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Structured Eurobonds

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Research Papers in Economics
No. 9/11

Abstract

This paper develops a market-based approach to implement so called Eurobonds, i.e. common sovereign debt securities of European Monetary Union (EMU) countries. By applying an asset-backed security (ABS) approach positive implications of a common bond can be achieved and negative incentives (e.g. moral hazard) can be prevented. Within an ABS structure a special purpose vehicle (SPV) buys a portfolio of EMU countries debt instruments (pooling) and then issues a set of subordinated Eurobonds with varying risk and rating (tranching). By pooling and tranching the default risk is concentrated in one part of the capital structure, resulting in a large share of less risky securities and overall risk premia reduction. A fraction of the cash flows from the SPV to the countries is diverted to a trust fund, which covers the first losses in case of a country default. By contrast to propositions on Eurobonds made so far, our proposal has one major advantage: All EMU countries can benefit from participating in the ABS-structure. These benefits are driven by the following reasons: Firstly, we only introduce partial liability (10 % of initial notional) instead of joint liability in order to limit moral hazard. Secondly, interest gains are distributed among all participating and not defaulting countries.
Our simulation study shows that on average all EMU member states - both high rated and low rated countries - gain by taking part in a Eurobond ABS due to the implied diversification and tranching effects. Average savings range between 8 % and 33 % of the total credit amount. Nonetheless, in the worst case scenario, there is a probability of a disprofit ranging between 5.5 % and 0 %. In our simulation Germany and Greece represent the two opposite ends of the range and therefore serve as example in the discussion.

Key words: Eurobonds, EMU, asset-backed securities (ABS), financial instruments, indebtedness

JEL classification: E6, F34, G15

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1 Motivation

The current sovereign debt problems of peripheral European Monetary Union (EMU) member states have led investors to demand considerably higher risk premia, resulting in distinctly augmented interest spreads. As a consequence the liquidity and sometimes solvency problems of these countries have increased leading to financial turmoil in the Euro area and beyond.

In this situation the debate on Eurobonds has been rekindled. In this context two main arguments are put forward: Firstly, Eurobonds could reduce interest expenses and secondly they could lead to a deepening of the markets and therewith reduce vulnerability to speculation. Within our proposal, we focus on the first aspect using Eurobonds as a long-term financing instrument, instead of a short-term stabilization measure. Eurobonds should be used as a means of to lower interest costs of peripheral EMU countries.

So far, researchers and politicians have developed a variety of proposals frameworks to examine the necessity and form of Eurobonds[1]. A relevant recent proposition has been deplored by Delpla and von Weizsäcker (2010). Delpla and von Weizsäcker propose to pool up to 60 % of EMU countries national debt by issuing a so called "blue bond". By pooling government debt a new liquid and safe asset would be created and would reduce borrowing costs. Any further national debt should be issued as "red bonds". This junior tranche consists of more risky assets with higher yields, depending on a country's credibility. With this structure highly indebted countries get incentives to achieve and maintain sound budget positions as borrowing costs rise with increasing indebtedness. Possibly they will not be able to place

[1] This recent discussion about Eurobonds is proceeded by older proposals. Already in 1993 Jaques Delors, former president of the European Commission, launched the idea of EU joint bonds in his plan for growth, competitiveness and employment (European Commission, 1993). In 2000 the Giovannini-Report re-seized the idea of a common bond (European Commission, 2000). Due to strong opposition, mainly from Germany, the issue was not considered further.

their national assets as long as their government debt is too high. The authors emphasize on the fact that the "blue bonds" would have a quality comparable to German government bonds with high liquidity and low default probability. Instead of splitting debt into "blue and red bonds" Boonstra (2005, 2010) proposes to abolish the possibility for countries to nationally raise debt. Instead a newly established independent "EMU fund" would issue Eurobonds and lend the funds raised to the voluntarily participating countries. To receive money from the fund countries would have to pay a premium based on deficit and debt deviations from the average levels of Germany and France. With this proposal Boonstra aims at increasing liquidity and reducing borrowing costs. Furthermore market discipline would be more gradual, fiscal discipline would increase because of strengthening the enforcement of budgetary rules. Eurobonds would offer a shelter against speculation and shocks. A further important proposition has been set out by Economides and Smith (2011). The authors propose to create "Trichet Bonds". These bonds should be designed in the style of "Brady Bonds" which aimed at solving the Latin American financial crisis in the 1980s[2]. However, while the public is still debating the "if", a special type of new debt instrument very close to a Eurobond has already been established via the European Financial Stability Facility (EFSF). The EFSF is allowed to place bonds which are guaranteed by the EMU member states.

Still the current discussion on EMU countries debt crisis and the necessary actions to be taken is characterized by two extreme positions. On the one hand supporters of the idea bring forward the principle of solidarity and the liquidity boost generated by Eurobonds. They emphasize in this context that a further integration of EMU member states is inevitable in order to adequately react on extreme situations such as the current debt crisis. On the other hand opponents warn against moral

[2] Various further propositions have been put forward by Bonnevay (2010), De Grauwe and Moesen (2009), Eijffinger (2011), Jones (2010), Juncker and Tremonti (2010), Mayordomo et al. (2009).

hazard. They fear that EMU could become a transfer union where well performing countries pay for bad performing states. They point out that Eurobonds introduce bad incentives and would only aggravate the current situation, resulting in disintegration or even a break-up of EMU. Currently the public economic, political and juridical debate stalled in a controversial and sometimes highly emotional discussion. Especially northern EMU countries manifest their rejection.

In this situation a fresh, objective and unprepossessed look on the Eurobonds proposal seems necessary. In particular we propose a Eurobond structure using modern financing techniques, i.e. asset-backed securities (ABS)[3]. Within such a structure a special purpose vehicle (SPV) buys a portfolio of EMU countries debt instruments (pooling) and then issues a set of Eurobonds with varying risk and rating (tranching). These Eurobonds consist of various claims against the pooled underlying portfolio. By pooling and tranching the default risk is concentrated in one part of the capital structure, resulting in a large share of less risky securities. Due to the overall risk premia reduction interest savings can be realized. These savings result from the difference of interest payments of the pooled product compared to the interest payments of the individual countries. To secure the ABS-structure a trust fund, which covers the first losses in case of a country's default, is installed. A fraction of the initial cash flows from the SPV to the countries (i.e. 10 % of the initial notional) is transferred to the trust fund. This partial liability of the participating countries (instead of joint and several liability as proposed in other Eurobond-propositions) is one of the reasons why all countries can benefit from participating in an ABS-structured Eurobond. Furthermore the benefits for all EMU countries are driven by the fact that interest gains are distributed among all participating and not defaulting countries. With our structured Eurobond proposition we manage to reasonably

[3] This paper is based on the considerations of Bauer et al. (2008) for emerging markets.

spread risks and benefits among all participants in a way that all EMU countries can gain. There is an intrinsic incentive for all EMU countries to participate in the common bond issuance. Regardless of whether EMU is in a crisis situation or not, our proposal develops a stable Eurobond structure.

The paper is structured as follows. In section 2 we present a market-based approach to implement Eurobonds through an ABS. The proposed model is defined in section 3. The results of our simulation are presented and discussed in section 4. Our main findings are summarized in section 5.

2 The Euro Sovereign ABS: a modern financial instrument

2.1 Principles of Asset-Backed Securities

Since its beginning in the 1970s the phenomenon of securitization became increasingly important in financial markets. The ancestor of ABS transactions originated in the United States in the form of mortgage-backed securities. Asset-backed securities were first issued in the 1980s in the US and about 10 years later in Europe. Since then the global ABS-market constantly grew until the financial crisis in 2007. Today ABS are typically collateralized by a number of different assets, like credit card receivables, home equity loans, auto loans or student loans[4]. In regard to asset-backed securities typically three main participants take part in the structure: The originators, an independent separate institution the so called Special Purpose Vehicle (SPV) and the investors. The SPV buys a portfolio of debt instruments, and then pools and tranches the assets. To finance itself the SPV issues claims against the pooled portfolio (Schmittat, 2007, pp. 16)[5]. Within this type of structure, two key

[4] For more detailed information about the development of the ABS market see Rudolf et al. (2007, pp. 37–40) or Agarwal et al. (2010).

[5] See Bank for International Settlements (1992), Fender and Mitchell (2005, p. 70) or Rudolf et al. (2007, pp. 40) for further detailed explanations about ABS structuring.

ingredients play a major role: (1) The pooling of the assets, and (2) the tranching of the liabilities. Participants and key ingredients of ABS structures are illustrated in figure 1.

