Luxembourg	0.0	0.0	0.0	15.8	0.0	0.0	0.0	21.7
	Austria	0.0	0.0	65.2	20.3	0.0	0.0	0.0	21.9
	Finland	0.0	65.2	0.0	20.3	0.0	0.0	0.0	27.7
	France	0.0	0.0	0.0	49.0	0.0	0.0	0.0	49.4
	Belgium	0.0	90.6	0.0	50.7	0.0	0.0	0.0	49.6
	Estonia	0.0	0.0	0.0	57.8	0.0	100.0	100.0	61.2
	Slovakia	0.0	100.0	0.0	83.3	100.0	100.0	100.0	100.0
	Ireland	0.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	Latvia	0.0	100.0	100.0	100.0	0.0	100.0	0.0	95.6
	Lithuania	0.0	100.0	100.0	100.0	100.0	0.0	100.0	100
	Malta	0.0	0.0	100.0	100.0	100.0	100.0	100.0	87.7
	Slovenia	0.0	100.0	100.0	100.0	100.0	0.0	100.0	100.0
	Spain	0.0	0.0	100.0	100.0	92.1	100	100.0	100.0
	Italy	0.0	100.0	100.0	100.0	82.6	0.0	100.0	100.0
	Portugal	0.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	Cyprus	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	Greece	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Note: The table shows the loss rates suffered by the senior and junior tranches of sovereign bonds in the national tranching case, and the (senior) debt held by the E-bond intermediary and (junior) debt held by a normal investor in the E-bond case, respectively, for various tail-events. It corresponds to lines (1) and (3) of the "adverse calibration" panel in table 10. For each of the two proposals, the first three columns show values at risk, while the final column shows the expected shortfall. The loss rate shown by the "safe asset" in the top line of the table is the weighted average loss rate of the senior claims, using the portfolio weights shown in table 2 (national tranching) and table 3 (E-bonds).

Source: Eurostat and authors' calculations based on simulation model of Brunnermeier et al. (2017) (adverse calibration, see box 1).