Risk Analytics

Risk and regulation

Dr. Paul Larsen

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TABLE Timeline

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1995	Collapse of Barings Bank
1998	Collapse of LTCM (Merton, Scholes on board)
2007	Subprime mortgage crisis/Lehman Brothers falls
2008	European sovereign debt crisis
2010	Slovenian credit crisis

Risk types

Risk of losing money due to

- Credit: counterparty default
- Market: market movements
- Operational: something going wrong that shouldn't
- Liquidity: funding mismatches
- Insurance: unexpected loss of premiums or increase of claims

A brief history of financial disaster, II

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A brief history of financial disaster, II

TABLE Timeline

1929	Stock market crash/Great Depression MR, CR, LR
1995	Collapse of Barings Bank MR, OR
1998	Collapse of LTCM (Merton, Scholes on board) MR
2007	Subprime mortgage crisis/Lehman Brothers falls MR, CR, OR, LR
2008	European sovereign debt crisis CR
2010	Slovenian credit crisis CR

Regulatory responses

TABLE Timeline

1933	Banking Act (FDIC/Glass–Steagall, USA)
1988	Basel I (G10)
2004	Basel II (Europe)
2010	Dodd-Frank (USA)
2016	Solvency II (Europe)
2019	Basel III (Europe, USA)

Lehman Brothers collapse

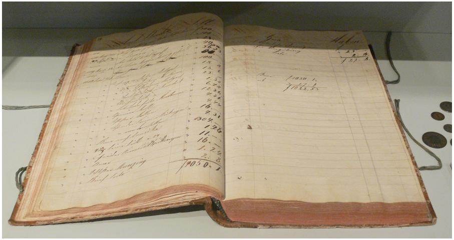
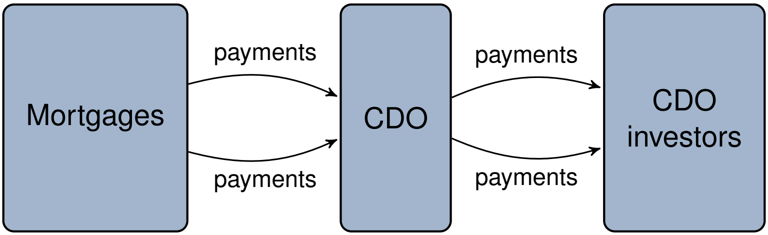


Image: [3, 7]

Three quantitative criminals

- Collateralized debt obligation (CDO)
- Gaussian copula
- Credit default swap (CDS)

Collateralized debt obligation



Intuition: bundle products together and distribute according to high risk (higher returns) and low risk (lower returns)

Question

How do you measure risk of bundled products?

Gaussian copulas

Let Φ_R be the k-dimensional normal distribution $N(\mathbf{0}, R)$, and let Φ be the 1-dimensional standard normal distribution $N(0,1)$.

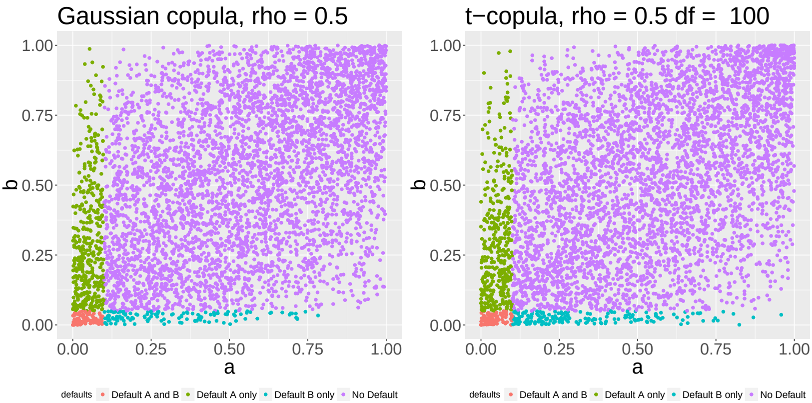
Definition (Gaussian copula)