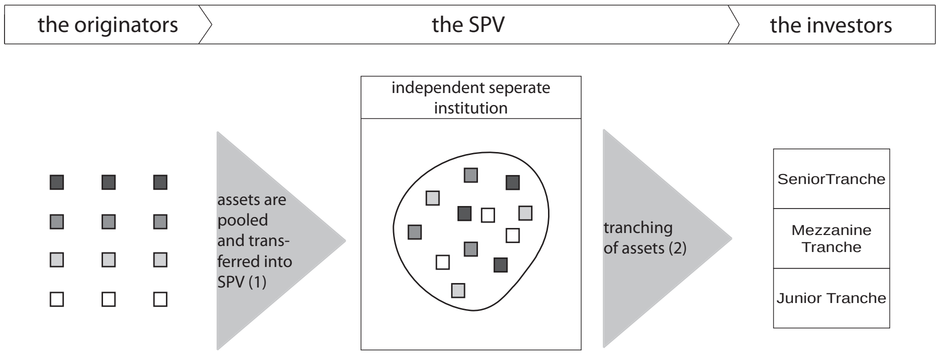


Figure 1: Participants and key ingredients of ABS transactions

The first key ingredient of securitization is the pooling of assets. This pooling can either be cash based or synthetical[6]. The pooling matters because it introduces diversification as long as the correlation between the pooled assets is not perfect ($\rho \neq 1$). By pooling the variance of the asset pool is reduced, in other words, the variance of the single assets is higher than the variance of the pooled assets. The lower the variance, the lower the risk of assets.

The following example illustrates the principle of diversification. Consider a portfolio comprised of two risky assets. Asset A is characterized by an expected yield of μ_A and a risk of σ_A and accounts for x_A in the portfolio. Asset B is characterized by an expected yield of μ_B and a risk of σ_B and accounts for x_B in the portfolio.

The variance of the portfolio is given by $\sigma_P^2 = x_A^2\sigma_A^2 + x_B^2\sigma_B^2 + 2\rho x_A x_B \sigma_A \sigma_B$, with a correlation of $-1 \leq \rho \leq 1$.

Thus, the risk is given by: $\sigma_P = \sqrt{x_A^2\sigma_A^2 + x_B^2\sigma_B^2 + 2\rho x_A x_B \sigma_A \sigma_B}$

[6] Cash based means the credit sensitive assets are purchased into a pool. Synthetic could refer to a synthetic Collateralized Debt Obligation (CDO) where the assets are originated synthetically by issuing credit default swaps.

The risk of the portfolio (σ_P) can be less or equal to the accumulated risks of the single assets ($x_A\sigma_A + x_B\sigma_B$) depending on the correlation (ρ) between the two assets.

$$\sigma_P = \begin{cases} x_A\sigma_A + x_B\sigma_B & \text{with } \rho = 1 \\ \sqrt{x_A^2\sigma_A^2 + x_B^2\sigma_B^2} & \text{with } \rho = 0 \\ |x_A\sigma_A - x_B\sigma_B| & \text{with } \rho = -1 \end{cases}$$

In the case of $\rho = 1$ pooling has no diversification effect as the portfolio risk corresponds to the accumulated single asset risks. However, as soon as the correlation is $\rho < 1$ risk diversification effects are realized and rise, the more ρ declines.

Obviously, as can be seen correlation matters because lower asset correlation implies a bigger part of risk-free AAA-rated securities within the structured product. By reducing risk with diversification senior tranches issued enjoy a higher credit quality than the average obligor in the pool.

The second key element is the tranching of the assets. Tranching the portfolio is nothing else than a mathematical optimization. By doing so, the SPV slices the product into 1 *to* n tranches with different characteristics related to level of seniority, risk, rating and yields. Depending of the repartition method of the cash flows (pay-through- or pass-through-structure) securitization results differ. Within a pass-through-structure interest and capital repayments from the underlying asset pool are transferred to the investors without modification. All investors are in an identical position, related to risk and yield. Within a pay-through-structure the pooled assets are sliced into tranches with different priority and credit-worthiness. Instead of issuing one bond with a given rating (depending on a given risk) and a given yield several tranches with different ratings and characteristics (risk, yield) are issued. Tranches with a high rating pay lower interest rates and are less risky than tranches with a low rating. The senior tranche with the best rating has the highest priority on cash flow and therefore carries the lowest risk. The next class receives a lower rating. This tranche is subordinated to the senior tranche and pays higher interest rates due to higher risk. The lowest tranche implies the highest risk. After the payment of all costs related to the SPV[7] interest is paid to the most senior tranche before the remaining interest is paid to the subordinated tranches. In case of default on participating bonds, the lowest tranche is hit first, if the structure does not have a trust fund, which covers first losses[8]. Because of the cascading effect in an ABS structure this kind of financial design is also knows as cash flow waterfall illustrated in figure 2.

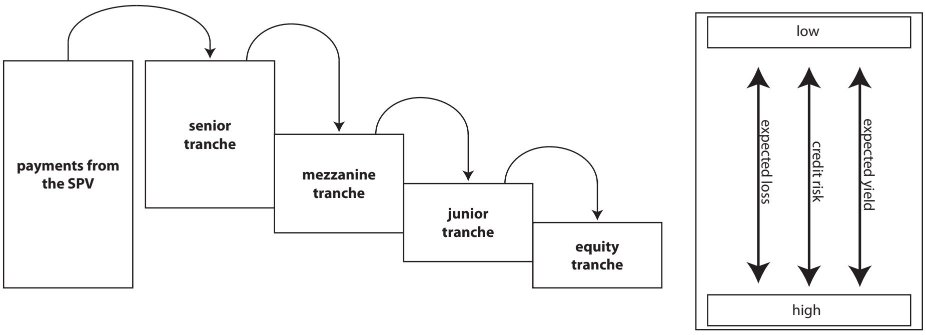


Figure 2: Cascading effect in an ABS transactions

Furthermore the thickness of the tranches differs. The rating of each tranche (and thereby also the number and thickness of the tranches) is based on a complex calculus of the rating agencies. In general, the rating of a tranche depends on its expected loss. A tranche is eligible for a specific rating if the tranches default probability is lower than a predefined idealized default rate. The expected loss of a tranche (probability of a tranche being hit) decreases with increasing subordination and/or increasing tranche thickness[9]. The main focus here is on the question as to "how thick can a tranche be to attain a given rating?".

[7] With this kind of structure administrative costs can be kept low.

[8] If a trust fund has been installed, it is in a first loss piece position. It covers all first losses, before the lowest rated tranche is hit. In this way, even investors of the lowest tranche benefit from a certain security.

[9] Increasing the fixed recovery rate also leads to a decrease of the expected loss.

2.2 Eurobonds in the form of ABS

As mentioned above, ABS are today collateralized by a number of different assets, like credit card receivables, home equity loans, auto loans or student loans. Our general idea involves the issuance of a Eurobond by issuing asset-backed securities backed by national government bonds of all EMU member states. By pooling EMU countries debt securities and by tranching the new product, the Eurobonds credit quality is increased above that of the underlying asset pool. A detailed illustration of the structure is given in figure 3.

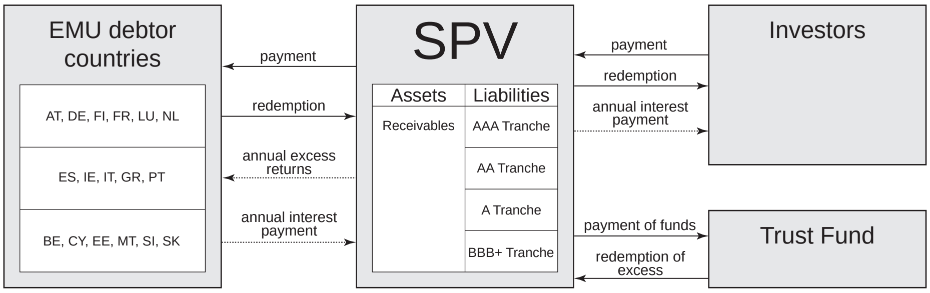


Figure 3: The structure of the ABS transaction[10]

The main three participants within this structure are

- the 17 EMU debtor countries,
- the investors, and
- a so-called special purpose vehicle (SPV) with a related trust fund.

The process of the ABS transaction is structured as follows: The transaction is initiated by the SPV[11] which invests into a pool of assets - in this case government

[10] Figure according to Bauer et al., 2008, pp. 1517.

[11] An existing institution, like for example the EFSF/ESM, could take over the role of the SPV. To avoid any kind of destabilizing effects all property rights have to be decoupled. The SPV has to be an independent institution. None of the countries should have access to the SPV or the trust fund, installed by the SPV to secure the structure. All surplus payments are decoupled from interest payments.

bonds of EMU countries. To fund its investments the SPV issues a new asset - a Eurobond[12]. By pooling the government bonds of all 17 EMU countries into the SPV diversification effects are realized. In a next step the new product is subdivided into different tranches with diverse ratings and corresponding risks. Different categories of subordination are established. The structuring of the product includes a cascading effect between the tranches. As mentioned above tranches with a high rating pay lower interest rates and are less risky than tranches with a low rating. The senior tranche with the best rating has the highest priority on cash flow and therefore carries the lowest risk. The subordinated tranches have lower ratings pay higher interest rates due to higher risk. After the payment of all costs related to the SPV[13] interest is paid to the most senior tranche before interest is paid to the subordinated tranches. In case of default on participating bonds, the lowest tranche is hit first, if funds out of the trust fund do not cover all first losses. The trust fund is in a first loss piece position, which means that even investors of the lowest rated tranche benefit from a certain safety. To make the structure safer and more credible $a\,\%$ of the initial notional are transferred by the SPV to the trust. The trust fund governs the collaterals and reinvests its capital at a risk-free interest rate. By doing so the collateral increases as long as no country defaults. The structuring and thereby the rating of the tranches of the Eurobond by rating agencies are based on a complex calculus. Fender and Mitchell review the principal features of structured finance ratings[14]. The structuring of Eurobonds is considered in more detail in section 3.

