Will Investors Buy Extreme Cyber Risks?

Abstract

This paper aims to investigate investor preferences for cyber insurance-linked securities (ILS) and lays a foundation to understand the drivers of demand for cyber ILS. We run a choice-based conjoint (CBC) analysis for ILS in the cyber context. The analysis is based on an online survey among fund managers in the ILS market and will include five central product attributes: risk type, ILS instrument, maturity, trigger and spread. Based on this approach we aim to estimate individual-level part-worth utilities by means of a hierarchical Bayes model. Drawing on the elicited preference structures, we will then compute relative attribute importances. Our findings will give issuers of ILS contracts (e.g. insurers) a deep understanding of proper instrument attributes for different cyber risk classes they can expect to be accepted by the capital market. In addition, the results can help to find (dis-) similarities to the established transfer of other risk categories that lead to a sharper image of the cyber risk transfer.

Keywords: ILS, Cyber Risk, Preferences, Choice-based conjoint analysis

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1. Motivation

The market for insurance-linked securities and other alternative risk transfer solutions has been growing rapidly over the last decade with the total amount of capital under management in ILS funds surpassing $100 billion in 2018 (Artemis, 2018a). With increasing market size, also the perception and acceptance of ILS grew amongst both investors and (re-) insurers providing both parties new possibilities to trade risks and further facilitate the convergence between the capital and insurance market. For investors, investments in ILS help to diversify their portfolios due to the low or uncorrelated nature of the insured risks with traditional financial market products such as equities and bonds. For (re-) insurers, ILS help to overcome the limited risk-bearing capacity of reinsurance markets especially for catastrophic losses and to manage risk that was historically considered to be uninsurable in the reinsurance market (Cummins and Weiss, 2009; Kampa and Siegert, 2010).

The past evolution of the ILS market has been mainly driven by covering “traditional” lines of property and casualty insurance related to natural disasters such as hurricanes or earthquakes, which belong to the class of low frequency and high severity risks (Kampa and Siegert, 2010). An emerging member of this class are extreme cyber risks. Extreme cyber risks, in contrast to small cyber risks, can be characterized by their high impact across borders and industries in case of an event resulting in significant losses. The Center for Strategic and International Studies estimates the global loss potential for cyber risk to be close to $600 billion, which is nearly one percent of the global GDP and exceeds that for natural catastrophes (Lewis, 2018). In contrast to catastrophe risks like hurricanes and earthquakes, the impact of extreme cyber events is not restricted to a predefined geographical area, but can also spread its influence across boundaries and markets. Geographical diversification as one fundament of cat bond investing thus might not work for cyber risk.

Cyber risks are considered as one of the biggest future threats for the economy and society and for this reason also as a potentially big insurance market.[1] Although the current market volume for cyber risk insurance is rather small, the huge growth potential has triggered an immense interest to find alternative solutions for the insurability of those risks. Some industry experts considered cyber risks as a natural target for ART (Artemis, 2018b) and first transactions already exist (Artemis, 2016). However, given the special characteristics of cyber risks it remains unclear in how far an ART will work on a broader scale for these types of risks.

There is a large body of literature on the use of ART, mainly focusing on catastrophic risk financing. Cummins and Trainar (2009) analyze strengths and weaknesses of reinsurance and securitization. Basis risk, which results when a loss index and the true losses of the insurance company are not perfectly correlated, is examined in Doherty and Richter (2002) and Gatzert and Kellner (2011). Possible explanations for the gap between theoretical and true catastrophe insurance demand are discussed in Froot (2001). The potential use of ART techniques to transfer extreme cyber risks has been discussed in a few industry studies (e.g. Eling and Wirfs, 2016), but has not been subject of deeper academic examination. Consequently, this paper lays the foundation to further investigate whether ART works for cyber risks. The scope of this paper focusses on the demand side by conducting a choice-based conjoint (CBC) analysis on the drivers of investor demand for different classes of cyber risks. To the best of our knowledge, this is the first paper to empirically examine this issue.

The paper is organized as follows. Section 2 outlines the methodology for this paper and gives a brief review of CBC analysis and random utility theory (RUT). In Section 3, we discuss the selection of product attributes we will consider in the analysis. We conclude in Section 4 by giving an outlook on the expected results.

[1] PWC suggests it will be the biggest non-life sector by 2032.

