Industry Loss Warranties: Contract Features, Pricing, and Central Demand Factors

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INDUSTRY LOSS WARRANTIES: CONTRACT FEATURES, PRICING, AND CENTRAL DEMAND FACTORS

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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 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 the aspects of basis risk. Finally, we study central drivers of demand for ILWs under different models frameworks from the purchaser's viewpoint.

1. INTRODUCTION

The convergence of insurance and capital markets, in addition to the development of new and innovative products, are driven by several trends. One aspect is the limited supply capacity in the 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. Other reasons are the benefits of enterprise risk management due to the effects of diversification–insurance risk is generally uncorrelated with main sources of financial risk–and reduction in counterparty risk (see WEF, 2008, p. 9). In the course of financial innovation, new insurance risk transfer instruments were developed to close this gap.

In this paper, we focus on the innovative class of industry loss warranties (ILWs), which have become recently grown in popularity. The contract payment is triggered by an industry loss that may depend on, for example, geographic region, type of catastrophic event, line of business, or duration. ILWs are either binary or indemnity-based; 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 reference index used is most frequently the insured catastrophic loss data provided by the Property Claim Services (PCS) in the United States. In Europe, the first index has only recently been established by PERILS based on European catastrophic loss data in October 2009. In Asia, there is no industry index in so far.

ILWs are easier to draw up, more flexible, and incur fewer frictional costs than, e.g., catastrophe bonds. Due to the integration of the industry index, ILWs are highly standardized and moral hazard – as faced in the traditional insurance sector – is substantially reduced. 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 has 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). Most of the previous literature on ILWs has 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) have conducted 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 must take some additional aspects into consideration. In the literature, there has been no comprehensive presentation of ILW characteristics relevant for demand. This paper intends to fill this gap by 1) providing a comprehensive overview of main factors relevant for the demand for ILWs; 2) discussing the adequacy of pricing approaches; and 3) presenting concrete model setups that explain the demand for ILWs from the insurer's perspective by means of a broad literature review.

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

2. CHARACTERISTICS OF INDUSTRY LOSS WARRANTIES

Market and recent developments

The first ILW contracts had been traded in the 1980s (Swiss Re, 2009). Since the mid 1990s, the market for insurance-linked securities (ILS) in general has grown substantially and only during the recent financial crisis has experienced a reduction in growth (CEIOPS, 2009). ILW contracts in particular became very popular after Hurricane Katrina in 1995 and the breakdown in the retrocessional reinsurance market due the commitment of several hedge funds using ILWs as preferred trading vehicles.

The notional value of the total ILS market now amounts to around USD 50 billion with annual growth rates of 40-50% since 1997 (WEF (2008, p. 6)). ILWs, together with cat derivatives, face an estimated outstanding notional volume of approximately USD 10 billion in 2008 (WEF 2008, p. 10; Swiss Re, 2009, p. 34), whereby ILWs have a substantial share. An exact track volume is unknown so far as the ILW market has no general exchange or clearing source (Cummins, 2008). However, according to several industry reports, the growth rate over the last years appears to be considerable. In 2001, the ILW capacity was estimated to USD 2 billion (Benfield, 2008). The volume increased to USD 5-8 billion in 2005-2006 (Green, 2006) and reached approximately USD 7 billion in 2007 (Benfield, 2008). Furthermore, experts assume that the

ILW market approximately has the size of the cat bond market (Cummins, 2008). According to Guy Carpenter (2009), large ILW capacities have been purchased for 2009 very early, induced by the financial crisis and the associated fear of a drying up cat bond market along with a tight retrocession market.

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. Similar expectations are raised in Swiss Re (2009) due to new ILW creations and an increasing demand by investors from the capital markets. In order to arrive at 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, for example, geographic region, type of catastrophic event, line of business, or duration. Another and more 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).

Indemnity triggers are often included in the contract design to achieve similarity to traditional reinsurance products, which in many countries is necessary for having ILWs accepted as risk transfer instruments for reducing solvency capital requirements (see, e.g., Cummins and Weiss, 2009). If an indemnity trigger is set so low as to be almost surely exceeded, company-specific underwriting costs may be reduced but is not eliminated. The presence of an industry index will imply basis risk and reduce the opportunity of an ILW contract being 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).