After the SPV has issued the newly created tranched Eurobonds subdivided into different tranches, investors can buy these securities depending on their risk prefer-

[12] To eliminate interest rate risks the maturity of the backed government bonds and the maturity of the newly created Eurobond have to have the same duration.

[13] Administrative costs are rather low. In our simulation we neglect such costs.

[14] Das and Stein (2011) review the mathematics of evaluating the credit risk of tranches of structured transactions for two common tranching approaches: tranching based on the probability of default of a tranche and tranching where the expected loss on a tranche is the quantity of interest.

ences. In a first step the investors pay the declared amount to the SPV. The SPV transfers $a\,\%$ of the issuance proceeds to the trust fund. The remaining $100 - a\,\%$ of the initial notional are equally distributed between the 17 EMU member states[15]. Every year, the EMU member states pay their interest to the SPV. Countries have to pay interest on 100 % of the loan, although they only receive $100 - a\,\%$ at the beginning of the transaction, as $a\,\%$ have been transferred to the trust fund to make the structure more credible and safer. The level of interest payments differ from country to country and depend on the governments' default risk as indicated e.g. by their credit ratings. In a next step the SPV makes interest payments to the investors. These interest cash flows depend on the tranche and the related risk. Because of diversification effects the sum of interest payments paid by the SPV to the investors is smaller than the total of interest payments paid by the countries to the SPV. This allows the structure to pay excess funds to the debtor countries at maturity if they have not defaulted.

At maturity all countries that have not defaulted repay their debt by making a payment to the SPV. Countries repay 100 % of the loan although they only received $100 - a\,\%$ at the beginning of the transaction. With these funds investors can be redeemed. Furthermore the capital out of the trust fund (interest surplus and unused collateral) is transferred to the SPV. The most senior tranche is served first, and then follow the remaining tranches subject to their degree of subordination. After reimbursement to the investors, remaining funds (unused collateral and interest savings) are allocated to the participating countries.

These remaining funds are distributed to the countries in a defined distribution scheme. Funds are distributed on a percentage basis (relative distribution), meaning,

[15] This assumption is based on the idea, that only a small part of government refinancing is financed through such a structure. In case of a major financial boost through Eurobonds, e.g. where up to 60 % of GDP can be financed with common bonds like Delpla and von Weizsäcker (2010) propose, model adjustments related to the distribution of the initial notional have to be undertaken.

that every country gets back a given percentage $b\,\%$ of the initially effected interest payments[16]. This distribution method involves bigger gains for countries with higher initial interest rates. However, if a country defaults during the term of maturity, it does not receive any final cash backflows out of the trust fund.

The event of a country default has an impact on the investors and on the remaining countries. As long as funds out of the trust fund are sufficient to serve the investors (interest payments and final payback) a country default does not affect them. However, as soon as claims of the investors exceed funds out of the trust fund, investors suffer financial losses. In any way, a country default hurts the remaining countries. First, net final cash flows decline, because cash outflows from the SPV to the investors remain constant while cash inflows (debt service of the countries to the SPV) decrease. Second, the remaining countries lose part of their deposit transferred to the trust fund, as it has to be used to fulfill obligations.

3 A Monte Carlo Simulation Study

To determine if interest gains can be achieved by implementing a Eurobond in the European Monetary Union, we run a Monte Carlo Simulation with $m = 10,000$ loops. Within our model we compare two cash flow situations, to analyze the effects of a Eurobond on the participating countries. We first calculate the payment flows of all 17 EMU countries in their current situation and then compare this to

[16] In our robustness check (see chapter 4.2) we have changed the distribution scheme from relative to an even distribution. This means, that every participating debtor country receives the same absolute interest rate advantage. This distribution method is more advantageous for countries with low initial interest rates. The following example illustrates the two different distribution methods. Given that the average unweighted initial interest rate of the participating debtor countries is at 8 %, and assuming that through the ABS-structure it is possible to reduce the interest due of the investors to 4 %, an interest advantage of 4 percentage points can be achieved, and in other words, the average advantage is 50 %. In the even distribution every country gets back 4 % of the borrowed money. In the relative distribution every country gets back 50 % of their initially effected interest payments.

the simulated payment flows when participating in an ABS Eurobond structure. To calculate the interest payment flows a simulation on country defaults is run[17]. To simulate the implementation of a Eurobond through an ABS structure, diverse information and assumptions are needed. Conceptionally, we base our simulation structure on Bauer et al. (2008).

The core portfolio and market characteristics needed to run our simulation, are illustrated in table 1, based on the financial and economic situation in January 2011[18]. We build our model with a standard 10 year bond with given yields[19] for a sample of $n = 17$ sovereign debtors, the 17 EMU member states. The average rating of these bonds is AA- (S&P methodology)[20]. The average unweighted interest rate of the underlying asset pool is 4.97 %. The average default probability of the underlying assets, based on calculations given in table 12 (appendix), is 3.98 %. One further assumption is needed concerning the recovery rate. For simplicity we assume a fixed recovery rate on defaulted 10 year government bonds of 50 %. This corresponds to figures derived by Becker (2009) and Moody's (2010). To set up reserves for the structure in case of country defaults a trust fund has been set up. We assume that countries have to settle 10 % of the initial notional[21] to the trust fund. The capital in the trust fund is reinvested at the assumed risk-free interest rate of 2.7 %.

As explained before the structuring of the product into different tranches requires a complex calculus. Every tranche has an expected probability of default. A tranche is eligible for a specific rating if the tranches default probability is lower than a

[17] The total interest surplus depends crucially on the timing of the defaults of the participating countries. The earlier a country defaults, the smaller total savings will be.

[18] We simulate an Eurobond within a crisis situation. Obviously results will be different in case of a non-crisis situation, when e.g. interest spreads are smaller.

[19] The 10 year government bond interest rates are given in column 2 of table 12 in the appendix.

[20] An overview of the EMU countries ratings is given in table 13 in the appendix.

[21] This means that countries only receive 90 % of the issuance proceeds at the beginning of the loan period. Only if all countries behave according to the rules and do not default, the total deposit is refunded.

Table 1: Portfolio Data and Market Characteristics

Portfolio Data	
Maturity	10 years
Number of countries	17
Average Rating	AA-
Average Default Probability	3.98 %
Assumed Recovery Rate	50.00 %
Payment to the trust fund of initial notional	10.00 %
Market Characteristics	
Average unweighted interest rate of underlying assets	4.97 %
Assumed risk-free interest rate	2.7 %

predefined idealized default rate. We proxy the country's ability to repay their debt using their S&P rating. We use the rating as an aggregate economic indicator, as it includes different economic criteria, such as overall sovereign debt burden, monetary stability or political risk (Standard & Poors, 2009). Furthermore, we use the yields of 10 year government bonds to calculate the implied probability of default (IPD) of every single participating country (see table 12 in the appendix). This gives us the probability of default of the total pool. To take into account for contagion effects[22], we assume positive correlations between the countries, which impact the diversification effect within the structure. Arghyrou and Kontonikas (2010) find that countries such as Portugal, Ireland and Spain have experienced contagion from Greece.

[22] In the literature empirical evidence on different channels of contagion are identified for both, developing and industrialized countries (see e.g. Lowell et al. (1998), Kaminsky et al. (2003) and Horta et al. (2008)). Three main channels of transmission are of particular interest: intensive trade relations (see e.g. Eichengreen et al. (1996)), strong financial linkages (see e.g. Van Rijckeghem and Weder (2001)) and similar investor behavior for example related to risk aversion (see e.g. Caramazza et al. (2000)). A brief literature overview about contagion effects is given by Rose and Spiegel (2009, pp. 2–11). In our model we assume positive correlations between the countries, as the economies of the European Monetary Union are strongly connected to each other. The economic and financial relations between the member states are intensified through the implementation of the European Internal Market. The countries manifest similar economic developments, intensive trade relations, a high probability to similar shocks and analogical reaction to these shocks and intense financial links. Also in the EMU the influence of investors behavior, for example related to risk evaluation, can have an impact in contagion effect.

