Risk Measurement and Management of Operational Risk in Insurance Companies under Solvency II

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Introduction

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Motivation

- Operational risk – Definition Solvency II
  - "The risk of loss arising from inadequate or failed internal processes, personnel or systems, or from external events. Operational risk […] shall include legal risks, and exclude risks arising from strategic decisions, as well as reputation risks"
- Can substantially impact a firm's risk situation, e.g.
  - Bankruptcy of Barings Bank 1995 - $1.3 billion loss due to rogue head derivatives trader
  - Insurance fraud by policyholders in the German insurance market estimated to about €4 billion per year
  - ➢ Adequate measurement and management of operational risk is vital (also required in Basel II/III, Solvency II)
- Previous literature: focus on modeling, dependence between risk cells

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Aim of this paper

- Examine the effects of operational risk from an enterprise perspective under Solvency II
  - Study impact of operational risk on fair premiums, shortfall risk, and solvency capital requirements (*SCR*)
  - Compare three different approaches for the *SCR*: 1) Solvency II standard model, 2) partial internal model, and 3) full internal model
  - Identify key characteristics that increase or decrease capital requirements
  - Take into account dependencies between operational, insurance, and market risks by means of copulas

Model framework

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Modeling operational risk (Gourier, Farkas, and Abbate, 2009)

- Total aggregate loss is given by $Z_t = \sum_{i=1}^{N_t} X_i$
- Loss frequencies N_t: homogenous Poisson process with intensity λ >0
- Loss severities X_i : spliced distribution function
  - Lognormal distribution for body of distribution
  - Generalized pareto distribution GPD for tails (extreme value theory)

$$F(x) = \begin{cases} F_{\log}(x) \cdot q, & \forall x \leq u \\ 1 \cdot q + F_{GPD}(x-u) \cdot (1-q), & \forall x > u \end{cases}$$

- Distribution function of total aggregate loss Z_t

$$G_t(x) = P[Z_t \leq x] = \sum_{n=0}^{\infty} P[N_t = n] P[Z_t \leq x \mid N_t = n] = \sum_{n=0}^{\infty} P_n(t) F^{n*}(x)$$

Model framework

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Overview of the insurance company

- Balance sheet at time *t*

Assets	Liabilities		
A_t	E_t		equity
	S_t	L_t	S_t policyholders' claims (total value of liabilities)
	Z_t		Z_t operational losses (total value of liabilities)

- Operational losses are covered first
- Claims
  - Operational loss claims: $L_1^Z = \min\left(A_1, Z_1\right) = Z_1 - \max\left(Z_1 - A_1, 0\right)$
  - Policyholders' claims: $L_1^S = \min\left(A_1 - L_1^Z, S_1\right) = S_1 - \max\left(S_1 - \left(A_1 - L_1^Z\right), 0\right)$
  - Equityholders' claims: $E_1 = \max\left(A_1 - L_1^S - L_1^Z, 0\right)$

Model framework

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Fair contracts and determination of premiums

- Valuation *V*(.) conducted using CAPM
- Fair situation from the shareholders' perspective:

$$V_0(E_1) = e^{-r_f} \cdot \left[E(E_1) - \eta \cdot Cov(E_1, r_m) \right] \overset{!}{=} E_0 \qquad (1)$$

- Policyholders' premiums are calculated in two steps:
  - Basic premiums: $\pi^{S_1,basic} = V_0\left(L_1^S\right)$
  - Fair premiums (calibrate δ to ensure that (1) holds): $\pi^{S_1} = \pi^{S_1,basic} \cdot \left(1 + \delta^{S_1}\right)$
- Compare three different cases to assess impact of operational risk
  1. Without operational risk
  2. With operational risk, but not taken into account in basic pricing
  3. With operational risk and taken into account in basic pricing

Model framework

Solvency capital requirements and risk measurement

- Risk-Bearing Capital (*RBC*): $RBC_1 = A_1 - L_1 = A_1 - S_1 - Z_1$
- Solvency Capital Requirements (*SCR*):

  $$SCR = -VaR_\alpha\left(e^{-r_f} \cdot RBC_1 - RBC_0\right)$$

- Three approaches for deriving the *SCR*:

	Standard model (*k* = *SM*)	*Partial internal model* (*k* = *PM*)	*Full internal model* (*k* = *IM*)
$BSCR$	$-VaR_\alpha\left(e^{-r_f} \cdot RBC_{1,SM} - RBC_{0,SM}\right)$		
$SCR_{k,Op}$	$0.3 \cdot BSCR$	$VaR_\alpha\left(e^{-r_f} \cdot Z_1 - Z_0\right)$	$\left(SCR_{IM,total} - BSCR\right)$*
$SCR_{k,total}$	$BSCR + SCR_{SM,Op}$	$BSCR + SCR_{PM,Op}$	$-VaR_\alpha\left(e^{-r_f} \cdot RBC_1 - RBC_0\right)$

*Residually derived

Numerical results

Input parameters

Expected value of operational losses	€60 million
Standard deviation of operational losses	€540 million
Frequency of operational loss events	0.15
Adjustment factor	0.30
Expected value of company losses	€110 million
Standard deviation of company losses	€22 million
Expected value/standard deviation of high-risk assets	1.12 / 0.23
Expected value/standard deviation of low-risk assets	1.06 / 0.07
Investment in high-risk assets	0.25
Kendall's tau between assets and op. risk	-0.27
Kendall's tau between company losses and op. risk	-0.05
Kendall's tau between assets and company losses	0.10
Kendall's tau between low-risk and high-risk assets	0.20

Numerical results

Shortfall probability for basic and fair premiums

	Case 1 (without operational risk)	Case 2 (with operational risk but not taken into account in basic pricing)	Case 3 (with operational risk and taken into account in basic pricing)
a) Basic premium			
Basic premium	117.55	117.55	116.77
Shortfall probability	0.67%	1.54%	1.60%
b) Fair premium			
Fair loading	-0.6%	0.9%	1.6%
Fair premium	116.86	118.63	118.63
Shortfall probability	0.70%	1.46%	1.46%

