The Impact of Counterparty Risk (Management) in Non-Life Insurance Risk Transfer: A Shareholder Value Maximization Perspective under Solvency Constraints

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Introduction: Motivation and research question

- **Counterparty risk** involved in risk transfer arrangements **of increasing relevance**
  - **Alternative risk transfer** with **increasing relevance** (15% of overall reinsurance capital by mid-2020; Aon Securities, 2020) and shift from mainly low-rated to **almost exclusively unrated counterparties** (Lane and Beckwith, 2020)
  - **"Negative"** instead of "stable" **sector outlook** for the global **reinsurance** industry (Nadeem, 2020; Moody's Investor Service, 2020)
- **Insurance and reinsurance contracts** as **promises of contingent future cash flows:** value critically depends on counterparty's ability to fully meet its obligations

➢ **Research question: How does counterparty risk (and its management) impact the optimal risk transfer decision** of a non-life insurer in a shareholder value maximization setting under solvency constraints?

Introduction: Previous research and contribution

Research on counterparty risk

- Mainly **related to reinsurance,** concerning, e.g., **contracting behavior** (Asimit et al., 2013; Cai et al., 2014), **demand sensitivity** (Park et al., 2019) and **value adjustments** (Ceci et al., 2020)
- Impact on **valuation** of catastrophe bonds (Lee and Yu, 2002) and equity puts (Wu and Chung, 2010)
- Interaction effects with the **basis risk of industry loss warranties** (**ILW**s; Bockius and Gatzert, 2020)
- Role of **collateralization** (Lakdawalla and Zanjani, 2012) and related cost (Biffis et al., 2016)

Research on gap insurance

(i.e. reinsurance to cover the difference between an index-based indemnity and the actual loss)

- **Favorability** of gap insurance (e.g., Doherty and Richter, 2002; Nell and Richter, 2004)
- **Practical application** to earthquake risk in Mexico (Härdle and Lopez Cabrera, 2010)
- **Effectiveness in reducing the ILW's basis risk** (Gatzert and Kellner, 2014) in a shareholder value maximization setting with shortfall constraint
- Comparison of **risk transfer strategies based on cat bond and reinsurance** (Trottier and Lai, 2017), involving counterparty risk for reinsurance

- **Key contribution: Joint evaluation and comparison** of traditional and alternative risk transfer instruments subject to counterparty risk (management) **in the shareholder value maximization setting** of a non-life insurer
- Insurer can combine a **reinsurance contract** and an **ILW** and decide about (partial or full) **collateralization**

Methodology: Model framework (1/2)

Development of assets and liabilities

- Initial asset volume: $A_0 = E_0 + \pi_0^{S_T} - \pi_0^{re} - \pi_0^{ILW}$
- Invested assets follow a geometric Brownian motion (GBM) with
  - $dA_{t,I} = \mu_A A_{t,I} dt + \sigma_A A_{t,I} dW_{A_t}^P$
  - $A_{T,I} = A_{0,I} \cdot e^{(\mu_A - 0.5\sigma_A^2)T + \sigma_A W_A^P}$ under P
  - $A_{T,I} = A_{0,I} \cdot e^{(r - 0.5\sigma_A^2)T + \sigma_A W_A^Q}$ under Q
- Asset volume at $t = T$: $A_T = A_{T,I} + X_T^{re,cr} + X_T^{ILW,cr}$

- Insurer loss S_t, industry loss index I_t and reinsurer loss R_t also follow a GBM (i.e. are log-normally distributed)
  - $dS_t = \mu_S S_t dt + \sigma_S S_t dW_{S_t}^P$
  - $dI_t = \mu_I I_t dt + \sigma_I I_t dW_{I_t}^P$
  - $dR_t = \mu_R R_t dt + \sigma_R R_t dW_{R_t}^P$
- Correlations imposed with Kendall's tau ρ_τ between S_t, I_t and R_t

Available risk transfer instruments under counterparty risk

- Indemnity payments without consideration of counterparty risk
  - Reinsurance contract: $X_T^{re} = \omega^{re} \cdot \min(\max(S_T - M^{re}, 0), L^{re}),\ \omega^{re} \in [0,1]$
  - ILW: $X_T^{ILW} = \omega^{ILW} \cdot \min(\max(S_T - M^{ILW}, 0), L^{ILW}) \cdot 1\{I_T > Y\},\ \omega^{ILW} \in [0,1]$
- Indemnity payment under consideration of counterparty risk (see Bockius and Gatzert, 2020), e.g. for the reinsurance contract

$$X_T^{re,cr} = \begin{cases} \max[X_T^{re} \cdot (1 - LGD^{re}), \min(X_T^{re}, coll^{re} \cdot \omega^{re} \cdot L^{re})], & if\ R_T > R_{\alpha^{re}} \\ X_T^{re}, & else \end{cases}$$