Therefore we divide our country sample into three groups[23]:

- The AAA rated countries (Austria, Germany, Finland, France, Luxemburg and the Netherlands),
- the so called PIIGS-states (Portugal, Ireland, Italy, Greece and Spain), and
- the remaining countries (Belgium, Cyprus, Estonia, Malta, Slovenia, Slovakia).

As correlation plays an important role in the pooling process (see section 2.1) we devote special attention to the correlation assumptions. The correlations between and within the three groups are subject to mathematical constraints as country defaults are binary events[24]. Our assumptions are based on calculations by using the approach of Leisch et al. (1998)[25]. The correlation between the PIIGS is assumed to be higher than the correlation between the countries of the first and the third group. To pursue the most prudent and cautious approach we set the correlation within the first and second group at 0.19 and between the countries of the third group at 0.45. The correlation between the three country groups is set at 0.11[26]. Concerning the maximum default probability of the newly created Eurobond, we use information published by rating agencies in their rating methodology on the probability of default of assets with a given maturity subject to a specific rating. In our model we draw on S&P's rating methodology shown in table 14 (see appendix).

[23] Within our sensitivity analysis we have changed the composition of these three country groups. We included for example Belgium to the second group (PIIGS-group) and eliminated Italy. By using the approach described (in the appendix) this leads to a different maximum correlation. However, this change of composition of the groups only induces minor neglectable changes the results.

[24] The joint distribution of two binary random variables X and Y is fully determined by p_X, p_Y and either p_{XY}, $p_{X|Y}$ or $p_{Y|X}$. The correlation coefficient (r_{XY}) can be written as:
$r_{XY} = \frac{p_{XY} - p_X p_Y}{\sqrt{p_X(1-p_X)p_Y(1-p_Y)}}$

[25] See Appendix B - Statistical Appendix for further information.

[26] The assumed correlations are decisive in the pooling process, as diversification effects become higher the lower correlations are. The sensitivity analysis in chapter 4.2 shows that loosening the correlation assumptions (i.e. lowering the correlations) lead to better results (i.e. higher interest gains).

With these information it is possible to run a Monte Carlo Simulation[27] to generate default behavior scenarios for all 17 EMU countries and to derive a probability distribution of all payments (interest and final payments). Furthermore it enables us to structure the Eurobond and to define the size and the rating of each tranche of the newly created Eurobond. The results of our study are given in section 4.

4 Structuring Eurobonds

4.1 Simulation results

We run our simulation study with $m = 10,000$ loops for a maturity of 10 years. Our simulation allows us to structure the Eurobond ABS as given in table 2. We limit the number of tranches to four to ensure reasonable liquidity and market depth.

Table 2: Structuring the Eurobond

Tranche	**Thickness**	**Rating**	**Interest Rate**
Tranche I	85.07 %	AAA	2.9 %
Tranche II	7.38 %	AA	3.3 %
Tranche III	2.96 %	A	4.3 %
Tranche IV	4.59 %	BBB+	5.3 %

The biggest tranche in our structure accounts for 85.07 % and is rated with AAA. It pays the lowest interest rate (2.9 %)[28] and has the lowest risk. The second tranche accounts for 7.38 % and is AA rated with an interest rate of 3.3 %. The third tranche accounts for 2.96 % and is A rated. Investors of this tranche receive 4.3 %. Our riskiest tranche is rated BBB, still investment grade, and accounts for 4.59 % in the Eurobond structure. It is still considered to be a secure investment, but in

[27] For all further details concerning the simulation methods see Appendix B - Statistical Appendix.

[28] Figures of cash outflow payments from the SPV to the investors are compiled from data from the primary and secondary market for European government bonds over the period 1999-2009. Table 17 summarizes the cash outflows.

case of a decline of the overall economic situation, this investment could easily turn into speculative grade. As risk is higher, this tranche pays the highest interest rate (5.3 %). It is hit first if the funds out of the trust fund are depleted. The trust fund is in a first loss piece position. It covers all first losses, before the lowest rated tranche is hit.

Our simulation study shows that on average all EMU countries gain by taking part in a Eurobond ABS due to the implied diversification and tranching effects. As Germany and Greece are the two extreme cases we use these countries as an example in the subsequent discussion. An overview of the results for these two exemplarily countries are given in table 3.

Table 3: Results of the simulation study for Germany and Greece

	Germany	**Greece**
Average accumulated undiscounted saving as % of credit amount	8.53 %	33.06 %
Average accumulated saving in years of interest payment	3.16 *yr.*	2.88 *yr.*
Maximum Profit	10.40 %	34.34 %
Maximum Loss	10.69 %	11.70 %
Probability of net loss	5.47 %	0.02 %

On average the participating countries gain 14.74 % of the credit amount if they participate in the structure and do not default. The average gains a single EMU country can realize range between 8.53 % (as it is the case for Germany) and 33.06 % (as it is the case for Greece) of the total credit amount of the ten year period. The volatility of returns (square root of the variance, σ^2, given in column 3 table 4) is quite low. For Germany 95 % of the values range between 7.78 % and 9.28 %. The variance for greek results is even lower at 0.11, meaning, the volatility of returns is smaller. For Greece 95 % of the values are between 33.73 % and 31.41 %. The amount of total savings can also be expressed as number of years of interest payment savings. With a Eurobond ABS Germany could on average save 3.2 years of interest payments, Greece around 2.9 years.

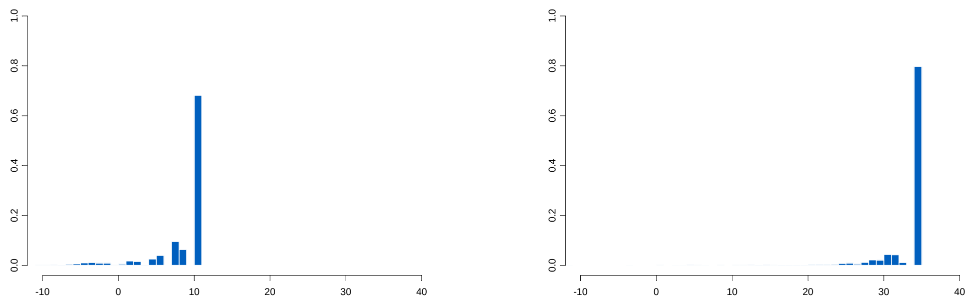
Generally all countries gain as long as no country defaults. These maximum savings range between 10.40 % (Germany) and 34.34 % (Greece) of the credit sum. In our simulation the probability of no country defaulting is around 70 %. Even if up to three countries default all remaining countries still benefit. However a higher number of defaults obviously lowers the benefits of each remaining country. This is illustrated and explained in more detail for the two exemplarily countries with plots shown in figure 4.

While on average all countries benefit from a Eurobond in a worst case scenario a net loss is also a possible event. Net losses occur, if countries default and do not pay off debt and interest. In this case the money of the trust fund is used to redeem investors. The capital in the trust fund consists of 10 % of the initial notional plus the gains achieved through investment of the capital at the risk-free rate[29]. Countries do not get back their deposit (wholly or in part) if it has to be used to pay off investors. As soon as a country defaults, it drops out of the structure. In this case it neither receives the deposit nor any interest surpluses at maturity. The average probability of a disprofit for a non-defaulting country is at 2.55 %, however it ranges between 0.02 % (for Greece) and 5.47 % (Germany). In case of a net loss, the highest loss incurred is at 10.69 % of the credit amount (Germany). The probability of a net loss for Greece is close to zero. However, if Greece does not default, it would in the worst case suffer losses of 11.70 % of the credit amount.

Figure 4 shows the plots of the results for the two exemplarily countries, Germany (a) and Greece (b). The histogram displays the accumulated undiscounted savings

[29] The money in the trust fund is reinvested at the risk-free rate of 2.7 %. By doing so, the future notional of the trust fund at maturity is at 13.05 % of the total transaction balance if no country defaults.

plotted on the x-axes and the respective probabilities on the y-axes. The single right-side bar depicts the savings in the case of no country defaults. With a probability of about 70% Germany reaches gains of 10.40 %. With a probability of around 80 % Greece gains up to 31.34 %.



(a) *(b)*

Figure 4: Accumulated undiscounted savings for (a) Germany and (b) Greece

On the left hand side of the sole line one can see smaller humps. The first hump represents the results if one country defaults. Germany still receives gains from surpluses (about 8 %) with a probability of about 10 % if one country defaults. Analogously the second hump depicts the case of two countries defaulting, and the third hump shows the case for three country defaults. With two countries defaulting Germany still receives gains of about 5 %. However the probability of this event is only at 4 %. In case of three countries defaulting Germany still saves about 2 % of the credit sum. This event occurs with a probability of 1.5 %. These results show that high rated countries like Germany still achieve savings even in the event of countries defaulting. It gains even if up to three countries default. Obviously, the interest savings decline the more defaults occur and eventually turn into losses. However, it is remarkable that for Germany losses only occur if four or more countries default. This is depicted in a fourth small hump in plot (a) of figure 4. Analogously plot (b) in figure 4 can be analyzed for Greece. If one country defaults Greece gains about

30 % of the credit amount. However this event only occurs with a probability of 4 %. If two countries default Greece still gains 28 % with a probability of 2 %. Three country defaults lead to gains of about 23 % of the credit amount with a probability of 1 %. The humps on the left side of the sole line in plot (b) are smaller than the ones in plot (a). This is due to the fact that the probability of default is higher for Greece, than it is for Germany. Meaning that if a country defaults (neither Greece nor Germany), then the probability that Greece has defaulted before (and drops out of the simulation) is higher, than it is for Germany.

