WHAT DRIVES THE DEMAND FOR INDUSTRY LOSS WARRANTIES?

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ABSTRACT

Industry loss warranties (ILWs) belong to the class of alternative risk transfer instruments that have become increasingly popular especially in the retrocession reinsurance market. ILW contracts feature an industry loss index to be triggered, and, in some cases, a double-trigger design that additionally includes a company indemnity trigger. In this paper, we first point out key characteristics of industry loss warranties important to investor and cedent, including transaction costs, moral hazard, basis risk, counterparty risk, industry loss index, and regulation. Next, we present and discuss the adequacy of actuarial and financial approaches for pricing ILWs as well as aspects of basis risk. Finally, drivers of demand and associated models frameworks from the purchaser's viewpoint are studied.

1. INTRODUCTION

The increasing convergence of insurance and capital markets as well as and the development of new and innovative products are driven by several trends. One major factor is limited supply capacity in traditional reinsurance and retrocession markets, especially after hurricane Andrew in 1992 and hurricane Katrina in 2005. For insurers to manage their capital effectively, they need flexible access to capital in case of need for extra capacity. Further reasons include enterprise risk management benefits due to diversification effects (insurance risk is in general uncorrelated with main financial risk sources) and reduction in counterparty risk (see WEF, 2008, p. 9). In the course of financial innovation, new insurance risk transfer instruments were developed to cover this gap.

In this paper, we focus on the innovative class of industry loss warranties (ILWs), which have become increasingly popular during the last years. The contract payment is triggered by an industry loss that may depend on, e.g., geographic region, type of catastrophic event, line of business, or duration. ILWs are either binary or indemnity-based, whereby binary contracts pay a fixed amount only if the industry loss is triggered and indemnity-based contracts additionally account for the reinsured company's loss (SwissRe, 2006). The relevant reference index used is most frequently the insured catastrophic loss data provided by the Property Claim Services (PCS) in the United States, as there is currently no industry index in Europe or Asia.

ILWs are easier to draw up, more flexible, and incur fewer frictional costs than, for example, catastrophe bonds. Due to the integration of the industry index, ILWs are highly standardized and moral hazard is reduced substantially. Hence, the underwriting and claims processes are rather simple. In general, this type of contract can be offered at a lower price than that charged for traditional indemnity-based reinsurance contracts. Despite these advantages, the purchaser is confronted with the basis risk induced by ILWs, which arises if the industry-wide loss and the actual book of business are not fully correlated (see, e.g., Harrington and Niehaus, 1999; Doherty and Richter, 2002). This leads to a difference between the index-based payoff and the reinsured's actual loss.

To date, the literature is primarily focused on other forms of alternative risk transfer instruments, such as cat bonds, for which pricing approaches, basis risk, and moral hazard have been analyzed (see, e.g., Doherty and Richter, 2002; Lee and Yu, 2002, 2007). Previous literature on ILWs has generally concerned itself with pricing binary contracts by calculating a risk load using the coefficient of variation (Ishaq, 2005) or with analyzing basis risk in the case of binary ILW contracts (Zeng, 2000). Beyond this, Zeng (2003) analyzes the tradeoff between basis risk and the cost of index-based instruments.

Cummins et al. (2004) conduct an empirical study of general index-based instruments for catastrophic losses. In particular, basis risk is analyzed by examining the hedging effectiveness of risk reduction using different risk measures. In addition, the relationship between hedging effectiveness and insurer characteristics is studied. Zeng (2005) applies an optimization method based on the genetic algorithm to measure the reinsurance efficiency of index-based contracts, thereby taking into account cost and benefit. Gatzert, Schmeiser and Toplek (2007) provide a comprehensive overview and comparison of different pricing approaches and measures of basis risk using numerical examples.

While pricing and basis risk are important considerations in regard to ILWs, decisions on whether or not to add an ILW contract to the reinsurance portfolio involve some additional aspects. In the literature, there has been no comprehensive presentation of

ILW characteristics relevant for demand. This paper intends to fill this gap by providing a comprehensive overview of main key factors driving the demand for ILWs as well as a discussion of the adequacy of pricing approaches and for a concrete determination of the ILW demand for an insurer using different model setups.

The remainder of the paper is organized as follows. In Section 2, the characteristics and key factors of ILWs are discussed, including the main impact factors on the attractiveness of ILWs. Section 3 presents the model of the ILW contract, provides a discussion of the functioning and adequacy of actuarial and financial pricing approaches, and includes a measure of basis risk. Section 4 studies drivers for the demand of ILWs based on several models proposed in the literature, and Section 5 concludes.

