# How safe are European Safe Bonds? An analysis from the perspective of modern credit risk models

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# Portfolio credit risk: European Safe Bonds

So-called European Safe Bonds or ESBies. were recently proposed as a tool to improve functioning of euro area. Brunnermeier et al. [2017]

- ESBies are the senior tranche of a CDO backed by a portfolio of sovereign bonds from all members of the euro area.
- Junior tranches would be sold in the form of so-called EJBs.
- Creating a market for ESBies could
  - drastically increase the supply of safe assets in euro area
  - help to break the 'vicious circle' between bank solvency and the credit quality of home sovereigns

  without eliminating market discipline.
- ESBies are different from Eurobonds (no *joint liability*), but some of our results are also relevant for current debate on financing instruments for dealing with Corona crisis

# How safe are European Safe Bonds?

- Potential advantages of ESBies hinge on the fact that "European Safe Bonds are really safe"
- Based on a simple simulation study, Brunnermeier et al. [2017] claim that default risk of ESBies is really low
- This neglects problems with CDOs during the financial crisis; in particular 'safe' senior tranches experienced fairly high *market risk* during crisis time. This is unsuitable for a safe asset, see Golec and Perotti [2015].
- Hence we carry out a careful quantitative analysis of ESBies within the context of *affine models with Markov modulated mean reversion*.
  - We successfully calibrate a model to euro area CDS spreads from 10 countries
  - Risk analysis of ESBies, both static and dynamic (market risk)
- Introducing Markov modulation is a very useful extension of affine models

# The Model

- We consider $J$ sovereigns with default times $\tau^j$ and default indicators on $(\Omega, \mathcal{F}, \mathbb{Q})$, where $\mathbb{Q}$ is the risk-neutral measure.
- $X$ is a $K$-state Markov chain with generator matrix $Q$ and state space $S^X = \{1, \dots, K\}$
- $\tau^1, \dots, \tau^J$ are conditionally independent doubly stochastic default times with $\mathbb{F}$-adapted hazard rate processes $\gamma^j$.
- Hazard rate processes $\gamma^1, \dots, \gamma^J$ have dynamics

$$d\gamma_t^j = \kappa^j(\mu^j(X_t)e^{\omega^j t} - \gamma_t^j)dt + \sigma^j \sqrt{\gamma_t^j} dW_t^j, \ 1 \le j \le J, \qquad (1)$$

for constants $\kappa^j, \sigma^j > 0$, $\omega_j \ge 0$ and functions $\mu^j : S^X \to (0, \infty)$.

# Comments

- Conditional independence ensures tractability. Moreover, contagion effects are difficult to predict
- Dependence on common chain $X$ ensures co-movement in average spread level; diffusion part of $\gamma^j$ generates country-specific fluctuations.
- We typically work with $K = 3$, corresponding to expansion, mild- and strong recession.
- Observed spreads respectively calibrated hazard rates show clear evidence for 'common regimes'.

# Affine transforms for Markov modulated CIR processes

## Proposition 1

*Consider vectors* $\mathbf{w}$ *and* $\mathbf{u} \in \mathbb{R}_+^J$ *and* $\mathbf{g} \in \mathbb{R}^K$. *Then*

$$E\left(e^{-\int_t^T \langle \mathbf{w}, \gamma_s \rangle \, ds} \langle \mathbf{g}, X_T \rangle e^{-\langle u, \gamma_T \rangle} \mid \mathcal{F}_t \right) = \langle f(t), X_t \rangle \exp\left( \sum_{j=1}^J \beta^j(t,T) \gamma_t^j \right).$$

*Here the functions* $\beta^j(\cdot, T)$, $1 \le j \le J$, *solve the Ricatti equation*