Table 4 illustrates the results of the simulation study for all EMU countries. It summarizes accumulated undiscounted savings as a percentage of credit amount (column 2) and in years of interest payment (column 7), the variance of the profit (column 3), the probability of a net loss (column 4) and the maximum profit (column 5) and maximum loss (column 6).

Table 4: Summary of the results

Country	**Avg saving in % of credit amount**	σ^2	**Proba disprofit in %**	**Max profit in % of credit amount**	**Max loss in % of credit amount**	**Avg saving in years**
AT	10.83	0.14	4.13	12.64	10.90	3.08
BE	12.40	0.14	2.74	14.16	11.91	3.04
CY	13.69	0.14	1.91	15.44	12.29	3.01
DE	8.53	0.14	5.47	10.40	10.69	3.16
EE	16.89	0.01	0.81	18.57	12.67	2.96
ES	15.99	0.11	0.69	17.51	11.56	3.01
FI	10.03	0.14	4.70	11.85	11.63	3.11
FR	10.39	0.16	5.05	12.36	12.15	3.04
GR	33.07	0.11	0.02	34.33	11.78	2.88
IE	25.16	0.10	0.13	26.44	11.33	2.93
IT	14.23	0.11	1.10	15.79	12.36	3.04
LU	10.16	0.14	4.65	11.98	11.41	3.10
MT	13.49	0.13	1.88	15.20	12.25	3.03
NL	10.00	0.14	4.77	11.82	12.02	3.10
PT	20.28	0.10	0.27	21.68	11.06	2.97
SI	12.84	0.14	2.60	14.62	12.14	3.02
SK	12.53	0.13	2.57	14.27	12.59	3.04

The plots of the results for all EMU countries are illustrated in figures 5, 6 and 7 in the appendix. It is shown that all countries generate interest savings if only one country defaults (first hump from the right, next to the sole line). These savings occur with a probability between 5 % and 10 % and result in savings of 8 % to 30 %. Even if two countries default all countries still receive interest gains. The savings in percentage of credit amount become rather small for high rated countries (2 to 4 % of credit sum). This event occurs with a probability of about 1.5 %. For lower rated countries savings go up to 23 % of the credit sum with a probability of about 1 %. Only if four or more countries cannot pay their debts the remaining countries will have to bear the costs. These costs appear with a probability between 0.02 % and 5.47 % and range between 10.90 % and 12.67 % of the credit amount.

4.2 Robustness check

To test the simulation results for robustness, we have varied several parameters, like the defined correlations, the assumed recovery rate as well as the number and thickness of tranches in the structure. Furthermore we have also changed the distribution method. Taken together, these changes give the qualitatively expected results. In the following some exemplarily parameter changes and their consequences are discussed.

Change of the correlation matrix

At this juncture we have to emphasize explicitly the importance of the structure of the correlation matrix. We build up our correlation matrix in the most restrictive way by using the highest possible correlation between the countries[30]. By weakening this assumption (i.e. lowering assumed correlations and thereby decreasing the dependencies between EMU member states related to default events) our results

[30] For further information see chapter 3 and Appendix B - Statistical Appendix.

become better, as shown in table 6. Exemplarily we have set the following correlations: The correlation within the first and third group is set at 0.10 (compared to 0.19). The correlation between the PIIGS-states is set at 0.20 (compared to 0.45) and between the three groups is at 0.05 (compared to 0.11). These correlations allow for a simpler structure with three tranches, rated from AAA, AA and A, as shown in table 5.

Table 5: Eurobond structure with less restrained correlations

Tranche	**Thickness**	**Rating**	**Interest Rate**
Tranche I	95.41 %	AAA	2.9 %
Tranche II	2.94 %	AA	3.3 %
Tranche III	1.65 %	A	4.3 %

As expected this looser alternative gives better results, illustrated in table 6. The average profit increases of about one to three percentage points for every country. The variance and thereby the volatility of the results slightly decrease. The maximum profit rises between one to three percentage points (Germany: 11.21 %; Greece: 37.76 %). The probability of a net loss decreases up to two percentage points. The results of the maximum loss are similar to the results of the main analysis. For our two selected example countries average gains rise (Germany: from 8.53 % to 9.28 %; Greece: 33.07 % to 36.03 %), the probability of a net loss decreases (Germany: from 5.47 % to 3.63 %; Greece: 0.02 % to 0.01 %) and the maximum profit increases (Germany: from 10.40 % to 11.21 % ; Greece: 34.35 % to 37.76 %). These results underline the importance of our correlation assumption. Weakening it, leads to less strict preconditions and makes results less conservative.

The correlation assumptions included in our statistical model lead to a very restrictive but realistic perspective. However there is the possibility of implementing an even more conservative assumption, resulting in an imaginable but slightly unrealis-

Table 6: Summary of the results with changed correlations

Country	**Avg saving in % of credit amount**	σ^2	**Proba disprofit in %**	**Max profit in % of credit amount**	**Max loss in % of credit amount**	**Avg saving in years**
AT	11.78	0.11	1.66	13.69	11.20	3.35
BE	13.54	0.10	0.66	15.38	11.39	3.32
CY	14.94	0.10	0.47	16.80	10.46	3.28
DE	9.28	0.10	3.63	11.21	10.92	3.44
EE	18.42	0.11	0.27	20.27	11.94	3.23
ES	17.35	0.10	0.23	19.09	8.60	3.27
FI	10.91	0.10	2.25	12.81	10.33	3.38
FR	11.37	0.11	2.12	13.38	11.16	3.33
GR	36.03	0.13	0.01	37.76	6.96	3.14
IE	27.36	0.11	0.03	29.00	10.87	3.18
IT	15.40	0.01	0.42	17.12	8.76	3.29
LU	11.06	0.10	2.10	12.96	7.23	3.37
MT	14.70	0.10	0.52	16.52	6.66	3.30
NL	10.88	0.10	2.23	12.78	7.68	3.38
PT	22.09	0.01	0.04	23.71	8.19	3.23
SI	14.04	0.10	0.56	15.90	11.45	3.30
SK	13.65	0.10	0.61	15.50	11.40	3.31

tic and unusable conclusion. The assumption then implies if a country defaults, all other countries with a higher default probability also default and are dropped out of the simulation. Considering figures of the assumed default probability given in column 5 in table 12 in the appendix this implies that in the event a default of Italy all countries with a higher default probability (i.e. Spain, Estonia, Portugal, Ireland and Greece) have defaulted as well. Although possible, this event is very unlikely to happen.

This restrictive assumption leads - as expected - to smaller savings due to a higher number of defaults. These correlations require a change of the structure. The highest rated tranche (AAA) only accounts for 56.63 % within the structure. The remaining tranches are rated from AA- to BBB as shown in table 7.

The average saving as a percentage of credit amount only ranges between 5.83 % (Germany) and 19.28 % (Greece). However the overall probability of a disprofit

Table 7: Eurobond structure with strongly restrained correlations

Tranche	Thickness	Rating	Interest Rate
Tranche I	56.63 %	AAA	2.9 %
Tranche II	9.35 %	AA-	3.5 %
Tranche III	9.42 %	A	4.3 %
Tranche IV	20.01 %	BBB+	5.3 %
Tranche V	4.59 %	BBB	6.3 %

only increases insignificantly. A significant change can be noticed in the maximum profit and maximum loss. Germany's maximum profit decreases by 1/3 and Greece's profit is almost halved. The maximum loss increases by 2 percentage points for Germany whereas Greece never suffers losses. The same applies to Estonia, Ireland and Portugal. These countries have the highest default probabilities and are thereby dropped out of the simulation most frequently. As long as these countries do not default, they always benefit within a Eurobond structure. An overview of all results is illustrated in table 8.