2. CHARACTERISTICS OF INDUSTRY LOSS WARRANTIES

Since the mid 1990s, the market for insurance-linked securities (ILS) in general has grown substantially and only recently – during the financial crisis – experienced a reduction in growth (CEIOPS, 2009). Currently, the notional value of the ILS market amounts to around 50 billion USD with annual growth rates of 40-50% since 1997 (WEF (2008, p. 6)). ILWs, together with cat swaps, currently face an estimated outstanding notional volume of approximately 10 billion USD (WEF 2008, p. 10). In the insurance linked securities report published by CEIOPS (2009), the ILS market is expected to show considerable further growth which will most likely include the class of ILWs. In order to get a better understanding of this form of risk transfer, we discuss the main elements of ILWs in this section.

Contract design

Industry loss warranty contracts can be designed in a variety of ways.[1] A binary contract pays out a fixed amount if the industry-wide loss exceeds a predefined threshold where the contracted trigger amount varies by, e.g., geographic region, type of catastrophic event, line of business, or duration. Another common design is indemnity-based, i.e., in addition to an industry loss larger than a predefined trigger, the reinsured company’s loss must exceed a certain amount, too. This design essentially corresponds to a double-trigger reinsurance contract (see, e.g., Gründl and Schmeiser, 2002).

1 An overview of ILW contracts is provided in SwissRe (2006).

Indemnity triggers are often included to achieve similarity to traditional reinsurance products, which in many countries is relevant for having ILWs accepted as risk transfer instruments for reducing solvency capital requirements. If an indemnity trigger is set to a very low level and will be exceeded almost surely, company specific underwriting costs may be reduced but nevertheless exist. The presence of an industry index will generally imply positive basis risk and thus reduce the opportunity to have an ILW contract be accepted in accounting and regulation as a risk transfer instrument qualified as reinsurance. In the U.S., for instance, US GAAP requires risk transfer instruments to include "significance of the risk transferred" and a "certain probability of significant loss" (see WEF, 2008, p. 8).

Transaction costs

The most important advantage of ILWs compared to traditional products is substantially lower transaction costs.[2] The industry loss index is very transparent, and thus the underwriting process is simple to implement. The index is the only relevant pricing component when – and this is often the case – company specific indemnity triggers are not used or set to a rather low level. In addition, no legal costs or due diligence are necessary. A high degree of standardization – especially in respect to the contractual wording – allows fast and easy transactions within one day after requesting an offer and a low documentation effort.

Traditional reinsurance products, in contrast, typically take much longer (2-3 weeks) until the underwriting process is completed. This includes an analysis of the business and exposure of the purchasing company (see, e.g., Zeng, 2005, p. 7) and induces much higher transaction costs. The same is true in the case of insurance linked securities, which often involves the foundation of a Special Purpose Vehicle (SPV). This goes in general along with legal costs, costs for ratings, administration costs, and the purchase of interest rate swaps. In addition, according to WEF (2008), single ILWs can be offered with layer limits in the range of 1 million USD to 250 million USD, while cat bonds need to cover at least 100 million USD to be cost-effective.

[2] This aspect was pointed out by several industry experts interviewed by the authors. Hence, the lower price compared to traditional reinsurance is the most important factor that drives the demand of ILWs on the retrocession market.

Moral hazard

The introduction of an index trigger leads to a reduction of moral hazard compared to traditional products since the industry loss can usually not be influenced by the ILW purchaser. Indemnity trigger in reinsurance products, in contrast, may cause moral hazard. However, deductibles and limited layers are commonly included in traditional contract designs, which generally limit moral hazard incentives.

Basis risk

While the industry loss index is beneficial regarding the reduction of moral hazard, it also introduces basis risk at the same time. From a buyer’s perspective, the ILW contract should protect the company against losses that could endanger its survival. Thus, the situation where the insurance company suffers a severe loss while the industry has moderate losses represents a risk to the buyer since the triggering industry events must be fulfilled for the contract to pay out the insured amount. In general, this basis risk arises when using index triggers since company loss and industry loss are usually not fully correlated (see, e.g., Doherty and Richter, 2002). This may imply a reduction in the buyer's willingness to pay.

ILWs only represent an effective hedge for the purchaser if its portfolio highly matches the industry loss experience. Hence, for the most part, ILWs are traded on the retrocession market only, since even large global primary insurers often decide not to take the basis risk in their book of business. For large reinsurance companies, in turn, basis risk is controllable due to their sufficiently high degree of diversification and their specific underwriting knowhow. This also implies that from the perspective of active market participants like global reinsurers, basis risk will probably not be the determining factor for purchase decisions. Instead, there is also basis chance involved, since the ILW payoff is also taken out if the purchaser has little losses, even though the overall industry loss exceeds the predefined trigger.