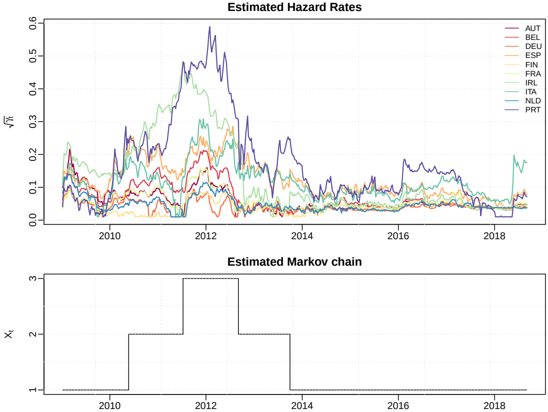
$$\frac{d}{ds} \beta^j(s,T) = w_j + \kappa_j \beta^j(s,T) - \frac{1}{2} \sigma_j^2 (\beta^j(s,T))^2, \quad \beta^j(T,T) = -u_j \,,$$

*and the function* $\mathbf{f} \colon [0,T] \to \mathbb{R}^K$ *solve an ODE system related to the generator of* $X$.

# Comments

- Single-firm case in Elliott and Siu [2009]; more general result in van Beek et al. [2020],
- The functions $\beta$ are explicitly known
- The proposition allows to derive near-explicit solutions for (joint) survival probabilities, bond- and CDS prices and the Laplace trafo of the portfolio loss (the latter after a Poisson approximation)
- Can be extended to other Markov processes $X$ (but then the ODE system becomes a more general backward equation)

# Calibrated trajectories of hazard rates and $X$



# Calibration

- We calibrate the model to weekly 1 and 5 year CDS spreads for the 10 largest euro area countries from January 7, 2009 until September 3, 2018, minimizing MSE between market and model spreads.
- We used an iterative procedure and several modern nonlinear optimizers
- Output: parameters $(\Theta^j, \sigma^j, Q)$ with $\Theta^j = (\mu^j(1), \ldots, \mu^j(3), \kappa^j, \omega^j)$; calibrated trajectories of hazard rates and of $X$.

**Results**

- Very good fit (given complexity of the problem)
- Typically $\mu(1) < \mu(2) < \mu(3)$, supporting the interpretation of the states; exception Germany and France (flight to quality)

# Stylized ESBies and EJBs

**Portfolio loss.** Given set $\mathbb{T}$ of payment dates $0 = t_0 < t_1 < \cdots < t_N = T$, define the loss process $L^j$ of sovereign $j$ as

$$L_t^j = \sum_{n=1}^{N} 1_{\{t_{n-1} < \tau^j \le t_n\}} 1_{\{t \ge t_n\}} \delta^j(X_{t_n}), \quad t \in [0, T], \tag{2}$$

$\delta^j : S^X \to (0,1]$ the LGD of $j$. Given weights $w^j > 0$ the portfolio loss is

$$L_t = \sum_{j=1}^{J} w^j L_t^j, \quad t \le T.$$

**ESBies.** Let $V_T = 1 - L_T$ and fix attachment point $\kappa \in (0,1)$. We define the payoff of stylized ESBies and EJBs as

$$\text{ESB}_T = \min(V_T, 1-\kappa) = (1 - L_T) - (\kappa - L_T)^+ \tag{3}$$
$$\text{EJB}_T = (V_T - (1-\kappa))^+ = (\kappa - L_T)^+ \tag{4}$$

# Risk analysis for ESBies

## Research questions

1. Risk neutral expected loss or credit spread of ESBies as function of $\kappa$
   - We consider 3 different parameter sets with identical expected loss: base parameter set from calibration; two risky parameter sets with less frequent but more severe 'crisis events'
   - Appropriate perspective for a buy and hold investor
2. Spread dynamics as function of $\kappa$ via historical simulation
3. Scenario-based analysis of market risk: impact of changes in risk factors on risk-neutral loss probability
   - Financial crisis: senior tranches can be subject to high market risk
   - Investors on markets for safe assets very sensitive to small changes in default probability
   - We include also contagious scenarios
4. Model-independent price bounds for given expected loss (worst case loss distribution) , related to comonotonicity