Change of recovery rate

To test the results we have furthermore varied the recovery rate. Changing the recovery rate also leads to expected results. Lowering it worsens the simulation results while increasing the recovery rate improves them. Exemplarily we increased the recovery rate from 0.5 to 0.7, meaning that in case of a default 70 % are received immediately after a default and are then reinvested at the risk-free interest rate. A change of the recovery rate involves a change of the default probabilities of the participating countries (approach of Sturzenegger and Zettelmeyer) as shown in table 15 in the appendix. Therefore the highest possible correlation has to be adjusted. With the new default probabilities we can set the correlations as follows: The correlation within the first and third group is set at 0.15. The correlation between the PIIGS-states is set at 0.35 and between the three groups is at 0.10. Increasing the recovery rate makes the assumptions less conservative. This alternative also results

Table 8: Summary of the results with strongly restrained correlations

Country	Avg saving as % of credit amount	σ^2	Proba disprofit in %	Max profit in % of credit amount	Max loss in % of credit amount	Avg saving in years
AT	7.22	0.10	3.88	8.02	13.52	2.05
BE	8.13	0.08	3.06	8.82	14.08	1.99
CY	8.94	0.06	2.17	9.48	13.85	1.96
DE	5.83	0.14	5.50	6.87	12.70	2.16
EE	10.90	0.01	0.00	11.10	-3.56	1.91
ES	10.05	0.06	1.92	10.55	9.63	1.89
FI	6.73	0.12	4.40	7.61	13.23	2.08
FR	6.73	0.16	5.89	7.88	13.42	1.97
GR	19.28	0.00	0.00	19.28	-19.28	1.68
IE	15.10	0.002	0.00	15.18	-11.36	1.76
IT	9.17	0.05	1.92	9.66	9.51	1.96
LU	6.82	0.11	4.28	7.69	13.28	2.08
MT	8.71	0.08	2.74	9.35	14.33	1.95
NL	6.71	0.12	4.44	7.60	13.22	2.08
PT	12.50	0.01	0.00	12.71	-4.65	1.83
SI	8.42	0.07	2.74	9.06	14.13	1.98
SK	8.18	0.09	3.06	8.87	14.12	1.99

Note: Column 6 illustrates the maximum loss in % of the credit amount. Estonia, Greece, Ireland and Portugal never suffer losses as long as they do not default (negative sign).

in better outputs. It allows us to structure the product with two tranches, rated AAA and AA, as shown in table 9.

Table 9: Eurobond structure with higher recovery rate

Tranche	Thickness	Rating	Interest Rate
Tranche I	97.12 %	AAA	2.9 %
Tranche II	2.88 %	AA	3.3 %

An increase of the recovery rate gives better results, similar to the ones whilst decreasing the correlations. The average profit increases of about one to three percentage points for every country. For our two exemplary countries Germany and Greece it reaches up to 9.91 % and 37.14 %. The variance of this result clearly decreases. The maximum profit also experiences an increase of one to three percentage points (Germany: 11.34 %; Greece: 38.31 %). The probability of a net loss clearly drops. For Germany it drops from 5.47 % (main results) to 1.46 % and for Greece it drops from 0.02 % (main results) to 0.01 %. The maximum loss slightly increases. An overview of all results is illustrated in table 10.

Table 10: Summary of the results with increased recovery rate

Country	**Avg saving in % of credit amount**	σ^2	**Proba disprofit in %**	**Max profit in % of credit amount**	**Max loss in % of credit amount**	**Avg saving in years**
AT	12.48	0.06	0.79	13.85	12.09	3.55
BE	14.26	0.06	0.35	15.57	12.42	3.50
CY	15.72	0.06	0.22	17.01	12.70	3.45
DE	9.91	0.06	1.46	11.34	10.54	3.67
EE	19.29	0.06	0.12	20.67	12.52	3.38
ES	18.19	0.05	0.13	19.39	10.99	3.44
FI	11.59	0.06	0.88	12.96	10.64	3.59
FR	12.02	0.08	1.29	13.55	12.03	3.51
GR	37.14	0.06	0.01	38.31	1.02	3.23
IE	28.47	0.05	0.03	30.14	7.59	3.31
IT	16.24	0.05	0.25	17.41	8.69	3.47
LU	11.75	0.06	0.92	13.16	11.45	3.58
MT	15.46	0.06	0.23	16.74	9.84	3.47
NL	11.54	0.06	0.97	12.93	10.64	3.58
PT	23.07	0.05	0.06	24.41	8.08	3.37
SI	14.78	0.06	0.30	16.09	9.84	3.48
SK	14.39	0.06	0.35	15.69	10.77	3.49

Change of the distribution method

Moreover we changed the distribution method from a relative distribution to an even distribution to check whether our results are robust. The structure of the Eurobonds hereby remains the same (see table 2). Within an even distribution scheme every participating debtor country receives the same absolute interest rate advantage. As expected the results confirm that this distribution method is more advantageous for countries with low initial interest rates as is summarized in table 11. Instead of 8.5 %, Germany gains on average 16.56 %. For Greece this distribution method is less advantageous, as it gains only 9.02 % on average compared to 33.06 % on average. The Greek maximum profit is cut by 2/3 whereas the German maximum profit is almost doubled. Within this distribution scheme the maximum loss only decreases slightly for Germany, however it increases by 5 percentage points for Greece. Overall, the probability of a net loss decreases within this distribution scheme for better rated countries whereas it increases for low rated countries.

Table 11: Summary of the results with different distribution method

Country	**Avg saving in % of credit amount**	σ^2	**Proba disprofit in %**	**Max profit in % of credit amount**	**Max loss in % of credit amount**	**Avg saving in years**
AT	15.73	0.18	1.62	17.80	9.87	4.47
BE	15.26	0.17	1.77	17.24	11.58	3.74
CY	14.83	0.17	2.08	16.77	12.35	3.26
DE	16.42	0.19	1.49	18.62	9.05	6.08
EE	13.83	0.16	2.38	15.62	13.20	2.43
ES	14.39	0.12	1.33	16.01	11.66	2.71
FI	15.99	0.18	1.48	18.09	11.03	4.95
FR	15.65	0.20	1.95	17.90	11.59	4.58
GR	8.83	0.06	2.01	9.83	17.06	0.77
IE	11.52	0.08	1.41	12.73	14.47	1.34
IT	14.93	0.01	1.07	16.64	12.45	3.19
LU	15.94	0.18	1.46	18.04	11.08	4.86
MT	14.97	0.16	1.81	16.86	12.34	1.88
NL	15.99	0.19	1.52	18.10	11.39	4.87
PT	7.11	0.01	0.98	7.34	1.26	3.36
SI	15.70	0.18	2.01	17.07	12.02	3.55
SK	15.24	0.16	1.67	17.20	12.29	3.70

Depending on the distribution method either high rated or low rated countries achieve greater savings. From a point of view of high rated countries (like Germany or France), gains should be evenly distributed, as in this situtaion a greater share of the savings is transferred to these countries. Low rated countries like Greece or Ireland, favour a relative distribution of the gains. The distribution method has to be defined before implementing a strucutured Eurobond, depending on which countries should be privileged. Thereby the distribution method can be used to generate different incentive structures.

All sensitivity tests lead to the expected results and thereby confirm the robustness of the empirical results. Further details on the robustness check are available from the authors upon request.

5 Conclusion

The current debate on why Eurobonds should be implemented mainly focuses on two arguments: Firstly, Eurobonds could reduce interest expenses. Secondly they could lead to a deepening of the markets and therewith reduce vulnerability to speculation. Our Eurobond approach focuses on the first aspect. We propose to use modern capital market instruments (ABS) to implement a structured Eurobond. Within an ABS structure a so-called SPV invests into a pool of EMU countries government bonds. To fund its investments the SPV issues a new asset - a structured Eurobond with several subordinated tranches. The structure is collateralized by a trust fund, which is in a first loss piece position and bears any initial losses. By pooling EMU countries debt securities and by tranching the new product, the Eurobonds credit quality is increased above that of the underlying asset pool. Due to diversification effects interest savings can be achieved.

Eurobonds do not only reflect European solidarity, but also imply possible interest gains. As our simulation results show all EMU member states - both high rated and low rated countries - can obtain profits due to interest savings. Additionally, low rated countries get cheaper access to the capital markets through structured Eurobonds compared to the current situation of national borrowing. However, this market based approach is not a solution for bad budget policy of heavily-indebted countries. Nevertheless it can be an answer to solve liquidity problems in times of crises when simultaneously necessary structural reforms have to be launched. In this situation it would allow downgraded EMU countries to maintain access to the capital market to finance reforms. Nevertheless highly-indebted countries have to strengthen their fiscal policies. This is firstly indispensable to achieve the debt and deficit targets given by the stability and growth pact. Secondly long-term structural reforms have to be undertaken to remedy national debt problems as they are one barrier to growth. In this context structured Eurobonds can play a major role to secure the financing of necessary long-term reforms in heavily indebted countries.