Counterparty risk

Another important factor regarding ILWs is the counterparty risk. While counterparty risk must be considered in the context of traditional reinsurance products, ILWs are often collateralized. Particularly hedge funds have to offer collateral since they have no rating and thus need to provide securities in order to be able to sell their products. However, there are also reinsurance firms with A- rating by A.M. Best founded on, e.g., Bermuda, that offer ILWs without collateral. The level of counterparty risk does not only depend on the purchaser's and buyer’s risk aversion, but is also driven by solvency capital requirements due and accounting rules.

Pricing and risk loads

The most important factor in rate making is the expected annual industry loss under the chosen specification regarding the type of natural hazard, geographic region, line of business, and duration. Modeling is highly complex and involves complicated models for natural hazards. In general, loss estimation is conducted by means of proprietary models for windstorm, earthquakes, and other natural hazards that are typically provided by companies specialized in modeling natural catastrophes, such as Risk Management Solutions (RMS), EQECAT (EQE), and Applied Insurance Research (AIR) (see Watson, Johnson, and Simons, 2004).

The price of an ILW is often calculated as the expected contract’s payoff and a company-specific risk load. Risk loads typically depend on internal and external costs. Internal costs may depend on the cost of capital, the reinsurer's book of business, risk management objectives and the degree of risk aversion. External costs involve in particular compensation for brokerage. In the case of ILWs, spreads are mainly generated by underwriting risk. In addition, ILW prices are highly correlated with reinsurance prices and may as well depend on insurance cycles.

Industry loss index and data quality

The most frequently used reference indices for insured catastrophic events are those provided by the Property Claim Services (PCS) in the United States. Thus, the industry loss is usually determined by referencing a relevant PCS index. Since there is currently no equivalent index in Europe or Asia, Sigma data by Swiss Re or the catastrophic loss data by Munich Re are used as an alternative (WEF, 2008, p. 10). However, late corrections in these data reports may imply substantial costs if triggers were previously hit.

Initiated by the Chief Risk Officer Forum, there are currently efforts and activities in Europe by major European insurers and reinsurers to develop European indexes based on data estimates of insured European natural catastrophe losses. These loss data should – similar to the PCS index – be provided by an independent organization and include windstorm exposures and losses in the UK, France, Switzerland, Luxembourg, Belgium, the Netherlands, Germany, Denmark, Norway and Sweden, broken down by business lines and CRESTA (Catastrophe Risk Evaluation and Standardizing Target Accumulations) zones (WEF, 2008, p. 15). Further, non-indemnity triggers include the Paradex Index for EU windstorms and US hurricanes (based on industry losses) as well as parametric ones as WindX for US hurricances and the Carvill Hurricane Index (CHI).

Regulation and accounting

The acceptance of ILWs as reinsurance instruments in accounting is a critical factor in the attractiveness of this forum of risk transfer. As pointed out in the convergence report of WEF (2008, p. 19) – while there is still uncertainty – ILWs with an indemnity trigger may typically be regarded as risk instruments under IFRS and US GAAP, and not as financial derivative (like other ILS). This reduces the volatility of results, since – in contrast to financial derivatives – risk instruments do not have to be measured at fair value (WEF, 2008, p. 19). Therefore, they are accounted for in the underwriting results, which play an important role for solvency considerations, too. In many regulatory frameworks, risk transfer instruments cannot be applied for solvency capital reductions if considered as financial derivatives as long as no gain is realized. Overall, however, the basis risk of ILWs remains a problem as it ceteris paribus increases the volatility of results. Basis risk can diminish the reduction in capital requirements for some insurers and thus, ILW sponsors with their non-indemnity based contracts need to deal with basis risk and develop adequate models in a portfolio context.

The WEF (2008) report further stresses the fact that designing contracts to satisfy solvency requirements by introducing company triggers may represent an increase in transaction cost for investors due to the assessment of company-specific data and due diligence. A summary of the characteristics of ILWs is presented in Table 1.