2. Methodology and theoretical foundations

Methodology

We investigate on growth opportunities of the cyber ILS market by conducting a choice-based conjoint analysis among ILS fund managers in the ART field and deriving key implications for the driver of investor demand in the context of extreme cyber risks transfer. There are several reasons for the CBC approach: First, the market for ILS is dominated by a small number of highly specialized investors. The current active investor base is estimated to be around 32 ILS funds represented by the Eurekahedge ILS Advisers index, which is tracked by a fund of hedge funds solely invested in ILS. Ben Ammar, Braun and Eling (2015) collected data of 56 ILS funds for their study, however also including dead funds.

Assuming a typical participation rate of 20%, this results in a total expected number of seven to ten responses. As a consequence, our study design has to reflect the lack of a broad investors base since it naturally imposes a restriction on the number of respondents. With the CBC approach, we tackle this issue by carrying out an analysis with a reduced number of five attributes and a maximum of three corresponding levels.

Also, we increase the response base by asking the participants 20 questions in a triad comparison. This approach maximizes the information we can retrieve and minimizes possible selection biases resulting from the small respondent base. Second, by conducting a CBC analysis we are able to estimate part-worth profiles and explain which combinations of the considered factors provide investors the highest utility. In the early stage of product development, these information give valuable insight into investors' preferences. Finally, the proposed adaption of five attributes with up to three discrete levels each ideally suits the CBC analysis design.

Theoretical foundations

The theoretical foundations of CBC analysis are documented, e.g. in Braun, Schmeiser and Schreiber (2016). Random Utility Theory (RUT) provides the theoretical basis for CBC analysis (see von Neumann & Morgenstern, 1944; Thurstone, 1927). Let C denote the set of all relevant alternatives, y_i a discrete-choice variable for individual i, and M the total number of alternatives shown in a given choice task $c_i \subset C$. Each individual i associates alternative a with a latent utility U_{ia}. In a utility-maximizing framework, alternative a is chosen (i.e., $y_i = a$), if and only if its utility exceeds that of all other available alternatives, i.e. if $U_{ia} = max(U_{i1}, U_{i2}, \dots, U_{iM})$. To account for the probabilistic nature of choice, RUT describes utilities by means of a deterministic component V_{ia} and a stochastic component ϵ_{ia}, which captures unobserved aspects as well as measurement error (see, e.g., Train, 2009):

$$U_{ia} = V_{ia} + \epsilon_{ia}.$$

The utility-maximizing condition under which a is selected can then be expressed as follows:

$$U_{ia} > U_{im} \qquad \forall\, m \neq a$$

$$V_{ia} + \epsilon_{ia} > V_{im} + \epsilon_{im} \qquad \forall\, m \neq a$$

$$\epsilon_{ia} - \epsilon_{im} > V_{im} - V_{ia} \qquad \forall\, m \neq a.$$

Therefore, the probability of individual i choosing alternative a equals

$$\Pr(y_i = a) = \Pr(U_{ia} > U_{im}) = \Pr(\epsilon_{ia} - \epsilon_{im} > V_{im} - V_{ia})$$

$$= 1 - \Pr(\epsilon_{ia} - \epsilon_{im} \leq V_{im} - V_{ia}).$$

From this point, the Lucean choice model can be derived by assuming that the ϵ are independent and adhere to a Gumbel (type-I extreme value) distribution (see, e.g., McFadden, 1974),

$$Pr(y_i = a) = \frac{\exp{(V_{ia})}}{\sum_{m=1}^{|C|} \exp{(V_{im})}},$$

which is characterized by the independence from irrelevant alternatives (IIA) property. We may now condition on the choice task c_i and explicitly specify V_{ia} and the V_{im} in terms of product attributes to derive the multinomial logit (MNL) model that lies at the heart of the CBC approach:

$$PR(y_i = a|c_i) = \frac{\exp\,(x_a\beta_i)}{\sum_{m=1}^{M}\exp(x_m\beta_i)}.$$

Here, the x are row vectors that include the Q predictors for the characteristics (attribute levels) of the alternatives that appear in choice task c_i and $\beta_i = (\beta_{i1}, \dots, \beta_{iQ})'$ represents the column vector of unknown individual-level parameters (part-worth utilities).