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Appendix A - Additional Facts and Figures

Table 12: EMU countries implied default probabilty (IPD)

Country	**yield of 10 year government bonds**	**Spread to German Bonds**	**IPD in %**	**IPD with DE at 0.37%**
Austria	3.54	0.82	1.57	1.94
Belgium	4.12	1.38	2.62	2.99
Cyprus	4.60	1.85	3.48	3.85
Germany	2.70	0.00	0.00	0.37
Estonia	5.78	3.00	5.52	5.89
Spain	5.38	2.61	4.84	5.21
Finland	3.25	0.53	1.03	1.40
France	3.44	0.72	1.38	1.75
Greece	11.73	8.79	14.63	15.00
Ireland	8.75	5.89	10.30	10.67
Italy	4.73	1.98	3.71	4.08
Luxemburg	3.30	0.58	1.13	1.50
Malta	4.51	1.76	3.32	3.69
Netherlands	3.23	0.52	1.00	1.37
Portugal	6.95	4.14	7.46	7.83
Slovenia	4.29	1.55	2.93	3.30
Slovakia	4.16	1.42	2.70	3.07

Notes: The country specific probability of default is calculated with the approach of Sturzenegger and Zettelmeyer (2007). The benchmark bond is the German 10 year bond yield. As German Government bonds are not 100 % risk free either, we assume Germanys default probability at 0.37 %. This is the maximum default probability assigned by S&P in 2006 (no more recent data available) for an AAA-rating. We add this default probability to the calculated default probabilities of each country. By doing this, we avoid a default probability of zero for Germany and imply the fact, that if Germany defaults, all other EMU-countries have defaulted before.

Table 13: Rating of EMU countries according to S&P

		Rating LT	**Outlook**
Austria	(AT)	AAA	stable
Belgium	(BE)	AA+	stable
Cyprus	(CY)	A	negative
Germany	(DE)	AAA	stable
Estonia	(EE)	A	stable
Spain	(ES)	AA	negative
Finland	(FI)	AAA	stable
France	(FR)	AAA	stable
Greece	(GR)	BB+	negative
Ireland	(IE)	A	watch negative
Italy	(IT)	A+	stable
Luxemburg	(LU)	AAA	stable
Malta	(MT)	A	stable
Netherlands	(DE)	AAA	stable
Portugal	(PT)	A-	watch negative
Slovenia	(SI)	AA	stable
Slovakia	(SK)	A+	stable

Notes: Data from January 2011.

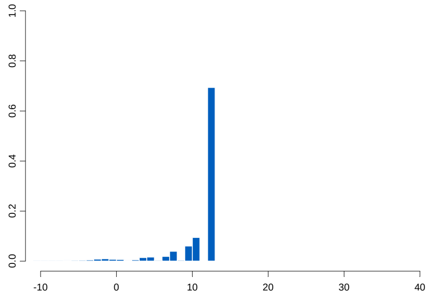
Table 14: Ratings and the corresponding assumed default probability

Rating	**Probability of Default (%)**
AAA	0.365
AA+	0.523
AA	0.898
AA-	1.164
A+	1.525
A	1.884
A-	2.606
BBB+	4.007
BBB	5.885
BBB-	10.737
BB+	13.500
BB	19.328
BB-	25.619
B+	33.231
B	44.083
B-	55.632
CCC+	68.013
CCC	75.506
CCC-	87.498

Notes: Depending on the rating agencies rating methodology the predefined idealized default probabilities for a given rating can differ. Changing these maximum default probabilities changes the structuring results within our simulation.

Table 15: EMU countries implied default probabilty (IPD) with higher recovery rate

Country	**IPD**
Austria	2.87
Belgium	4.53
Cyprus	5.86
Germany	0.37
Estonia	8.98
Spain	7.94
Finland	2.02
France	2.58
Greece	22.01
Ireland	15.98
Italy	6.22
Luxemburg	2.17
Malta	5.61
Netherlands	1.96
Portugal	11.87
Slovenia	5.01
Slovakia	4.64



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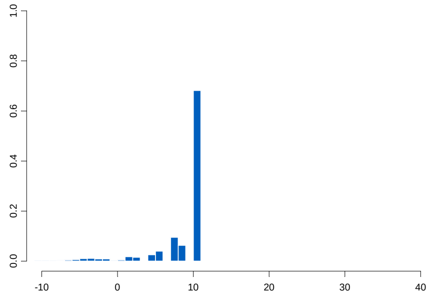

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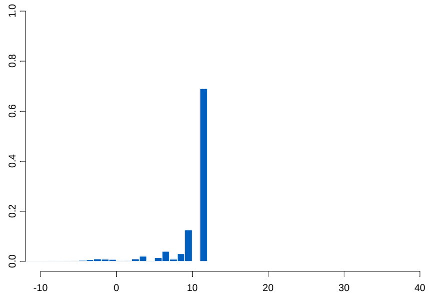

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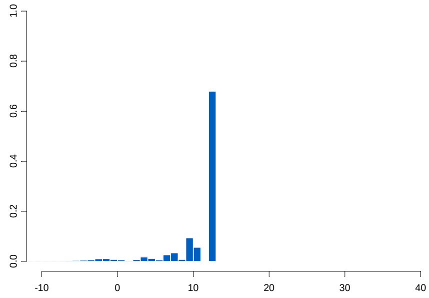

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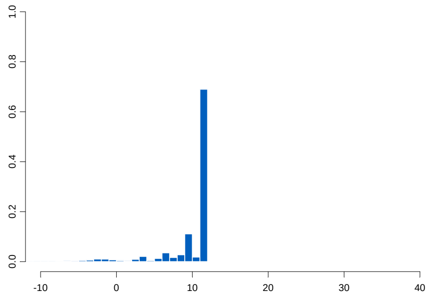

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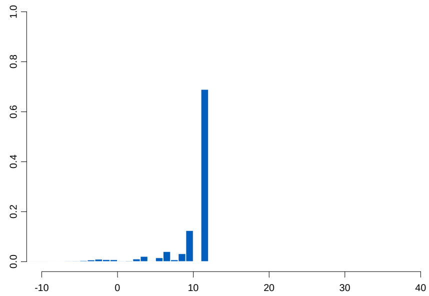
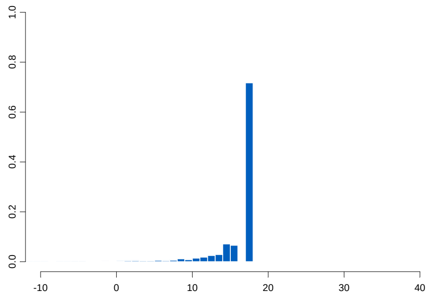


(f)

Figure 5: Accumulated undiscounted savings for (a) AT, (b) DE, (c) FI, (d) FR, (e) LU, and (f) NL.
Note: The accumulated undiscounted savings are plotted on the x-axes and the respective probabilities on the y-axes.



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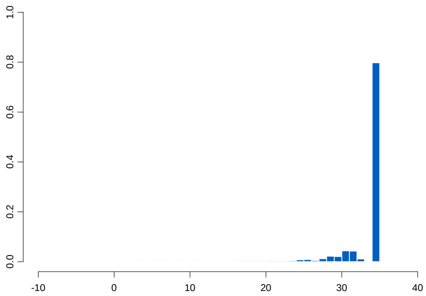

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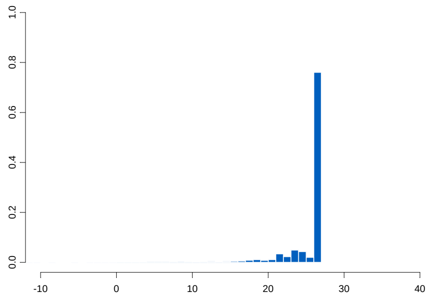

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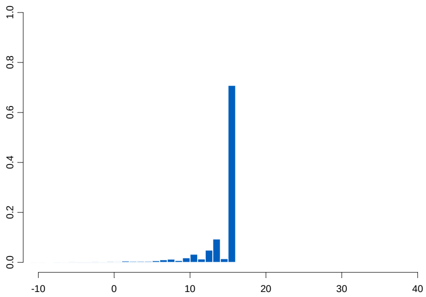

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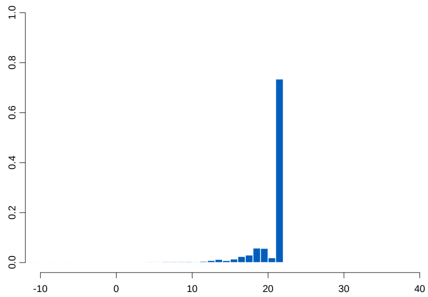
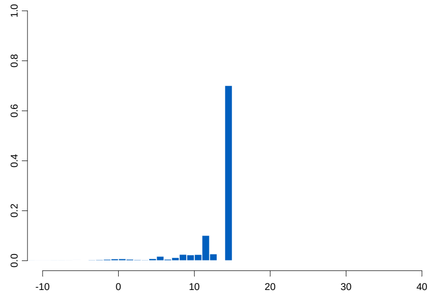


(e)

Figure 6: Accumulated undiscounted savings for (a) ES, (b) GR, (c) IE, (d) IT, and (e) PT. Note: The accumulated undiscounted savings are plotted on the x-axes and the respective probabilities on the y-axes.