Table 1: Summary - characteristics of ILWs

Contract design	Double-trigger or binary, industry loss index and indemnity-based with low indemnity trigger (similarity to reinsurance contracts, acknowledgement as risk transfer instrument) High degree of standardization, simple underwriting and claim processes (may also be offered by hedge funds)
Transaction costs	Low due to high standardization and transparency, simple underwriting, layer limits in the range of 1 to 250 million USD
Moral hazard	Low due to low indemnity level
Basis risk	High, existence of industry loss index; traded in retrocession market given portfolios with high correlation with market in order to reduce basis risk
Counterparty risk	Often offered with collateral, especially in case of hedge funds due to lack of ratings, depends on solvency and accounting rules
Pricing	Key pricing factor: expected industry loss (for given contract specifications, highly complex modeling conducted by experts) + company-specific loading (internal and external factors)
Industry index	Currently mainly based on PCS index (USA), Swiss Re Sigma data, Munich Re Cat Loss Data CRO Forum initiative to develop a European loss index
Regulation and accounting	Uncertainty in regard to treatment, but should be recognized as risk instruments under IFRS/US GAAP, not as financial derivatives; basis risk is a problem for acknowledgement under Solvency II

Table 2 summarizes the impact factors on the demand and attractiveness of ILWs from the purchaser's perspective and compares results with cat bonds and traditional reinsurance (see also Sigma, 2006, p. 20).

Table 2: Advantage (+) and disadvantage (-) of ILWs from the purchaser's perspective compared to other risk transfer instruments

Impact factor	ILWs	Cat Bonds	Traditional reinsurance
Complexy of contract design	+	-	-
Transaction costs	+	-	-
Risk loading caused by moral hazard	+	+	-
Basis risk	-	+/- (depends on trigger definition)	+
Counterparty risk	+/- (depends on existence of collateral)	+	-
Price and risk loads	+	-	-
Data availability	+	+	-
Regulation and accounting	+/- (in development)	-	+

More detailed comparisons between ILWs and traditional risk transfer forms is difficult due to the many contract specific factors that drive costs and benefits.

3. PRICING AND BASIS RISK FOR INDUSTRY LOSS WARRANTIES

In this section, we present two general concepts for pricing ILWs from the seller's perspective and also discuss the limitations of these approaches in their appropriateness for the valuation of ILWs and a measure of basis risk.[3]

General model specifications of ILW contracts

Industry loss warranty contracts are typically designed in one of the two following ways:[4] A binary contract pays out a fixed amount if the industry-wide loss exceeds a predefined threshold. Another ILW design is indemnity-based, i.e., the reinsured company's loss must exceed a certain amount and the industry loss must be larger than a

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[3] For a presentation of actuarial and financial pricing approaches as well as basis risk of ILWs, see also Gatzert, Schmeiser, and Toplek (2007).

[4] An overview of ILW contracts is provided in SwissRe (2006).

preset trigger. However, the one feature that occurs in all ILWs is the presence of a trigger based on industry losses.

Let S_1 denote the company's loss distribution in $t = 1$, I_1 the industry loss distribution in $t = 1$, A the attachment of the company loss, Y the industry loss trigger, and $1\{I_1 > Y\}$ the indicator function, which is equal to 1 if the industry loss in $t = 1$ is greater than the trigger and 0 otherwise. Hence, the payoff for a layer L of the two ILW contracts in $t = 1$, X_1^{ILW}, can be written as (the indemnity based contract is denoted with the superscript *ib*):

$$X_1^{ILW} = L \cdot 1\{I_1 > Y\}$$

$$X_1^{ILW,ib} = X_1 \cdot 1\{I_1 > Y\}$$

with

$$X_1 = \min\left(\max\left(S_1 - A, 0\right), L\right).$$

In this context, X_1 stands for the payoff of an aggregated excess of loss reinsurance treaty.

Actuarial pricing approaches

In general, actuarial valuation methods rely on the individual decision-maker's risk preferences, usually assuming risk aversion (see Cummins, 1990a, p. 125) and thus calculate a loading that is added to the net risk premium (expected loss) of the contract in order to determine a certainty equivalent for the loss distribution. In the actuarial literature, the assumption of a loading on the expected loss is usually based on classical ruin theory, which states that a premium equal to the net risk premium leads to certain ruin in an infinite planning horizon, regardless of how much equity capital the insurer holds (see, e.g., Bühlmann, 1996, pp. 141–144). Bühlmann (1985) also relates insurance premiums to ruin theoretical stability criteria, i.e., a certain probability of ruin, and thus deduces actuarial premium calculation principles with the implicit assumption of risk aversion. There are several different actuarial approaches for determining the loading, resulting in correspondingly different pricing principles.[5] In practice, the actuarial ILW premium is typically obtained by adding risk loads (and a com-

5 For an overview see, e.g., Goovaerts et al. (1984).

pensation for transactions costs) c to the expected losses. If π stands for the ILW premium, r denotes the continuous one-period risk-free rate of return and E indicates the expectation of a stochastic variable under the objective real-world measure P, we get for the binary contract form

$$\begin{aligned}\pi^{ILW} &= \exp(-r)\cdot\left[\left(E\left(X_1^{ILW}\right)\cdot(1+c)\right)\right] = \exp(-r)\cdot\left[\left(E\left(L\cdot 1\{I_1 > Y\}\right)\cdot(1+c)\right)\right]\\ &= \exp(-r)\cdot\left[\left(L\cdot P\left(I_1 > Y\right)\cdot(1+c)\right)\right].\end{aligned}$$