Methodology: Model framework (2/2)

Premiums for risk transfer instruments under counterparty risk

- Premium for risk transfer instrument $i = re, ILW$: $\pi_0^i = e^{-rT} \cdot E^Q\left(X_T^{i,cr}\right)\left(1+\delta^i\right) + c_0^{coll,i}$
- Respective premium loading (with minimum loading $\delta^{\min}$): $\delta^i = \max\left[v^l \cdot \left(E^P\left(X_T^{i,cr}\right)/E^P(S_T)\right)^k, \delta^{\min}\right], l = 0, 1, v, k \in \mathbb{R}$
- Surcharge for collateralization for $i = re, ILW$: $c_0^{coll,i} = coll^i \cdot \omega^i \cdot L^i \cdot \delta^{coll}$

Policyholders' stake and contributed premium volume under default risk

- Position of policyholders: $V_T = S_T - \max(S_T - A_T, 0)$
- Actual ("true") ruin probability of the insurer: $RP = P(S_T > A_T)$
- Communicated target ruin probability of the insurer: $\alpha \in (0,1]$
- Premium reduction (Klein and Schmeiser (2019) based on Zimmer et al. (2018)) : $PR(\alpha) = 1 - \exp(-g \cdot \alpha)$
- Premium volume adjusted for the target ruin probability, including policyholders' sensitivity to default risk $\xi \geq 0$ (Eckert and Gatzert, 2018):
  - $\pi_0^{S_T} = p \cdot \max(1 - \xi \cdot PR(\alpha), 0)$, with
  - $p = e^{-rT} \cdot E^Q(V_T)\left(1 + \delta^{S_T}\right) = (S_0 - DPO_0) \cdot \left(1 + \delta^{S_T}\right)$
- Default put option value $DPO_0 = e^{-rT} \cdot E^Q(\max(S_T - A_T, 0))$

Position of shareholders

- Net shareholder value: $SHV_0 = e^{-rT} \cdot E^Q(E_T) - E_0$, with $E_T = \max(A_T - S_T, 0) = A_T - S_T + \max(S_T - A_T, 0)$
- Therefore, $SHV_0 = A_0^V - S_0 + DPO_0 - E_0$

Methodology: Decision problem of the insurer

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Maximization of the insurer's net shareholder value…

$$SHV_0^{max} = \max_{\substack{\omega^{re},\omega^{ILW},\\ coll^{re},coll^{ILW}}} \Big\{(S_0 - DPO_0)\cdot\left(1+\delta^{S_T}\right)\cdot\max(1-\xi\cdot PR(\alpha),0) - S_0 + DPO_0 - \sum\nolimits_{i=re,ILW}\left(\delta^i\cdot e^{-rT}\cdot E^Q\left(X_T^{i,cr}\right) + c_0^{coll,i}\right)\Big\}$$

… under a set of constraints *c*

- Insurer needs to maintain its communicated target ruin probability α
- Contract fractions and levels of collateralization can range from 0% to 100%
- DPO value needs to be adequately reflected in the collected premium volume (necessary due to interrelations)

$$c = \begin{pmatrix} RP \leq \alpha \\ 0 \leq \omega^i, coll^i \leq 1 \\ p\ (=!)\ (S_0 - DPO_0)\cdot\left(1+\delta^{S_T}\right) \end{pmatrix}, i = re, ILW$$

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Methodology: Calibration of the model framework

Variable	Symbol	Value
Time horizon	T	1 year
Company loss: expected value	$E(S_T)$	\$117 million
Company loss: drift and volatility	μ_S, σ_S	0.0250, 0.5256
Industry loss index: expected value	$E(I_T)$	\$5.39 billion
Reinsurer loss: expected value	$E(R_T)$	\$539 million
Industry and reinsurer loss: drift and volatility	$\mu_{I/R}$, $\sigma_{I/R}$	0.0250, 2.5837
Kendall's tau for company and index losses as well as for company and reinsurer losses	$\rho_\tau(S_T, I_T)$, $\rho_\tau(S_T, R_T)$	0.6
Kendall's tau for index and reinsurer losses	$\rho_\tau(I_T, R_T)$	0.8
Return on invested assets: drift and volatility	μ_A, σ_A	0.0343, 0.0315
Risk-free interest rate	r	0.01
Initial equity capital	E_0	\$90 million
Premium loading for primary insurance	δ^{S_T}	30%
Insurer's communicated target ruin probability	α	0.5%
Constant of the premium reduction function	g	23.75
Policyholders' sensitivity to default risk	ξ	0.3

