Estimating Bond-CDS portfolio VaR with Copulas

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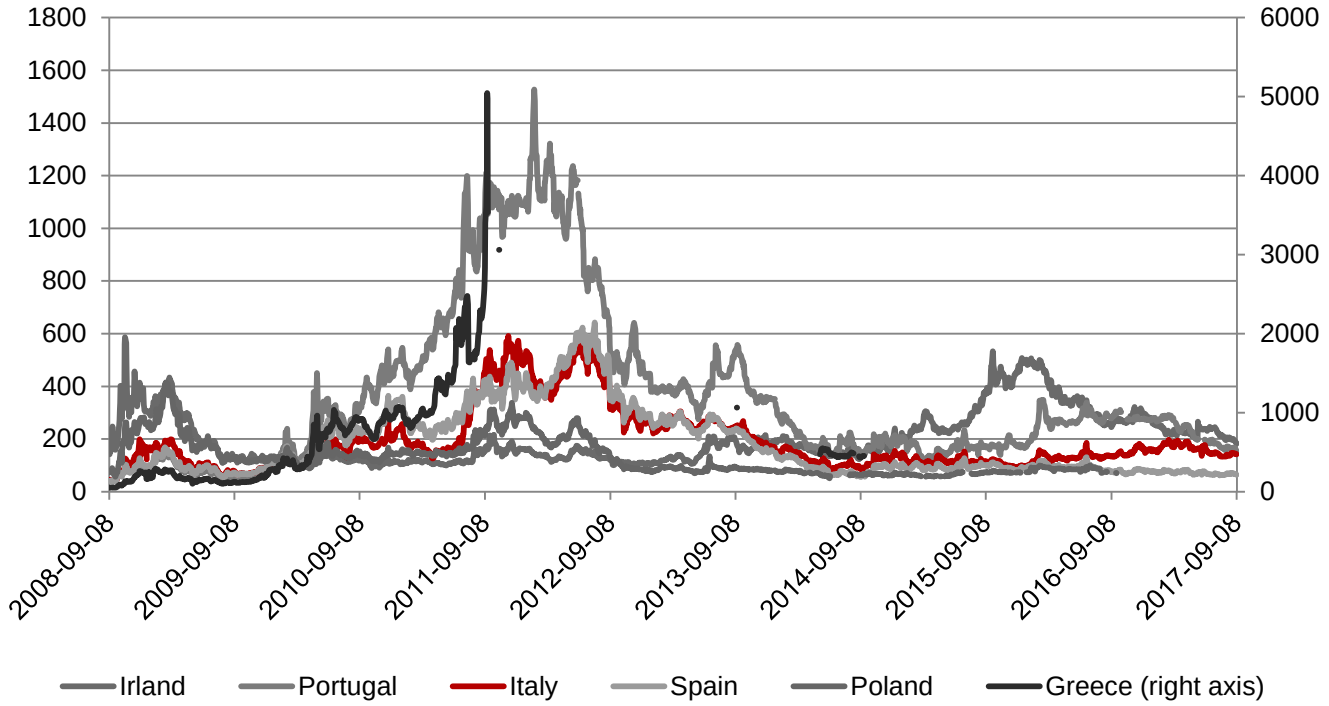
CDS Market – a short review

- In 2012 spreads of many sovereign CDS reached historically highest values
- Drop in volatility of CDS upfront prices after naked-CDS ban introduction in EU (september 2012)
- ISDA introduced contract standardization for maturity dates and premium payments (constant premiums, upfront varies)