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

Transaction costs

The most important advantage of ILWs over traditional products is substantially lower transaction costs.[2] The industry loss index is very transparent, and thus the underwriting process is simple to implement, as only little information is needed. The index is the main relevant pricing component when – and this is often the case – company-specific indemnity triggers are either not used or are set to a rather low level (see Cummins and Weiss, 2008; Swiss Re, 2009). The usual retention for the indemnity trigger is often set to around USD 10,000 (Swiss Re, 2009) or USD 100,000 only (see Green, 2006), while the industry trigger can go up to USD 100 million (Green, 2006) or even USD 250 million (Swiss Re, 2009). In addition, essentially 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. Contracts may even be available up to ten minutes before a storm actually hits (see Green, 2009). The flexibility is also due to the fact that one contract and one price can be used for multiple transactions, since the industry loss is the relevant and simple pricing component, which does not require extensive negotiations.

Recent efforts to further increase the standardization in the ILW market were already successful, as can be seen by the Swiss Re initiatives "Swiss Re Natural Catastrophe Swaps" (SNaCS™) for standardized contracts on U.S. wind and earthquake events and the International Swaps and Derivatives Association (ISDA), which released definitions of key terms to increase transparency and liquidity in the market (see Swiss Re, 2009).

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) and are thus much less flexible (see Breen, 2006; Green, 2006). In particular, this goes along with legal costs, costs for ratings, administrative costs, and the purchase of interest rate swaps. In addition, according to WEF (2008), single ILWs can be offered with layer

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[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 in the demand of ILWs on the retrocession market.

limits in the range of USD 1 million to 250 million, while cat bonds need to cover at least USD 100 million to be cost-effective. Due to the low transaction efforts, the ILW market has low entry barriers for market participants, which, apart from reinsurers, include hedge funds, sidecars and other institutional investors (see Benfield, 2008).

Moral hazard

The introduction of an index trigger leads to a reduction of moral hazard compared to traditional products, since the industry loss usually is 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 in terms of reducing moral hazard, it also introduces basis risk. 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. Using an industry index thus induces a tradeoff in regard to moral hazard and basis risk, which has been frequently analyzed in the literature (see, e.g., Doherty and Richter, 2002).

ILWs only represent an effective hedge for the purchaser if its portfolio highly matches the industry loss experience. For the most part, ILWs are traded only on the retrocession market, 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 expertise. 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, basis chance is also involved, since the ILW payoff is taken out if the purchaser has little losses, even though the overall industry loss exceeds the predefined trigger.

Counterparty risk

Another important factor in ILWs is the counterparty risk. While counterparty risk must be considered in the context of traditional reinsurance products, ILWs are often collateralized. According to estimates, up to 40 percent of the ILW market supply is drawn from collateralized markets (Guy Carpenter, 2009). Particularly hedge funds have to offer collateral since they have no rating and thus need to provide securities to be able to sell their products. However, there are also reinsurance firms with A- rating by A.M. Best founded in, for example, Bermuda, that offer ILWs without collateral. The level of collateralization and thus the 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. Hence, while cat bonds set up an SPV to eliminated default risk, ILWs use collaterals, whereby the management of collaterals might as well drive up the transaction costs of ILWs. However, to our knowledge, this effect has not been investigated empirically to date.

Pricing and risk loads

Due to the low set second (indemnity) trigger, 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. Loss estimation is conducted by means of proprietary models for windstorm, earthquakes, and other natural hazards that are 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; Swiss Re, 2009).

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. The main difference between ILWs and traditional reinsurance is that the latter is priced based on the insurance portfolio of the protection buyer, whereas ILW prices depend on the probability of occurrence of a catastrophic event (Green, 2006). Prices are typically given as a rate-on-line, which describes the price of the contract as the ratio of the reinsurance premium to the maximum possible payout under the contract (Cummins and Weiss, 2009, p. 502)

In addition, ILW prices are highly correlated with reinsurance prices and may as well depend on insurance cycles. An overview of the development of the rate-on-line of ILWs from April 2002 to July 2008 is provided in Cummins and Weiss (2009, p. 512), and in Benfield (2008, p. 7) from 2004 to 2008, also illustrating the increase in prices for U.S. windstorm exposure over the last years. A very recent increase in ILW prices of around 40 to 60 % has been caused by the Deepwater Horizon oil catastrophe in the Gulf of Mexico in June 2010 (Sclafane, 2010).