In the case of an indemnity-based ILW, the premium is given by

$$\pi^{ILW,ib} = \exp(-r)\cdot\left[\left(E\left(X_1^{ILW,ib}\right)\cdot(1+c)\right)\right] = \exp(-r)\cdot\left[\left(E\left(X_1\cdot 1\{I_1 > Y\}\right)\cdot(1+c)\right)\right].$$

In the case, S_1 and I_1 are assumed to be stochastically independent, the premium for an indemnity-based ILW simplifies to

$$\pi^{ILW,ib} = \exp(-r)\cdot\left[E\left(X_1\right)P\left(I_1 > Y\right)(1+c)\right].$$

Many actuarial pricing principles base the risk loading c on statistical figures (e.g., variance or quantile) of the payoff distribution X_1^{ILW}. In the case of an indemnity-based ILW, the dependency (linear or non-linear) between S_1 and I_1 play an important role to obtain the premium $\pi^{ILW,ib}$. We expect that in many cases, closed-formed expressions for $X_1^{ILW,ib}$ do not exist and approximations – e.g., by using a Monte-Carlo-Simulation – need to be derived.

In general, counterparty risk can be taken into account by transforming the loss distribution X_1^{ILW} to an indemnity payment distribution X_1^{ILW*} assuming that under certain circumstances, losses are not (fully) paid by the seller of the ILW. The premium must then be based on the actual indemnity distribution X_1^{ILW*}, which thus accounts for counterparty risk.

Financial pricing approaches

In contrast to actuarial pricing approaches, standard financial pricing concepts rely on the duplication of cash flows and are thus independent of individual preferences. Hence, in this model framework, financial instruments are needed that allow the replication of the underlying variables I_1 and—in case of and indemnity based ILW contract— S_1 given no arbitrage in the capital market. Under these assumptions, the market value of the ILW contract's payoff, discounted with the risk-free interest rate *r*, is a martingale under the risk-neutral measure *Q* (see, e.g., Björk, 2004):[6]

$$\pi^{ILW,(ib)} = \exp(-r) \cdot E^Q\left(X_1^{ILW,(ib)}\right).$$

In the special case of the Insurance Capital Asset Pricing Model (ICAPM), $E^Q\left(X_1^{ILW,ib}\right)$ coincide with the certain equivalent *CE*: [7]

$$CE = E^Q\left(X_1^{ILW,(ib)}\right) = E\left(X_1^{ILW,(ib)}\right) - \lambda \cdot Cov\left(X_1^{ILW,(ib)}, r_m\right),$$

where r_m stands for the return of the market portfolio in $t = 1$. The market price of risk λ is given by

$$\lambda = \frac{E(r_m) - r^d}{\sigma^2(r_m)}$$

with r^d denoting the discretely compounded risk-free interest rate.

The ICAPM can only coincide with the multi-factor pricing models proposed by Doherty (1991), Froot and Stein (1998) as well as Froot (2007), if the cash flow of the ILW contract can be fully duplicated by marketable assets (hence, in this case, the contract only consists of tradable risk exposure). Otherwise, nondiversifiable risk components still left in the ILW provider's portfolio – after establishing a hedge portfolio trying to eliminate the nontradable risk part – need to be taken into account. In contrast to the ICAPM and due to the assumption that the cost of capital is a convex function of the amount of equity capital needed for post-loss financing, (endogenous) risk-averse behavior on the ILW provider's is derived (see Doherty (1991), Froot and Stein (1998), Froot (2007)). The greater the nondiversifiable risk part of the ILW payoff, the higher the certainty equivalent and the price of the contract.

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6 For an overview of this so called contingent claims approach see, e,g,, Doherty and Garven (1986), Cummins (1990b), and Gatzert and Schmeiser (2007).

7 For pricing insurance contracts in a CAPM framework, see, e.g., Fairley (1979), Hill (1979), D'Arcy and Doherty (1988), and Cummins (1990a).

If replication or diversification is not achievable, other valuation approaches may be implemented. One can first assume that individuals can not diversify at all. In this case, the concept of utility functions can be used in order to analyze whether in this case purchasing or selling an ILW is of value. Results depend on different assumptions on initial wealth and degree of risk aversion. The second valuation approach is based on an incomplete market setting where claims cannot be fully replicated. This leads to the problem of identifying risk-minimizing strategies (see, e.g., Møller, 1998).