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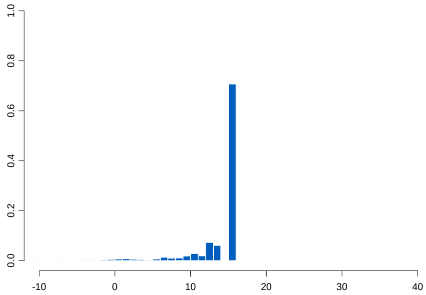

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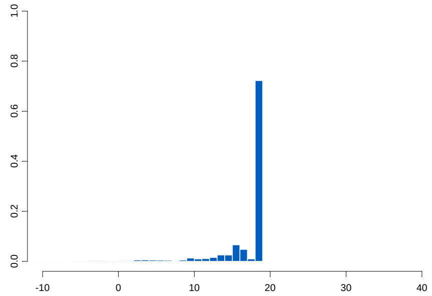

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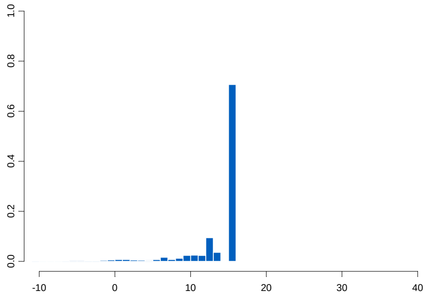

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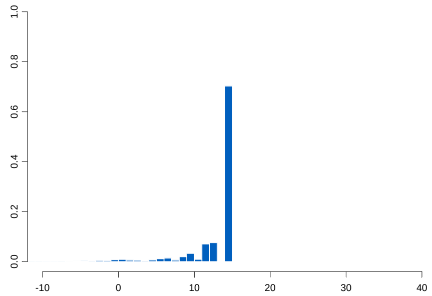

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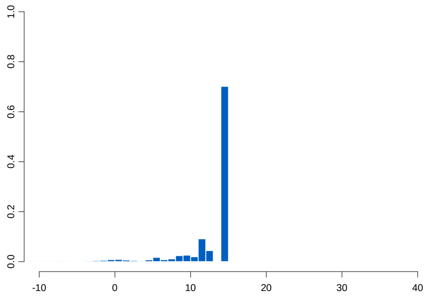

(f)

Figure 7: Accumulated undiscounted savings for (a) BE, (b) CY, (c) EE, (d) MT, (e) SI, and (f) SK.
Note: The accumulated undiscounted savings are plotted on the x-axes and the respective probabilities on the y-axes.

Appendix B - Statistical Appendix

Within our simulation we compare interest flows with and without an Eurobond structure. To do so, we first simulate default events of all EMU countries with a Monte Carlo Simulation in SPlus. Therefore we use an algorithm of Leisch et al. (1998) adapted to SPlus, which generates multivariate binary distributions with a given correlation structure.

Every country d has a default probability $dp \in [0,1]^d$, calculated with the approach of Sturzenegger and Zettelmeyer (2007) (see table 12). For simplicity, we assume a constant default probability over n years (in our case 10 years). We then set up a correlation matrix C in which we define our assumed correlations between the EMU member states. As the creation of binary random vectors (random vectors where variables can only take the two values 0 or 1) is much more demanding than the generation of normal random vectors if the covariance matrix is not trivial, we need to apply the cut-off algorithm of Leisch et al. (1998). We divide the countries into three groups: The first group consists of all AAA-rated EMU-countries[31], the second group comprises of the PIIGS-states[32] and the third group gathers all remaining countries[33]. The higher the correlation is set, the more conservative the structuring will be. Lowering the correlation improves the results but does not account for dependencies between the EMU countries. Therefore we opt for the most restrained alternative and set the highest possible correlation. With the approach of Leisch et al. (1998) we are able to calculate the highest possible correlation that binary random vectors admit. The correlation within the first and third group is set at 0.19. The correlation between the PIIGS-states is set at 0.45 and between the three groups is at 0.11.

We run our simulation with $m = 10,000$ loops. $X^{i,i=1\cdots m} \in \{0,1\}^{n\times d}$ indicates the events of default of loop i. $Y^i \in \{0,1\}^{n\times d}, Y^i_{k,l} = 0 \Leftrightarrow X^i_{r,l} = 0 \forall r \leq k$ denotes the history of defaults. This means: $Y^i_{k,l} = 0$ if country l has not defaulted in year k

[31] These are Austria, Germany, Finland, France, Luxemburg and the Netherlands.
[32] Portugal, Ireland, Italy, Greece and Spain.
[33] These are Belgium, Cyprus, Estonia, Malta, Slovenia, Slovakia.

or any year before. $Y^i_{n,l} = 1$ if country l has defaulted in loop i of the simulation. $def^i = \sum_{l=1}^{d} Y^i_{n,l}$ denotes the total number of defaults.

At maturity the SPV redeems the investors with the funds available due to repayment of the non defaulting countries. This is given by:

$f^i = max\left(0, \frac{d}{10} \cdot (1+i_0)^n - def^i\,(1-rec)\right)$, where rec is the recovery rate we assume to be $rec = 0.5$. With these funds the trust fund covers first piece losses resulting from missing interest payments and refunding of credit due to country defaults. An approximation of the distribution of f is generated by running $m = 10,000$ loops. By calculating the quantiles q of f for the maximum default probabilities (given in table 14) we can define the steepest possible shaping of our ABS structure. To ensure reasonable liquidity and market depth we decided to structure the product with four tranches, as presented in table 2.

To calculate the advantage we reuse the random sample $Y^{i,i=1\cdots m}$ to compute the interest inflows to the SPV during $n = 10$ years, given by $\pi^i_{in} = \left(1 - Y^i\right)(i_0 + i_{spread.in})$ $+rec \cdot \sum_{l=1}^{d} Y^i_{\cdot,l} \cdot i_0$. The term $(i_0 + i_{spread.in})$ denotes the vector of interest rates each country has to pay to finance itself on the international capital market without a Eurobond. In case of a country default, we assume that the recovery rate ($rec = 0.5$) is immediately received and reinvested at the risk-free interest rate ($i_0 = 2.7\,\%$) until the final repayment at maturity. This figure is then compared to the interest outflows flows the SPV has to pay to the investors every year, which is constant for all n years and m loops. This is given by $\pi_{out} = \vec{q} \cdot (i_0 + i_{spread.out})$. At maturity overall surpluses are distributed to the countries that have not defaulted at maturity. We then compare the costs of a Eurobond ABS to the costs of a credit without Eurobond over a period of $n = 10$ years and only $90\,\%$ of the credit sum. The costs without Eurobond are given by $0.9 \cdot n \cdot (i_0 + i_{spread.in}) + 0.9$. Again, only years in which a country has not defaulted are taken into account[34].

The spreads used for the simulation are compiled from different sources. Table 16 presents the spreads of national bonds to German government bonds. These rates plus the risk-free interest rate $i_0 = 2.7\,\%$ represent the payments the SPV receives

[34] The simulation calculations are all made with SPlus 8.1 for Windows. The scripts can be requested from the authors.

from all 17 participating country, as long as they don't default. Table 17 illustrates the spreads to the risk-free interest rate $i_0 = 2.7\,\%$ the SPV has to pay to the investors for a given rating. These are calculated with data from the primary and secondary market for government bonds over the period 1999-2009.

Table 16: Spreads: Cash inflow payments from countries to SPV

Country	**Cash inflow payments of debtor countries**	**Country**	**Cash inflow payments of debtor countries**
Austria	0.82 %	Ireland	5.89 %
Belgium	1.38 %	Italy	1.98 %
Cyprus	1.85 %	Luxemburg	0.58 %
Germany	0.00 %	Malta	1.76 %
Estonia	3.00 %	Netherlands	0.52 %
Spain	2.61 %	Portugal	4.14 %
Finland	0.53 %	Slovenia	1.55 %
France	0.72 %	Slovakia	1.42 %
Greece	8.79 %		

Notes: These figures show the interest rate spreads of national to German 10 year government bonds, which we assume to be the risk-free interest rate 2.7 %. Every country pays the risk-free interest rate plus the spread to the SPV.

Table 17: Spreads: Cash outflow payments from SPV to investors

Rating	**Cash outflows - payments to investors**	**Rating**	**Cash outflows - payments to investors**
AAA	0.20 %	BB+	4.60 %
AA+	0.30 %	BB	5.10 %
AA	0.60 %	BB-	5.60 %
AA-	0.80 %	B+	6.10 %
A+	1.10 %	B	6.50 %
A	1.60 %	B-	–
A-	2.10 %	CCC+	–
BBB+	2.60 %	CCC	–
BBB	3.60 %	CCC-	–
BBB-	3.80 %		

Notes: These figures show the spread of interest for any given rating to the risk-free interest rate set at 2.7 %. To allow for a conservative restrictive setting, we assume that investors ask more for a AAA rated Eurobond, than for German government bonds. These figures are compiled from data from the primary and secondary market for European government bonds over the period 1999-2009.