# Expected loss of ESBies

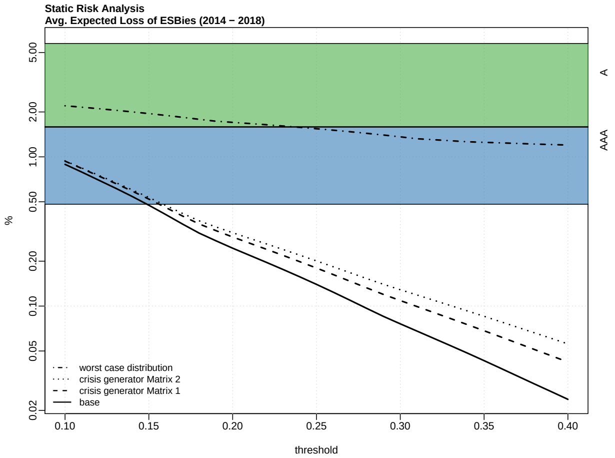



Figure: Average expected loss of ESBies over the period from 01/2014 to 09/2018 as a function of $\kappa$, together with 'indicative rating range' on log scale

# Spread dynamics via historical simulation

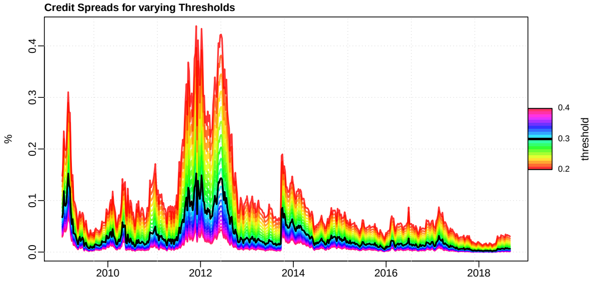



Figure: Spread of ESBies as a function of calibrated risk factors $X$ and $\gamma$ for various $\kappa$

# Risk neutral loss probability for different scenarios

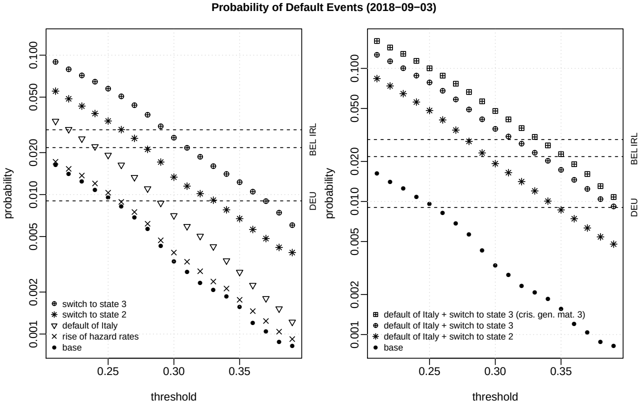



Figure: $\kappa \mapsto \mathbb{Q}(L_T > \kappa)$ for different risk factor changes (scenarios); left: ordinary scenarios, right contagious scenarios (both on a logscale)

# Results

- Investors holding ESBies until maturity face little risk of default-induced losses already for $\kappa \geq 0.2$
- For $\kappa < 0.3$ spreads are very volatile
- Changes in *gamma* or a non-contagious default has only small impact on loss probability of ESBies; changes in $X$ are more important;
- Implications of contagious scenarios can be quite severe, in particular for $\kappa$ low

# Policy implications

- ESBies can be made safe, but safety margin wrt $\kappa$ is needed
- ESBies should be implemented in conjunction with other measures limiting contagion, see Bénassy-Quéré et al. [2018];
- The loss distribution of Eurobonds or bonds issued by European Stability Mechanism is akin to that of ESBies with high $\kappa$. Hence these bonds would probably sell at reasonably low spread.
- But for Eurobonds there are incentive problems due to separation of liability and control.

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