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 have long not been equivalent indices 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, which may raise concerns regarding availability and reliability of the data.

Initiated by the Chief Risk Officer Forum, efforts and activities in Europe by major European insurers and reinsurers have successfully led to the development of a European index based on data estimates of insured European natural catastrophe losses. These loss data – similar to the PCS index – are provided by an independent organization named PERILS, located in Zurich, 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 Catastrophe Risk Evaluation and Standardizing Target Accumulations (CRESTA) zones (WEF, 2008, p. 15). Moreover, 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 hurricanes and the Carvill Hurricane Index (CHI). The first deals based on this new European index have been launched in October 2009.

Regulation and accounting

The acceptance of ILWs as reinsurance instruments in accounting is a critical factor in the attractiveness of this form 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 be regarded as risk instruments under IFRS and US GAAP, and not as financial derivatives (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 likewise play an important role in solvency considerations. 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 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	Not existent in case of binary contract design; low in case of an indemnity-based contract if indemnity trigger is set to a low level and thus almost surely exceeded
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	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	Uncertainty in regard to treatment, but should be recognized as risk instru-

accounting	ments under IFRS/US GAAP, not as financial derivatives; basis risk is a problem for acknowledgement under Solvency II

Example of an ILW contract

To illustrate an ILW contract and to show its potential differences to traditional reinsurance treaties, we refer to an example given in Zeng (2000), p. 28-29.[3] The insurer in focus has a geographically diversified underlying portfolio in Florida. Loss coverage can be provided by an aggregate excess of loss reinsurance treaty with an layer of 300 million USD and an attachment point fixed to 1.4 billion USD. Given an approximation of the loss distribution of the underwriting portfolio of the insurer, the attachment point is derived in respect to the 100-year-loss (1%-quantile). Alternatively, an ILW contract with an layer of 300 million USD could be purchased by the insurer based on the industry loss index in Florida. The 100-year loss indicated by the index is approximately given by 40 billion USD. As described in the section "basic risk", the net probable loss when purchasing the ILW can be greater or less than the one remaining in case the aggregate excess of loss contract had been purchased due a not perfect correlation between the industry loss and the company's loss. In the parameterization used in Zeng (2000), the excess of loss coverage reduces the probability to exceed a loss greater than 1.4 billion USD from 1% to 0,5%, while the ILW only reduces this probability to 0,7%. However, not only the payoff of the two contracts will differ in insurance practice, the same holds true for market prices and technical prices (see Section 3 for more details).

Another example is provided by Swiss Re (2009, pp. 16-17), where a company is considered that seeks protection for U.S. nat cat exposure and thus purchases an ILW contract based on the overall PCS index. The contract has the following characteristics:

Contract term	12 months from 1 January 2010
Industry loss attachment	USD 20 billion
Limit of protection	USD 10 million
Retention	USD 10,000 (indemnity trigger, usually small)
Rate-on-line	10% (of protection limit, i.e., the up-front premium amounts to USD 1 million)
Reporting period	36 months from the date of loss

[3] Zeng (2000) refers to Catalyst® for the used data in the example.

In this case, the contract pays 10 million if the PCS loss amounts to 20 billion or higher, provided that the protection buyer sustains an ultimate net loss of 10,010,000. If the PCS loss does not reach the attachment, the buyer has 36 months to make a recovery if the original loss develops to finally reach the attachment point. One could also adjust the contract design to model a linear payoff between USD 20 billion and 30 billion, such that the buyer receives 0 if the PCS loss is below 20 million, 50% if the PCS loss is 25 billion (i.e., the payoff is equal to 5 million) and 100% if the PCS loss is 30 billion or higher (i.e., the payoff equals 10 million).

Attractiveness of ILWs from the buyer's perspective

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). However, the categorization of factors in respect to advantage and disadvantage can only represent a general tendency, as the final evaluation of each factor depends on the individual company objective.