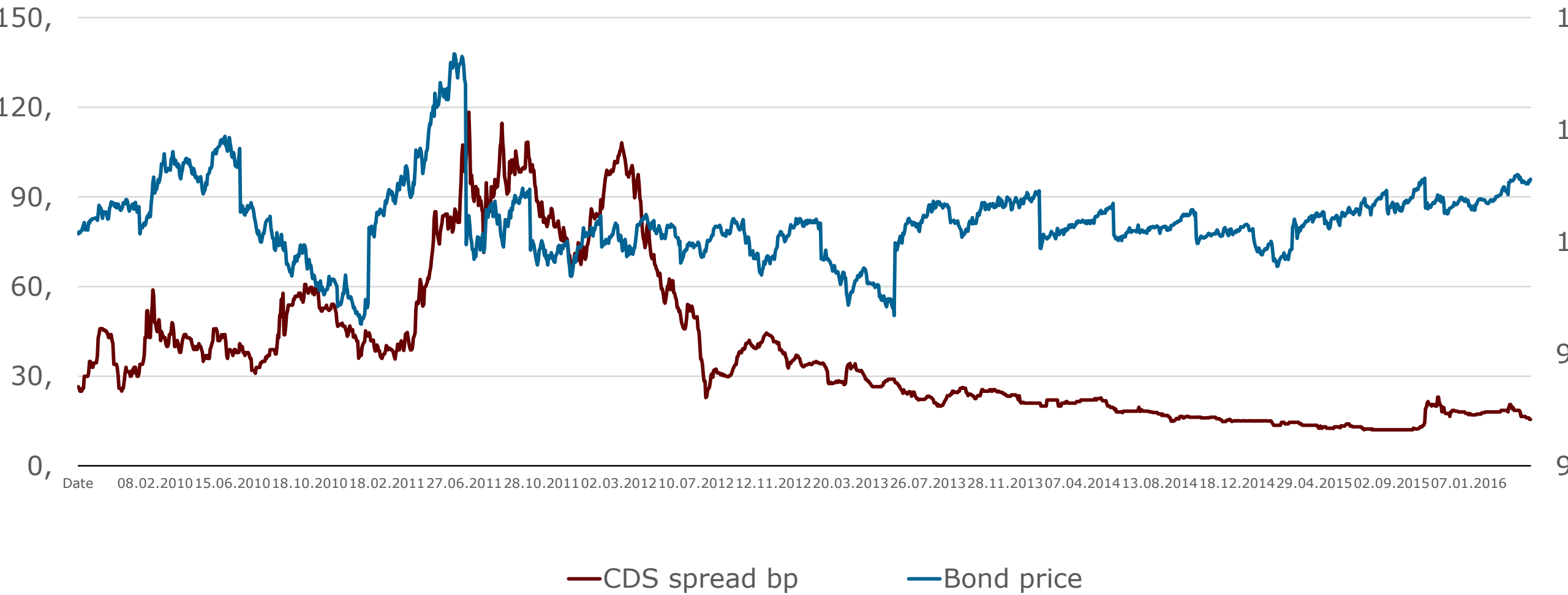
Motivation

- During 2009 and 2012 crises prices of CDS upfronts for sovereign debts reached 1600 bp (Portugal), 1300 bp (Ireland) and 3000 bp (Greece)
- In case of such disturbances, CDS accounts for significant share of the Bond-CDS portfolio
- Change of CDS upfront value can significantly influence the value of the portdolio
- Bond and CDS are exposed to the same risk factors: interest rate and credit risk
- Therefore, non-linear relationship between instruments is expected
- Pu and Zhang (2012) show that after introduction of limitations on CDS trading, liquidity on the market decreased significantly – therefore inefficiencies are expected to last longer