Variable	Symbol	Value
Attachment point ILW/reinsurance	M	\$100 million
Layer limit ILW and reinsurance	L	\$200 million
Industry loss trigger ILW	Y	\$4.5 billion
Parameters for the premium loading of ILW and reinsurance	k, l, v	1, 1, 0.5
Minimum premium loading	$\delta^{\min}$	5%
Counterparty probability of default ILW and reinsurance	α^i	0.5%
Loss given default ILW	LGD^{ILW}	100%
Loss given default reinsurance	LGD^{re}	50%
Collateral surcharge	δ^{coll}	1%
Number of simulation paths	n	300,000
Number of generations (in the differential evolution algorithm)	NG	200
Population size per generation	NP	150
Control parameter (in the algorithm)	cp	0.5

- **Techniques: Monte Carlo simulation** with **control variates** and **Latin hypercube sampling, differential evolution (DE) algorithm**
- **Sources:** Bockius and Gatzert (2020), Eckert and Gatzert (2018), Gatzert and Kellner (2011, 2014), Klein and Schmeiser (2019), Refinitiv Eikon, Zhang and Sanderson (2009), Zimmer et al. (2018)

Methodology: Stepwise approach to the research question

Optimal risk transfer decision and corresponding key metrics for a non-life insurer…

1

Neglecting counterparty risk

2

Considering counterparty risk, but **without** the possibility of **collateralization**

3

Considering counterparty risk, with the possibility of (full or partial) **collateralization**

+

- Varying **restrictions on the availability of collateral**
- Overview of **further analyses** and selected sensitivity tests

1 Results: Neglection of counterparty risk

The impact of neglected counterparty risk on the net shareholder value (SHV) and on the insurer's ruin probability for varying assumptions on counterparty probabilities of default

	Counterparty probabilities of default for both risk transfer instruments		
	0%	**0.5%**	**1%**
"Optimal" **fraction reinsurance** without counterparty risk	40.24%	40.24%	40.24%
"Optimal" **fraction ILW** without counterparty risk	75.93%	75.93%	75.93%
Corresponding **net SHV** with counterparty risk (in $mn)	28.10	28.05	28.02
Actual **ruin probability** of the insurer with counterparty risk	0.50%	0.78%	1.06%

- **Target ruin probability** of 0.5% **no longer maintained** when counterparty risk has been underestimated
  - ➢ **Critical in case of a regulatory limit** on the insurer's actual ruin probability (e.g., under Solvency II)
- Shareholder value almost unaffected and only slightly decreasing

2 Results: Consideration of counterparty risk

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The impact of varying assumptions regarding the counterparty probability of default

on the optimal contract fractions and on related key metrics when no collateralization is possible

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	1) Without consideration of counterparty risk			2) With consideration of counterparty risk		
	Counterparty probability of default for both risk transfer instruments			Counterparty probability of default for both risk transfer instruments		
	0%	0.5%	1%	0%	0.5%	1%
Optimal **fraction reinsurance**	40.24%	40.24%	40.24%	40.24%	60.53%	*n/a*
Optimal **fraction ILW**	75.93%	75.93%	75.93%	75.93%	87.48%	*n/a*
Corresponding **maximum net SHV** (in $mn)	28.10	28.05	28.02	28.10	27.27	*n/a*
Corresponding **actual ruin probability** of the insurer	0.50%	0.78%	1.06%	0.50%	0.50%	*n/a*

- **More risk transfer needed** to maintain the target ruin probability for a higher counterparty risk
- **Maximum net SHV** is **reduced more strongly** when counterparty risk is considered
- **Target ruin probability can be maintained** as long as counterparty risk is not excessive

3 Results: Introduction of collateralization

The impact of introducing collateralization (with the insurer choosing the optimal collateralization level)
on the insurer's optimal risk transfer and maximum net shareholder value (SHV)