Counterparty risk can be taken into account when pricing ILWs by using the concept of the Default Put Option (see Doherty and Garven, 1986). Let L_1 denote the stochastic value of the liabilities in $t = 1$ and E_0 the initial equity capital of the ILW seller in $t = 0$ before closing the ILW contract. In addition, $\hat{\pi}$ indicates the premium (paid at time $t = 0$) of the preexisting underwriting portfolio and r^* denotes the stochastic rate of return on the ILW seller's investment portfolio. The Default Put Option *DPO* in t = 1 is then given by

$$DPO_1 = \max\left(L_1 - \left(E_0 + \hat{\pi}\right)\left(1 + r^*\right), 0\right).$$

For the default free premium of the preexisting underwriting portfolio π, the following relationship holds true

$$\hat{\pi} = \pi - \exp(-r) \cdot E^Q\left(DPO_1\right).$$

Using the default-value-to-liability-ratio d (see Butsic, 1994; Gründl and Schmeiser, 2007) with

$$d = \frac{\exp(-r) \cdot E^Q\left(DPO_1\right)}{\pi}$$

in order to define the safety level of the ILW seller before signing the ILW contract and assuming, that the ILW seller wants to keep that safety level d after closing the ILW contract ($d^{new} = d$), the ILW premium taken into account the default risk of the seller, $\hat{\pi}_1^{ILW,(ib)}$, can be derived from

$$\hat{\pi}^{ILW,(ib)} = \exp(-r)\cdot E^{Q}\left(X_1^{ILW,(ib)}\right)\cdot(1-d)$$
$$= \pi_1^{ILW,(ib)}\cdot(1-d) = \pi_1^{ILW,(ib)}\cdot\frac{\hat{\pi}}{\pi}.$$

The default-value-to-liability-ratio *d* value serves as a measure for the safety level of the provider of the contract; hence, an increase of *d* reduces ceteris paribus the premium for the ILW treaty. As laid down in Section 2, ILWs are often collateralized in order to reduce counterparty risk.

Some aspects on actuarial versus financial pricing methods

There are several important differences in the pricing approaches discussed in the previous sections.[8] The actuarial methods evaluate individual contracts without considering diversification in the market or in the existing portfolio of the ILW seller.[9] Hence, only the contract's payoff is evaluated using specific assumptions about risk preferences. Because ILW sellers are in general business corporations, it is not clear how these preferences can be obtained in an objective manner.

In contrast, financial pricing methods typically assume that investors perfectly diversify unsystematic risk. Thus, in this context, only systematic risk is relevant for pricing ILW contracts. Since the financial pricing approaches lead to present-value concepts, prices are additive for any portfolio of contracts. Therefore, the composition of the portfolio of the ILW contract seller has no impact on pricing individual contracts.

In general, an increase of the volatility of the contract's payoff induces higher premiums. However, e.g., in the case of the ICAPM, this only holds true if there is systematic risk within the contract, i.e., if $Cov\left(X_1^{ILW,(ib)}, r_m\right) < 0$. For actuarial pricing concepts, the risk-free interest rate does only influence pricing via the discount factor. In contrast, the risk-free interest rate does have a substantial effect on premiums determined with financial pricing methods. Under the ICAPM, the market price of risk λ increases when the risk-free rate is decreasing. Hence, the effect of the covariance between the contract's payoff and the return of the market portfolio on the certainty equivalent is intensified if $Cov\left(X_1^{ILW,(ib)}, r_m\right) \neq 0$. Regarding the contingent claims ap-

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8 See also Gatzert, Schmeiser, and Toplek (2007) for a comparison of actuarial and financial pricing approaches.

9 An important exception is the portfolio-oriented actuarial valuation model as proposed, e.g, by Bühlmann (1985) and Straub (1997). These kind of pricing models do account for diversification effects in the provider's portfolio.

proach, lowering *r* implies a lower probability of exceeding the indemnity and industry triggers. Thus, the contract payoff is reduced.

In the context of ILW pricing, financial methods might have one major disadvantage which could be the main reason why rate making of ILW contracts is typically done in an actuarial framework. In most cases, we would assume that the central assumptions of traditional financial approaches – the replication of I_1 and S_1 (in the case of an indemnity based treaty) via traded financial instruments – is not fulfilled.

In general, pricing frameworks react very sensible to changes in the input parameters. This is in particular the case in respect to indemnity bases ILW contracts; hereby, assumptions regarding the joint distribution of S_1 and I_1 are needed in order to derive the contract's payoff distribution. In addition, the payoff structure $X_1^{ILW,ib}$ of an ILW contract typically display a high volatility in relation to the expected value of the distribution and are highly asymmetric. Hence, such payoff structures may not be adequately captured and valuated in EV/Std-frameworks using linear measures to capture the dependency between S_1 and I_1.