The Gaussian copula is the distribution on the unit cube $[0,1]^k$ with cumulative distribution function

$$C_R(\mathbf{u}) = \Phi_R\left(\Phi^{-1}(u_1), \ldots, \Phi^{-1}(u_k)\right)$$

- If $\mathbf{u} = \left(\Phi(x_1), \ldots, \Phi(x_k)\right)$, $\mathbf{x} \in \mathbb{R}^k$, then $C_R \circ \left(\Phi(x_1), \ldots, \Phi(x_k)\right) = \Phi_R(x)$
- **Intuition**: the marginal distributions can be arbitrary, but the interaction among marginals is normal

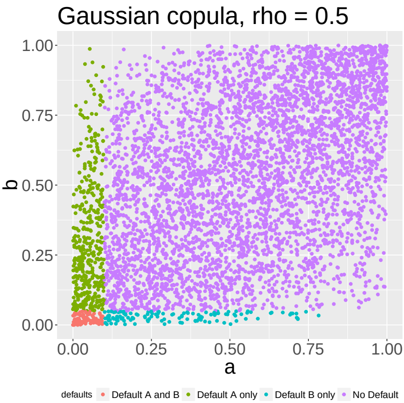
Gaussian copulas and tail events



$$A \text{ defaults } \leftrightarrow a \leq 0.1$$

$$B \text{ defaults } \leftrightarrow b \leq 0.05$$

Gaussian copulas and tail events



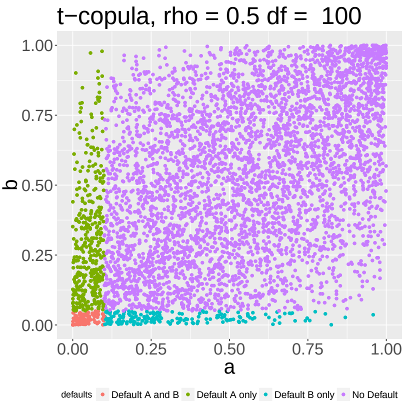
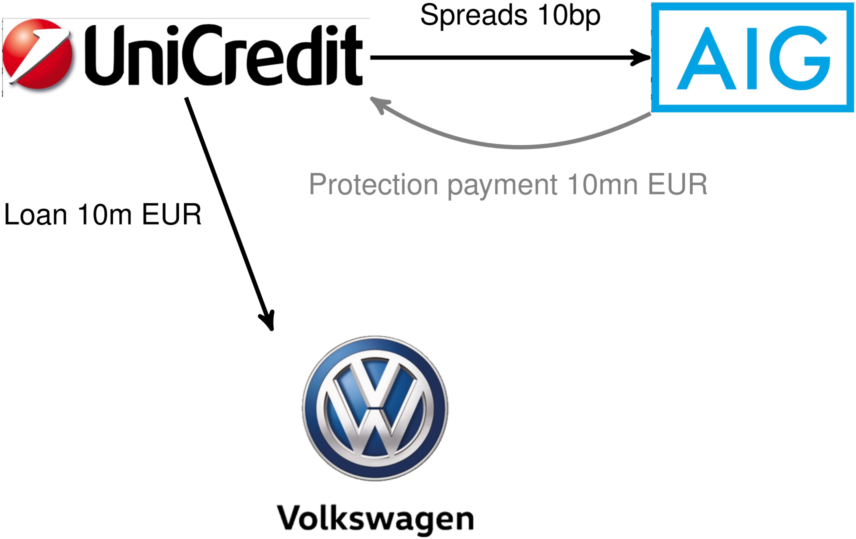


Table: Default counts

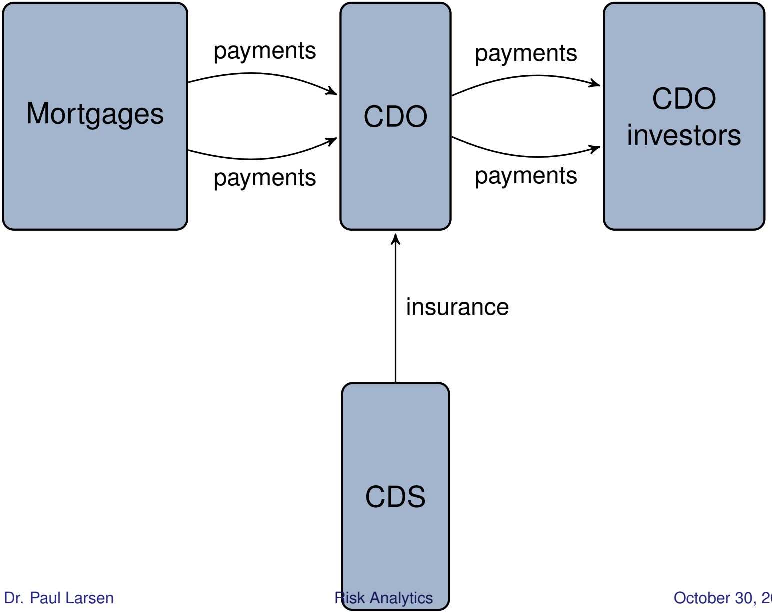
	0	1	2
Gaussian copula	4366	544	90
t-copula	4334	571	95