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	2) Without collateralization			3) With the possibility to collateralize both contracts		
	Counterparty probability of default for both risk transfer instruments			Counterparty probability of default for both risk transfer instruments		
	0%	0.5%	1%	0%	0.5%	1%
Optimal **fraction reinsurance**	40.24%	60.53%	*n/a*	40.24%	59.37%	56.64%
Optimal **fraction ILW**	75.93%	87.48%	*n/a*	75.93%	91.71%	66.63%
Optimal **collateral reinsurance**	0.00%	0.00%	*n/a*	0.00%	0.00%	0.00%
Optimal **collateral ILW**	0.00%	0.00%	*n/a*	0.00%	1.04%	74.04%
Maximum net SHV (in $mn)	28.10	27.27	*n/a*	28.10	27.27	26.62

- **Impact of collateralization negligible for low counterparty risk levels** (with a collateralization of 1.04% of the ILW fraction's layer limit corresponding to an absolute collateral amount of $1.91 million)
- **Increasing relevance of the ILW's collateralization in case of a higher counterparty risk** (with 74.04% equaling an absolute collateral amount of $98.67 million), **enabling the insurer to meet its target ruin probability**

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Results: Restrictions on the availability of collateral

The impact of different collateral restrictions on the insurer's optimal risk transfer and maximum net shareholder value (SHV) **for a varying counterparty risk of the ILW**

	a) With partial collateral			**b) Only full or no collateralization**			**c) Without collateral**		
	Counterparty probability of default for the ILW only (with a counterparty probability of default for reinsurance of 0.5% and $LGD^{re} = 50\%$)								
	0.5%	1%	1.5%	0.5%	1%	1.5%	0.5%	1%	1.5%
Optimal **fraction reinsurance**	59.37%	56.67%	56.33%	60.53%	55.63%	55.63%	60.53%	86.62%	96.49%
Optimal **fraction ILW**	91.71%	68.00%	64.93%	87.48%	50.63%	50.63%	87.48%	69.98%	48.73%
Optimal **collateral reinsurance**	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Optimal **collateral ILW**	1.04%	57.43%	69.20%	0.00%	100.00%	100.00%	0.00%	0.00%	0.00%
Total collateral (in $mn)	1.91	78.10	89.87	0.00	101.26	101.26	0.00	0.00	0.00
Maximum net SHV (in $mn)	27.27	26.79	26.70	27.27	26.69	26.69	27.27	25.98	25.44

- **Collateralization constraints** and the availability of collateral **impact** the insurer's **demand for risk transfer instruments:** When the insurer chooses a **higher** (lower) **level of collateralization than otherwise optimal**, **lower contract fractions** of the risk transfer instruments (a higher reinsurance fraction) **become optimal**
- Collateral may enable a **slight increase in the maximum net shareholder value** given higher counterparty risk

+ Results: Further analyses and selected sensitivity tests

1) Influence of the cost of collateralization and risk transfer

- Higher collateralization of the ILW becomes optimal in case of a lower **collateral surcharge**
- Maximum net shareholder value may be lowered substantially given **higher premium loadings**

2) Influence of the insurer's default risk in terms of the collected premium volume

- Maximum net shareholder value highly affected by **policyholders' sensitivity to default risk**
- Similar results for a different **shape of the premium reduction function** (based on the function's definition proposed by Lorson et al. (2012) instead of Klein and Schmeiser (2019))
- Shape of the premium reduction function with larger impact when the premium reduction is based on the **insurer's actual ruin probability** (instead of the target ruin probability)

3) Influence of the assumed dependencies between different losses

- For **lower basis risk** levels, a higher risk transfer is realized via a constant fraction of the ILW
- For a **higher default risk correlation**, a higher collateralization of the ILW becomes optimal

Summary

- **Neglection of counterparty risk** results in an **increase in the insurer's actual** ("true") **ruin probability** and in a **misestimation of the maximum net shareholder value**

- **Market supply of collateral impacts** the non-life insurer's **optimal risk transfer decision**
  - (Partial) collateral **attractive for the ILW** already at low counterparty risk levels, but tends to be unattractive for traditional reinsurance in our setting
  - **Optimal contract fractions** of the risk transfer instruments **can be reduced** in case (full or partial) collateralization is optimal
  - **Maximum net shareholder value may be slightly improved** by the provision of collateral, especially for higher counterparty risk levels and (default risk) correlations

- **Partial collateralization** is preferred to full collateralization in the present setting
  - Optimal collateral level for the ILW **increasing**, e.g. in case of a **lower collateral surcharge**
  - May be **attractive** from a market perspective especially **in light of trapped collateral**