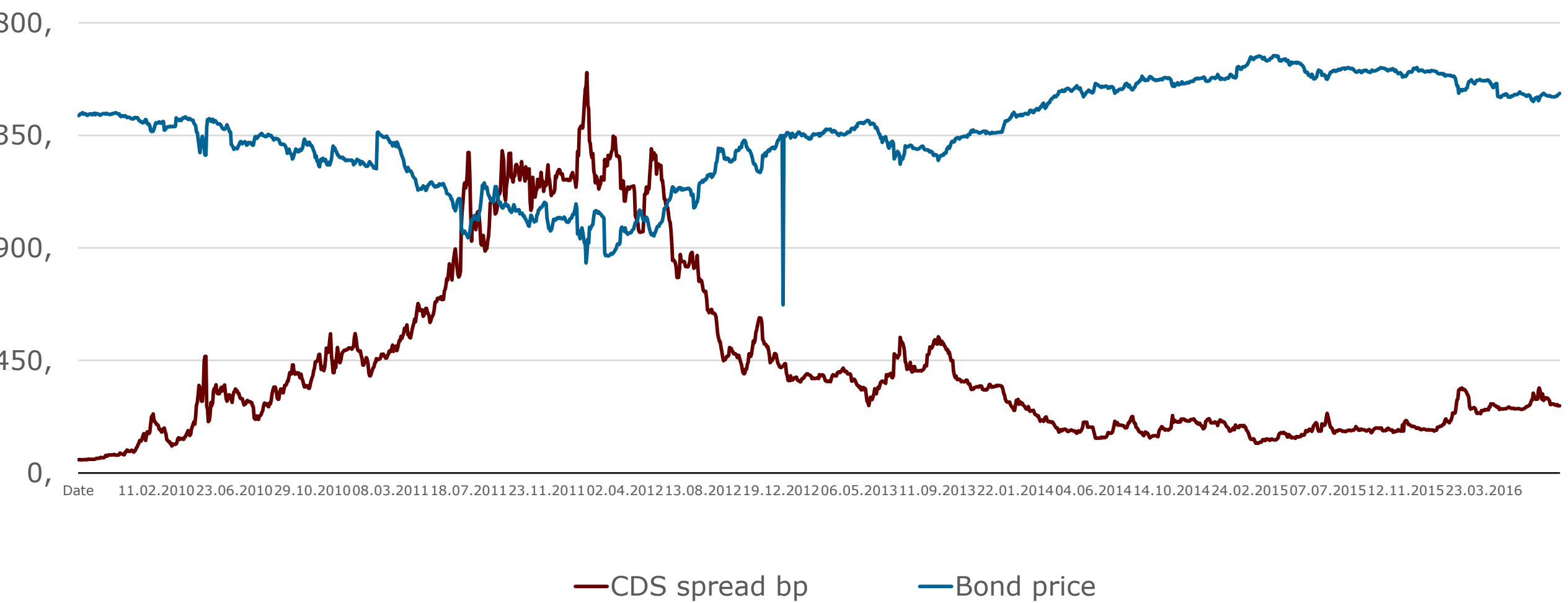
Analysed portfolio and assumptions

- Data:
  - Prices of 5Y bonds and 5Y sovereign CDS contractsCountries:
  - Italy, Spain, Portugal, Ireland, Poland
  - 16/06/2009 - 7/09/2017 (1856 daily observations)

Germany 5Y CDS spread and Bond price



Portugal 5Y CDS spread and Bond price



Procedure

- Distribution fitting to the individual rates of return of data series for marginals modeling

$$r_t = a_0 + \sum_{i=1}^{p} a_i r_{t-i} + \sum_{j=1}^{q} b_j \varepsilon_{t-j} + \varepsilon_t$$

$$\sigma_t^2 = \omega + \sum_{m=1}^{M} \alpha_m |\varepsilon_{t-m}|^{\delta} + \sum_{o=0}^{O} \gamma_o |\varepsilon_{t-o}|^{\delta} I_{[\varepsilon_{t-o}<0]} + \sum_{n=1}^{N} \beta_n \sigma_{t-n}^{\delta}$$

	Conditional mean	Conditional variance
Greece CDS	ARMA(2,3)	GJR1GARCH(2,3)
Greece bond	ARMA(1,4)	EGARCH(1,1)
Portugal CDS	ARMA(1,1)	ZARCH(2,1)
Portugal bond	ARMA(1,3)	GJR-GARCH(3,4)
Ireland CDS	ARMA(3,3)	GARCH(1,1)
Ireleand bond	ARMA(0,4)	AVGARCH(1,2)
Italy CDS	ARMA(1,5)	EGARCH(4,4)
Italy bond	ARMA(2,3)	EGARCH(4,3)
Spain CDS	ARMA(2,1)	GJR-GARCH(4,4)
Spain bond	ARMA(2,5)	GJR-GARCH(1,2)
Poland CDS	ARMA(3,1)	ZARCH(1,1)
Poland bond	ARMA(1,2)	EGARCH(3,2)

Procedure

- Genest et al. (2009) - minimize the distance to „empirical copula”
- Static Copula:
  - Gaussian
  - Clayton
  - Inverted Clyton
  - Plackett
  - Frank
  - Gumbel
  - Inverted Gumbel
  - t copula
  - Symetrized Joe-Clayton Copula (SJC)

Procedure

	Copula	p-value	Parameters
Greece	Clayton	0,07	3,278 (0,151)
Portugal	SJC	0,12	5,91E-08 (5,89E-08) 0,005 (0,008)
Ireland	Plackett	0,46	1.341 (0.089)
Italy	t-studenta	0,081	-0,729 (0,021) 19,56 (9,59)
Spain	Claytona	0,26	1,481 (0,372)
Poland	t-studenta	0,341	-0,413 (0,084) 11,41 (4,62)

Value at Risk

- 1-day simmulated VaR forecast using fitted marginal distributions and copulas (557 observations)
- 1-day simmulated VaR forecast using fitted marginal distributions and correlation coefficient
- Kupiec test for number of exceedance
- Christoffersen test for exceedance independency

Value at Risk

			Greece	Portugal	Ireland	Italy	Spain	Poland
VaR 95%	Copula VaR	Expected	15	28	28	28	28	28
		Actual	24	36	47	32	43	33
		Kupiec test	0,0277	0,1142	0,0001	0,3448	0,0036	0,2738
		Christoffersen	0,0226	0,0897	0,0009	0,2583	0,0021	0,2114
	Correlation VaR	Expected	15	28	28	28	28	28
		Actual	31	41	47	36	44	35
		Kupiec test	0,0035	0,0155	0,0001	0,1566	0,0042	0,2143
		Christoffersen test	0,0018	0,0146	0,0017	0,1205	0,0049	0,1573

VaR 99%	Copula VaR	Expected	3	6	6	6	6	6
		Actual	5	7	11	7	9	7
		Kupieca test	0,0628	0,3758	0,0319	0,3758	0,0605	0,3758
		Christoffersen	0,0557	0,1032	0,0021	0,2861	0,0554	0,2190
	Correlation VaR	Expected	3	6	6	6	6	6
		Actual	6	7	12	11	10	9
		Kupiec test	0,0328	0,3758	0,0000	0,0319	0,0472	0,0605
		Christoffersen test	0,0287	0,2861	0,0015	0,0374	0,0025	0,0554

Further developement

- Markov- Switching Copula Fei et al. (2017)
- DCC - GARCH
- Different testing period