Measuring basis risk

From a buyer’s perspective, the ILW contract should protect the company from losses that could endanger its survival. Thus, the situation where the insurance company suffers a severe loss while the industry has moderate losses represents a risk to the buyer since both triggering events must be fulfilled for the contract to pay out an indemnity. In general, this basis risk arises when using index triggers since company loss and industry loss are usually not fully correlated (see, e.g., Doherty and Richter, 2002).

There are several ways of defining basis risk (see Zeng, 2003, p. 253). In what follows, we consider basis risk as the situation where industry loss is not triggered, given the insurance company has a severe loss. This conditional probability can be written in the following way (see Zeng, 2000):

$$P\left(I_1 < Y \middle| S_1 > A\right) = \frac{P\left(I_1 < Y, S_1 > A\right)}{P\left(S_1 > A\right)}.$$

In addition, the extent of missed indemnity payments for the buyer can be considered by examining the difference between a traditional aggregate excess of loss reinsurance contract and an indemnity based ILW (see Gatzert, Schmeiser, and Toplek, 2007):

$$\begin{aligned} E(X_1) &= E\Big(\min\big(\max(S_1 - A, 0), L\big)\Big) \\ &= E\Big(\min\big(\max(S_1 - A, 0), L\big)\cdot 1\{I_1 > Y\}\Big) + E\Big(\min\big(\max(S_1 - A, 0), L\big)\cdot 1\{I_1 < Y\}\Big) \\ &= E\left(X_1^{ILW,ib}\right) + E\Big(\min\big(\max(S_1 - A, 0), L\big)\cdot 1\{I_1 < Y\}\Big). \end{aligned}$$

Hence, the relationship between the traditional reinsurance contract and an indemnity based ILW contract is in this context given by

$$E\left(X_1^{ILW,ib}\right) = E(X_1) - E\Big(\min\big(\max(S_1 - A, 0), L\big)\cdot 1\{I_1 < Y\}\Big).$$

The ILW buyer can expect payment for only a part of the expected loss that could be claimed in full under a traditional reinsurance contract. The remainder, that is, the expected amount of payment not made, can then also be considered as a measure of basis risk, i.e.,

$$E\Big(\min\big(\max(S_1 - A, 0), L\big)\cdot 1\{I_1 < Y\}\Big).$$

The above given Equation for $E\left(X_1^{ILW,ib}\right)$ also illustrates that prices based on expected losses under the ILW reflect the reduced indemnity payments and thus generally result in a lower price for this type of contract compared to a traditional reinsurance contract.

4. The Demand for Industry Loss Warranties

In a complete, frictionless, and continuous market, the valuation of ILW contracts can be derived using the present value approach revealed in Section 3 (see Subsection "financial pricing approaches"). If seller and provider of ILW contracts use the same fair pricing approach based on the replication of cash-flows, neither party will receive advantages or disadvantages while signing a contract. However, in insurance practice, some assumptions of "perfect" market conditions—like, e.g., information symmetry—may need to be relaxed and hence, the trading of ILW treaties could lead to advantages for buyers and sellers.[10] For instance, Mayers and Smith (1982) discuss several reasons that assist the relevance of (re-)insurance in general. In particular, we believe two aspects to be important in respect to the demand of ILWs. Firstly, this special form of risk transfer can help to shift risk away from those stakeholders (here: ILW buyers) who are at a relative disadvantages in risk-bearing terms. Secondly, the closing of an ILW contract may lower expected tax liabilities (and other regulatory costs) for the purchaser of an ILW treaty. Other reasons mentioned in the article by Mayer and Smith (1982) could also play a role in the context of ILWs. For instance, and in the case of an indemnity based contract, an ILW provider may enjoy comparative advantages in administering the handling of claims and, in this way, should be able to examine the underwriting activities of the ILW buyer that may otherwise give rise to the risk of higher claims due to moral hazard and adverse selection.

If one assumes that the replication of the underlying of an ILW contract via capital market instruments cannot be done to any extent, a preference dependent valuation is needed. A specific target function for the ILW buyer can be formulated in order to derive a company specific demand for such treaties. For instance–and in the context of ILW contracts–Zeng (2003) considers an insurer that wishes to limit basic risk and the probability of ruin to a predefined level while maximizing the company's expected net profits. The insurer's decision variables in order to achieve this goal are the ILW's trigger level and the upper layer limits. Zeng (2003) argues that because of the payoff structure of ILW contracts being non-linear and inherently not smooth, traditional numerical algorithms to solve the optimization sometimes fail to reach the global maximum. Hence, in the paper by Zeng (2003), numerical examples are provided using the concept of genetic algorithm.