The Impact of Counterparty Risk (Management) in Non-Life Insurance Risk Transfer: A Shareholder Value Maximization Perspective under Solvency Constraints

Thank you for your attention

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Results: Restrictions on the availability of collateral (backup)

The impact of different collateral restrictions on the insurer's optimal risk transfer and maximum net shareholder value (SHV) **for a varying counterparty risk of both risk transfer instruments**

	a) With partial collateral			**b) Only full or no collateralization**			**c) Without collateral**		
	Counterparty probability of default for both risk transfer instruments (with $LGD^{re} = 100\%$)								
	0.5%	1%	1.5%	0.5%	1%	1.5%	0.5%	1%	1.5%
Optimal **fraction reinsurance**	66.60%	51.36%	47.91%	66.74%	49.05%	51.30%	66.74%	*n/a*	*n/a*
Optimal **fraction ILW**	98.43%	89.29%	79.88%	98.30%	86.78%	90.17%	98.30%	*n/a*	*n/a*
Optimal **collateral reinsurance**	0.01%	14.30%	47.25%	0.00%	0.00%	0.00%	0.00%	*n/a*	*n/a*
Optimal **collateral ILW**	0.11%	82.01%	90.37%	0.00%	100.00%	100.00%	0.00%	*n/a*	*n/a*
Total collateral (in $mn)	0.23	161.14	189.65	0.00	173.56	180.34	0.00	*n/a*	*n/a*
Maximum net SHV (in $mn)	26.92	26.10	25.98	26.92	26.08	25.97	26.92	*n/a*	*n/a*

- **Availability of collateral more important related to the ILW** than for the reinsurance contract also at higher counterparty risk levels (with reinsurance yielding an indemnity payment in more states of the world than the ILW)
- **Without collateral, a certain safety level needs to be met by at least one counterparty** so that the insurer can maintain its target ruin probability and comply with regulatory requirements

+ Results: Cost of collateralization

The impact of the surcharge for collateral

on the insurer's optimal risk transfer and maximum net shareholder value (SHV) with partial collateral

	Collateral surcharge δ^{coll}				
	0.00%	0.25%	0.50%	0.75%	1.00%
Optimal **fraction reinsurance**	40.24%	44.29%	49.47%	54.65%	59.37%
Optimal **fraction ILW**	75.93%	70.78%	90.43%	93.45%	91.71%
Optimal **collateral reinsurance**	100.00%	0.00%	0.00%	0.00%	0.00%
Optimal **collateral ILW**	100.00%	98.79%	32.86%	13.70%	1.04%
Maximum net SHV (in $mn)	28.10	27.66	27.42	27.30	27.27

- **Without a surcharge, full collateralization** of both risk transfer instruments optimal
- **With a surcharge**, **collateralization** of the **reinsurance** contract declines rapidly to **0%,** while a partial collateralization for the **ILW** becomes optimal (**lower level of collateralization given a higher cost**)
- **Rise in the risk transfer via reinsurance** and reduction in the net shareholder value in case of a higher surcharge

Results: Policyholders' sensitivity to default risk

The impact of policyholders' sensitivity to default risk

on the insurer's optimal risk transfer and maximum net shareholder value (SHV) with and without collateral

Policyholders' sensitivity to default risk	No collateralization possible			Collateralization possible (partial or full)				
	Optimal fraction		Maximum net	Optimal fraction		Optimal collateral		Maximum net
	Reinsurance	ILW	SHV (in $mn)	Reinsurance	ILW	Reinsurance	ILW	SHV (in $mn)
$\xi = 0$	56.75%	88.33%	32.39	56.08%	90.07%	0.00%	0.76%	32.39
$\xi = 0.3$ (base case)	60.53%	87.48%	27.27	59.37%	91.71%	0.00%	1.04%	27.27
$\xi = 0.5$	63.08%	87.14%	23.84	61.16%	92.41%	0.00%	2.51%	23.86
$\xi = 0.7$	65.46%	86.81%	20.43	63.06%	94.68%	0.00%	3.56%	20.43
$\xi = 1$	68.95%	89.90%	15.28	65.81%	95.52%	0.00%	5.84%	15.29

- **High sensitivity of the maximum net shareholder value to the policyholders' sensitivity to default risk**, mainly driven by the decline in the collected premium volume (decreasing from $147.6 million to $131.1 million)
- **Increased risk transfer** becomes **optimal in case of a higher sensitivity of policyholders to default risk** (via a higher reinsurance fraction, and – with collateralization – also via a higher and partially collateralized ILW fraction)