3. Derivation of the determinants for extreme cyber risk transfer via ART

Derivation of Product attributes

The market for Alternative Risk Transfer solutions is well established by today after a slow start with investors utilizing such instruments to diversify their portfolios and receiving higher spreads than comparable corporate bonds (Ben Ammar, Braun and Eling, 2015). Narrowing the ART market down to the (re-) insurance context, ILS represent such instruments with ART structures. Depending on the transferred risk type, the ILS market currently comprises two main segments that refer to the major types of risk: Property-casualty (P&C) as well as life/health related instruments. Whereas most of the latter currently serve as financing tools to relieve capital or monetize future cash flows (Ben Ammar, Braun and Eling, 2015), the former are used to transfer risk and are therefore of particular interest as prospective candidates in the field of cyber risk management. Besides catastrophe bonds, which represent without a doubt the most successful of these ILS instruments, other important instruments include Industry Loss Warranties (ILWs), Sidecars, Collateralized Reinsurance, Contingent Capital and Cat Derivatives like Cat Swaps. These instruments belong to an asset class that is tradable and bond like and has a principal, maturity, interest payment and repayment schedule. A fundamental characteristic of ILS is the incorporation of a loss trigger mechanism, which exactly determines the conditions and characteristics under which the ILS defaults and which is linked to the specific risk it transfers. For a detailed examination of these instruments and triggers, we refer to Ben Ammar, Braun and Eling (2015).

The experience and acceptance of both insurers and investors for different combinations of ART instruments and triggers shows that there is not a single superior strategy to transfer risk. Instead, the optimal transfer for different kinds of risk varies to a great extend: Considering catastrophe risk and the catastrophe bond market in particular, the indemnity trigger is by far the most frequently used trigger (Artemis, 2019). This is not surprising given the associated low basis risk for insurers. However, also investors accept the related moral hazard issues for certain types of catastrophe risk like hurricanes. Contrarily, in the case of brevity risk, i.e. the risk of premature death, MacMinn and Richter (2006) outline a scenario in which index-based triggers are beneficial. Their findings show that for the same strike price cat bonds in conjunction with index-based triggers lead to higher current shareholder value than indemnity-based triggers. The transfer of longevity risk again demands different solutions than the afore-mentioned. The first longevity bond issued by the European Investment Bank in 2004 was withdrawn due to a lack of investor demand (Blake, 2018) although it inherited a longevity index resulting in low moral hazard risk for investors (Azzopardi, 2005). Instead, investors prefer the uncollateralized nature of longevity swaps causing the market for longevity swaps to double in 2019 (Artemis, 2018c). These examples illustrate the diversity of the risk transfer market for different types of risks. As a consequence, the discrimination between different instruments and triggers for specific kinds of risks resembles two key characteristics for the assessment of cyber ILS that we will consider in our analysis.

The determination of specific instruments and triggers is of particular importance in the case of extreme cyber risks. While several sources proclaim tremendous growth of cyber risk transfer in the future, it remains widely unclear which instruments and triggers will allow the market to realize its full growth potential. Describing extreme cyber risks as low frequency and high severity risks is neither enough nor adequate to ensure that instruments of other risks belonging to this class like hurricanes will also work properly here. One reason is the existence of extreme cyber risks like DDOS attacks, that simply do not satisfy this risk profile. Another widely anticipated argument is the correlated nature of extreme cyber risks across borders and markets that distinguishes extreme cyber from i.e. hurricanes. However, it might also be the case that investors will still buy these risks when they receive a compensation in terms of a higher premium in return. Consequently, we consider the spread that such instruments offer investors to be the third key characteristic for our study.

As shown in Eling and Wirfs (2016), the sole characterization as cyber risk is not sufficient to grasp the same understanding among investors. Thus, the examination of investors' interest in extreme cyber risks requires a deeper assessment of this risk category, and especially the large diversity within cyber risks with respect to investors' preferences. Among the central properties of cyber risks derived in Eling and Wirfs (2016), this includes two aspects: First, cyber risks can be both short and long tail and second, the (in-) dependency of cyber ILS with the market. Clearly, investors discriminate the attractiveness of cyber ILS with regard to these two attributes. Short tail and uncorrelated cyber risks will be preferred over long tail and highly correlated risks. To emphasize on the different nature of cyber risks, consider the following example. In 2009, a DDOS attack on Amazon AWS services led to a downtime of 19 hours resulting in websites hosted on AWS to be not accessible. However, as soon as Amazon was able to block the offending traffic, services returned to normal (The Register, 2009). In this case, the potential damage was restricted to the downtime of the service and websites hosted on the platform resulting in a short-tail and low correlation with financial markets. On the other hand, the power outage in Ukraine in 2015 caused by a cyber-attack has shown the vulnerability of the core infrastructure. As stated in Zetter (2016) such widespread e.g. on the U.S. can have a massive impact that is not restricted to the U.S. economy resulting in long tails and high correlation with financial markets. Consequently, a DDOS attack on cloud providers may have completely different characteristics concerning the correlation with the market and tail risk than a power outage. Therefore, it is crucial to distinguish between different types of cyber risks for the assessment of investors' willingness to accept specific instruments.