In an article by Doherty and Richter (2002), the trade-off between moral hazard and basis risk regarding index-linked securities is analyzed. A decision maker with mean-variance preferences is focused, who can purchase an index hedge–which could be an ILW contract–and an insurance contract that covers (partly) the gap between the decision-maker's actual losses and the index-linked payoff. The demand for index-linked securities strongly depends on the price offered by the seller of the product. In this respect, Doherty and Richter (2002) assume the providers of the index-linked securities

[10] For the following line of reasoning in the context of double-trigger reinsurance contracts, see Gründl and Schmeiser (2002), p. 461 ff.

and the gap insurance to be risk-neutral, such that only expected claims and transactions costs regarding the treaties are relevant for pricing.

Besides the advantage of index triggers to be able to reduce moral hazard in the relationship between insurance sellers and buyers, Finken and Laux (2009) argue that the demand for such contracts can also been positively affected by–compared to traditional reinsurance–a reduction in adverse selection. By referring to the banking literature on relationship lending and informational lock-in, the authors show that private information about insurers' risk in the case of the existents of less informed market participants regarding the information of claims distribution subject to adverse selection results in high reinsurance premiums and cross-subsidization from low-risk to high-risk insurers. Such adverse selection with major effects on the competition of an insurance market should not take place with products containing information-insensitive index triggers (like ILWs) and thus increase the attractiveness of such contracts from the viewpoint of potential buyers.

Doherty and Tinic (1981) as well as Cummins and Sommer (1996) derive the demand for risk transfer instruments for an insurer from the risk sensitivity of the insurer's policyholders.[11] Assuming that policyholder are willing to pay a price for insurance coverage that exceeds its present value in the case that the insurer's safety level (measured by the default put option value) is very high, ILWs could be used to adjust an insurer's safety level in a way that maximizes its shareholder value.

In Doherty (1991) and Froot and Stein (1998), an insurer's risk-averse behavior in the Arrow-Pratt sense (see Pratt, 1964, pp. 122–136) is a result of the assumption, that the cost of capital is a convex function of the amount of external capital needed in the case of post-loss financing. In this model setup, perfect hedging will be achieved by the provider of an ILW contract regarding the part of the ILW contract that can be replicated by assets traded on the capital market. However, for the fraction of the ILW contract that cannot be replicated, premium loadings necessary on the side of the seller to cover post-loss financing costs. The post-loss financing costs in this model set up depend on the portfolio composition ad the amount of equity capital and hence are firm-specific. Giving this line of reasoning, an insurer could save post-loss financing costs by buying an ILW contract. In particular, market conditions for ILW contracts could be derived that cause advantages for ILW sellers as well as for ILW buyers while clos-

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11 See Gründl and Schmeiser (2002), p. 461 ff.

ing a contract. This requires a situation in which the seller of an ILW contract faces advantages in post-loss financing—caused by its better diversified portfolios—compared to the situation by the ILW buyer.

5. SUMMARY

In this paper, we studied key characteristics of industry loss warranties. In addition, we presented different pricing approaches, measures of basis risk, as well as models for the demand of ILWs, and discussed their adequacy against the background of the specific characteristics of ILWs. In particular, financial pricing approaches are highly sensitive to input parameters, which is important due to the high volatility of the underlying loss index. In addition, the underlying assumption of replicability of the claims is not without problems.

Due to their simple and standardized structure and the dependence on a transparent industry loss index, ILWs are low barrier products, which can also be offered by hedge funds. In principle, traditional reinsurance contracts are still preferred as a measure of risk transfer, especially since these are widely accepted for solvency capital reduction. However, the main important impact factor for the demand of ILWs from the perspective of market participants, i.e., large diversified reinsurers and hedge funds, is the lower price due to rather low transaction costs and less documentation effort. Hence, ILWs are attractive despite the introduction of basis risk and the still somewhat opaque regulatory environment.

Overall, ILWs, along with other alternative risk transfer instruments, will become increasingly important in the future as risk transfer instruments. However, the attractiveness and the development in market volume of ILWs strongly depend on several factors. These factors include the regulatory and accounting treatment of ILWs and thus the question to which extend ILWs will be recognized as risk transfer instruments under, e.g., Solvency II. An important issue related to this is how reinsureds deal with the basis risk inherent in ILWs. Another central point is the development of a European industry loss index and the creation of an exchange platform to enable an even higher degree of standardization and a faster processing of transactions.

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