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**
Complexity of contract design and creation process	+	-	-
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)	-	+

In the following, two points listed in Table 2 are focused, namely complexity of contract design and creation process as well as transaction costs. A discussion of the first point appears necessary, since catastrophe bonds can also be classified into index-based bonds and indemnity-based bonds, similarly to ILWs, which may convey the impression that a cat bond is not more complex than an ILW contract. However, compared to cat bonds, ILWs can be emitted much faster due to a simplified and standardized pricing based on the industry loss index that does not need to be adjusted extensively for different contracts (Benfield, 2008). The design of cat bonds is in general more individual and specifically tied to the protection buyers needs, thus typically requiring the involvement of a model firm to estimate the probability of loss and expected payoff. Furthermore, ILWs are highly flexible with regard to the type of index used (it could even be ZIP-based), they do not require an SPV, and are often not rated, which further simplifies their creation compared to cat bonds (Breen, 2006). Finally, cat bonds offer a higher liquidity, which, due to the fact that the contract term of ILWs is typically at most one year, is not a severe impediment for investors (Green, 2006).

Tied to the overall lower complexity of contract design and creation process, ILWs also feature lower transaction costs compared to cat bonds and traditional reinsurance for several reasons. First, the costs of establishing a cat bond transaction are much higher compared to ILWs. Fees alone may already amount to USD 5-10 million, which are further increased by modeling costs, costs for counselors, legal costs, and rating agencies (Breen, 2006). Second, compared to traditional reinsurance, the pricing risk is substantially lower since only the industry loss distribution, or, to be more precise, the expected loss needs to be estimated instead of the whole insurance portfolio of the protection buyer, which considerably simplifies underwriting process. Third, costs are lower due to less information asymmetry (see Ishaq, 2005).

Overall, even if ILWs and the alternative risk transfer entrustments have the same payoffs and catastrophic loss process (using a similar trigger) and their prices should thus be the same theoretically, differences in prices can be caused by portfolio considerations, capacity, size, market inefficiencies as well as effects of regulation and taxes. In this situation, the ILW has an advantage in prices for (re)insurers to hedge catastrophic losses over a catastrophe bond.

In summary, even though ILWs are not actively traded as securities Green (2006), a company may sell an ILW with an industry loss trigger of USD 40 million and purchase another ILW with a trigger of USD 50 million, thus aiming to balance its risk. Alternatively, ILWs can also be used to hedge cat bond portfolio exposure by purchasing an ILW with a similar trigger. Furthermore, ILWs provide a possibility for reinsurers to increase their capacity and can also be used by primary insurers and reinsurers to cover existing gaps in protection (Green, 2006).

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 discuss the limitations of these approaches' appropriateness for the valuation of ILWs and a measure of basis risk.[4]

General model specifications of ILW contracts

Industry loss warranty contracts are designed in one of two ways.[5] In one, a binary contract pays out a fixed amount if the industry-wide loss exceeds a predefined threshold. The other ILW design is indemnity-based: the reinsured company's loss must exceed a certain amount and the industry loss must be larger than a preset trigger. However, the one feature that is common 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

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

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

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

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 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 links insurance premiums to ruin theoretical stability criteria – a certain probability of ruin – and thus deduces actuarial premium calculation principles with the assumption of risk aversion. There are several actuarial approaches for determining the loading, resulting in correspondingly different pricing principles.[6] In practice, the actuarial ILW premium is typically obtained by adding risk loads (and a compensation 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

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

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 an indemnity-based ILW, the dependency (linear or non-linear) between S_1 and I_1 plays an important role in obtaining the premium $\pi^{ILW,ib}$ (see Gatzert and Kellner, 2010). We expect that in many cas-

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

es, closed-formed expressions for $X_1^{ILW,ib}$ do not exist and approximations – for example, 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, which may be expressed as $X_1^{ILW*} = X_1^{ILW} \cdot \left(1-d^*\right)$, where *d** represents the portion of cases in which the counterparty is not able to cover the payments according to the loss distribution. Hence, counterparty risk is accounted for. A concrete example for *d** is laid out in more detail in the following description of financial pricing approaches, which can be interpreted similarly in the context of actuarial pricing concepts.

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 an 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 for the binary or the indemnity-based contract (denoted by *(ib)* in the following formulas), discounted with the risk-free interest rate *r*, is a martingale under the risk-neutral measure *Q* (see, e.g., Björk, 2004):[7]

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

In the special case of the Insurance Capital Asset Pricing Model (ICAPM), $E^Q\left(X_1^{ILW,(ib)}\right)$ coincides with the certainty equivalent *CE*: [8]

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

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

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

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

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

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) and 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.