The coverage of tail risk is closely related to the maturity of the ILS. In case of a securitized asset, the maturity does not only represent the duration of the contract but also how long the collateral is pledged to the issuer. Assuming that the market for ILS is rather illiquid, an investor has no chance to escape (i.e. by selling) the ILS before maturity. Hence, in addition to the risk type, the maturity represents the fifth characteristic considered in the following analysis.

Derivation of product levels

There is no generally accepted approach for the determination of appropriate product attributes and levels to be used in a CBC research design. As explained above we decided to adopt the following five attributes: (i) risk type, (ii) instrument, (iii) trigger, (iv) maturity and (v) spread. For the outcome of this CBC analysis, the differentiation between risk types in the extreme cyber risk context imposes a task of particular importance. Instead of differentiating between different risks like power or telco widespread, the attribute "risk type" differentiates between the characteristics of various extreme cyber risks. Since both power and telco outage belong to the class of low frequency, high severity and heavy tail risks, they will be assigned to the same risk category. Consequently, the second level of this attribute are low severity, high frequency risks with a short tail. As a representative of this class, we choose DDOS attacks. The reason to consider multi-peril ILS for the third level stems from the experience that such contracts are frequently traded. Also, the consideration of such a contract provides us with a benchmark to compare against in the evaluation.

For the second attribute "instrument", we differ between a funded format represented by a bond and an unfunded format like a swap or an ILW. This differentiation helps us to reduce the complexity and still capture the major difference between the most common instrument classes.

Third, concerning the maturity of the instrument we refer to standard indicators often used in similar asset classes for the sake of comparability with a range from one to ten years.

Fourth, the trigger choice covers a range from low (parametric trigger) to high (indemnity trigger) moral hazard. From an investor's perspective, moral hazard is closely linked to basis risk. Consequently, this attribute gains its importance in combination with the spread investors demand that is captured in attribute 5. Since cyber marks a new type of risk that most investors are not familiar with, it is likely that they will ask for a compensation of the associated uncertainty in form of a novelty premium. This has also been the case for the transfer of other catastrophe risks via bonds in the early stage (Bantwal and Kunreuther, 2000). Following this argumentation, however, the dimension of the novelty premium will decrease with rising investors' cyber risk expertise. As mentioned before, the severity of cyber risks is not necessarily limited to, say, a particular geographic area or industry. As a consequence, the accumulation risk has to be considered which may result in significant associated losses. When comparing cyber to traditional catastrophe risks, potential buyers of these risks will expect a compensation for the heavy tail risk associated with cyber. In contrast to the former, this premium is related to the core nature of extreme cyber risks. Therefore, we assume higher spreads than comparable corporate bonds ranging from 5% to 15%. Table 1 summarizes the attributes and levels of our study design.

		Level 1	Level 2	Level 3
Attribute 1	Risk type	Low severity, high frequency, e.g. DDOS	High severity, low frequency, e.g. Power/cloud widespread	Multi-peril
Attribute 2	Instrument	Funded, e.g. Bond	Unfunded, e.g. Swap	-
Attribute 3	Maturity (years)	1	3	10
Attribute 4	Trigger	Parametric	Industry Loss	Indemnity
Attribute 5	Spread (%)	5	10	15

Table 1: Study design

4. Outlook

The expected results can partially be explained by tendencies currently observable in the market: For long tail risks with possible correlations, investor's utility will sharply increase with an unfunded instrument format, a parametric trigger that incorporates low basis risk and a high spread. On the other hand, we expect a more balanced utility for uncorrelated risks with short tails. Specifically, it might be the case that investors are indifferent between parametric or indemnity trigger for those risks, when they receive a higher spread in return. Drawing from the natural catastrophe market, they might also prefer the simple bond structure in combination with short maturities. The evaluation of the multi-peril case could lead to the insight that investors do not discriminate between high severity/low frequency and multi-peril ILS.

Due to the focus on the demand side, our findings will give issuers of such contracts (e.g. insurers) a deep understanding of proper instrument attributes for different cyber risk classes they can expect to be accepted by the capital market. In addition, the results can help to find (dis-) similarities to the established transfer of other risk categories that lead to a sharper image of the cyber risk transfer.

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