Basic premium: $\pi^{S_1,basic} = V_0\left(L_1^S\right)$

Fair premium: $\pi^{S_1} = \pi^{S_1,basic} \cdot \left(1+\delta^{S_1}\right)$

Numerical results

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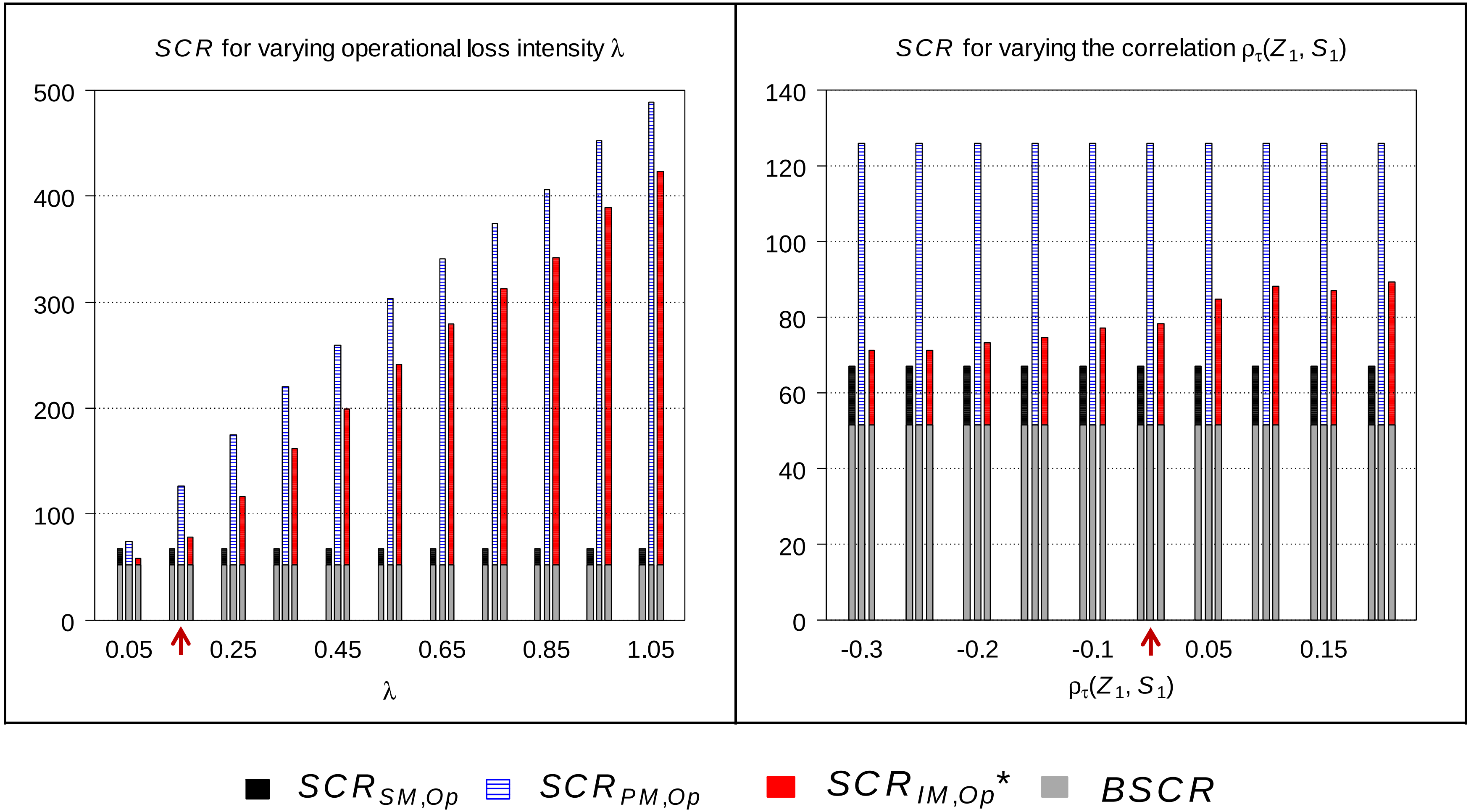
SCR for basic and fair premiums

	Case 1 (without operational risk)	Case 2 (with operational risk but not taken into account in basic pricing)			Case 3 (with operational risk and taken into account in basic pricing)		
		Standard model	Partial internal model	Full internal model	Standard model	Partial internal model	Full internal model
a) Basic premium							
BSCR	51.53	51.53	51.53	(51.53)	51.54	51.54	(51.54)
SCR_{Op}	0	15.46	76.06	27.40*	15.46	76.06	27.42*
SCR_{total}	51.53	66.99	127.59	78.93	67.00	127.60	78.96
b) Fair premium							
BSCR	51.54	51.55	51.55	(51.55)	51.55	51.55	(51.55)
SCR_{Op}	0	15.47	76.06	27.43*	15.47	76.06	27.43*
SCR_{total}	51.54	67.02	127.61	78.98	67.02	127.61	78.98

*Residually derived as $SCR_{IM,Op} = SCR_{IM,total} - BSCR$

Numerical results

Fair premiums and *SCR* for varying parameters (Case 3)



Summary

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- Results show: Presence of operational risk in general does not considerably impact fair premiums if the insurer's safety level is sufficiently high
- Internal model led to similar results as the Solvency II standard formula as long as the operational loss intensity was not too high
- For increasing operational loss intensities, the Solvency II standard model clearly tended to underestimate risk
- The Solvency II standard model and the partial internal model are not able to reflect diversification benefits due to imperfect correlations between market, operational, and insurance risks

Implications and further aspects

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- Results emphasize importance of adequately taking into account operational risk, but based on aggregate view

1. Additional aspects for measuring and modeling operational risk:
   - Adequate model needs to be chosen
   - Take into account individual risk cells along with frequency and severity dependence between different risk cells
   - Model needs to be adequately calibrated: Need sufficient loss data (challenging: external or internal database)
2. Management of operational risk
   - Insurance: helps reducing monetary losses, but: high reputational risk
   - Thus, prevention is vital to avoid / reduce operational loss events

➢ Operational risk measurement and management should be integrated in an enterprise risk management framework

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Thank you very much for your attention!

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