If replication or diversification are not achievable, other valuation approaches may be implemented. One can first assume that individuals cannot 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. An example where preferences are based on expected value and standard deviation ("EV/Std-framework") is given in e.g. Doherty and Richter (2002). The second valuation approach is based on an incomplete market setting in which 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

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

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

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

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 taking into account the default risk of the seller, $\hat{\pi}_1^{ILW,(ib)}$, can be derived from

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

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 stipulated in Section 2, ILWs are often collateralized in order to reduce counterparty risk, implying that a low safety level in terms of the default-value-to-liability ratio can be compensated for, thus increasing the ILW premium, i.e.,

$$\hat{\pi}^{ILW,(ib)} = \pi_1^{ILW,(ib)} \cdot \left(1 - \tilde{d}\right),$$

where $\tilde{d} \le d$.

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 index triggers are used, 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):

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

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

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

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.,

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

In line with the overview from the contract features laid out in Tables 1 and 2 (cf. section 2), the equation for $E\left(X_1^{ILW,ib}\right)$ also illustrates theoretically 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 in comparison to a traditional reinsurance contract.

Implications: Actuarial versus financial pricing methods

As described in the section on contract features, mainly actuarial pricing concept is used instead of financial pricing concepts. There are several important differences in the pricing approaches discussed in the previous sections.[9] The actuarial methods evaluate individual contracts without considering diversification either in the market or in the existing portfolio of the ILW seller.[10] 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, 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 only influences 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 decreases. 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 approach, lowering r implies a lower probability of exceeding the indemnity and industry triggers. Thus, the contract payoff is reduced.

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

10 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.

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 duplication of I_1 and S_1 (in the case of an indemnity-based treaty) via traded financial instruments – is not fulfilled and there is no unique price for ILWs. In this case, the price of ILWs depends on the participants' risk attitudes, which are also partly reflected in the loading of ILWs in the actuarial pricing model and in the risk premium in the financial pricing models. Hence, knowledge of the participant's risk attitudes is crucial when assessing the price of ILWs.

In general, pricing frameworks react very sensibly to changes in the input parameters. This is especially the case in respect to indemnity-based ILW contracts; whereby 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. Overall, the discussion shows that and knowledge of risk attitudes is a central issue and that an actuarial pricing approach is generally suitable for evaluating ILWs.

4. Models on Insurance Demand and there Implications 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 by signing a contract. However, in insurance practice, some assumptions of "perfect" market conditions – as in the case of information symmetry – may need to be relaxed and hence, the trading of ILW treaties could lead to advantages for buyers and sellers.[11] For instance, Mayers and Smith (1982) discuss several reasons that stress the relevance of (re-)insurance in general. In particular, we find two aspects to be important in respect to the demand of ILWs. Firstly, this special form of risk

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

transfer can help to shift risk away from those stakeholders (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 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 the replication of the underlying of an ILW contract via capital market instruments cannot be provided, a preference-dependent valuation is needed. In general, adequate instruments traded on the capital market that allow the derivation of a replicating portfolio for the payoff of an ILW contract do not exist. The reason for this is that the ILW-payoff is based on the company’s (and / or industry) loss distribution. In order to use a preference-dependent valuation technique, a specific target function for the ILW buyer must 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. To overcome this problem, Zeng (2003) provides numerical examples 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 in general is analyzed. A decision maker with mean-variance preferences is focused, who can purchase an index hedge – in our case, the 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 an ILW contract in this framework 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 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 existence 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.[12] In this context, policyholders 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. An insurer could use ILWs to improve its safety level in order to maximize 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. As laid down earlier, we believe the part that can be replicated by capital market instruments to be rather small. For the fraction of the ILW contract that cannot be replicated, premium loadings are 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 and 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 confer advantages upon both ILW sellers and ILW buyers when closing a contract. This requires a situation in which the seller of an

[12] See Gründl and Schmeiser (2002), p. 461 ff.

ILW contract faces advantages in post-loss financing—caused by its better diversified portfolios—compared to the situation of the ILW buyer.

5. SUMMARY

In this paper, we studied the key characteristics of industry loss warranties. In addition, we presented several pricing approaches, measures of basis risk, and 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 given 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 are offered, for instance, 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 as risk transfer instruments in the future. However, the attractiveness and the growth 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 extent ILWs will be recognized as risk transfer instruments under, for example, 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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