Credit default swaps



Images: [2, 4, 8]

CDS on a CDO

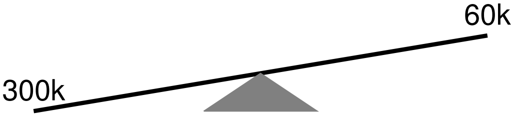

Mortgages
payments
payments
CDO
payments
payments
CDO investors
insurance
CDS

Balance sheets and capital ratios

Assets	Liabilities
House	Mortgage
	Equity

Example: Mortgage on house valued 300,000 €

- Own capital: 60,000 €
- Mortgage: 240,000 €
- "Leverage ratio"= $\frac{\text{Equity}}{\text{Assets}} = 20\%$

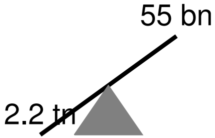


Balance sheets and equity ratios, II[1]

Assets	Liabilities
Reserves	Deposits
Short-term loans	Short-term debt
Long-term loans	Long-term debt
Infrastructure	
Investments	**Equity**
	Shareholder equity
	Retained earnings

Example: Deutsche Bank, 2011

- Total assets: 2.2 tn €
- Shareholder equity: 55 bn €
- Leverage ratio: 2.5 %



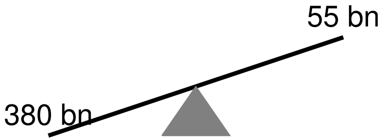
[1] [6],[1], pp. 48, 176

Balance sheets and capital ratios, III

Risk Weighted Assets	Liabilities
Reserves, $w = 0$	Deposits
Govt Bonds, $w = 0$	Short-term debt
Loans, w by internal model	Long-term debt
Operational	
Market	**Equity**
Credit	Shareholder equity
	Retained earnings

Example: Deutsche Bank, 2011, cont'd

- Risk-weighted assets: 380 bn €
- Shareholder equity: 55 bn €
- Core Tier 1 ratio: 14 %



Solvency II Capital Requirement

Article 101 of SII: The Solvency Capital Requirement (SCR) “shall correspond to the Value-at-Risk of the basic own funds of an insurance or reinsurance undertaking subject to a confidence level of 99.5% over a one-year period.”

Let N_t be the net value of assets minus liabilities at time t, and let $v(0,t)$ be a discount factor for the time period $[0,t]$. Then SCR is

- $\mathrm{VaR}_{99.5}\left(N_0 - v(0,1)N_1\right)$ or
- $\inf\left\{N_0 \in \mathbb{R} : \mathscr{P}\left(N_\epsilon \geq 0, \epsilon \in [0,1]\right) \geq 0.995\right\}$

or some other definition? [5]

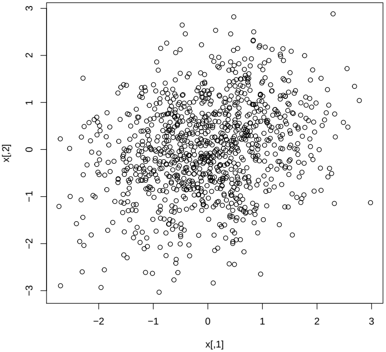
`R` in risk management

Why `R`?

- Extensive packages, development
- Graphics capabilities
- Reproducible research with `knitr` / `Sweave`
- `R` in industry: UniCredit OpRisk, Allianz OpRisk, Sava Zavarovalnica Risk, Deutsche Bank

knitr example

```
# Example of knitr chunk
require(MASS)
n <- 1000
x <- mvrnorm(n,
      mu = c(0,0),
      Sigma = matrix(c(1, 0.25, 0.25, 1), 2,2))
plot(x)
```



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