Risk Analysis of Catastrophe Bonds from the Perspective of Investors

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Scientific assessment of catastrophe bonds as investments:

- New asset class; “Pure Play” in insurance risk
- Almost no correlation with ordinary asset classes
  → Possibility to shift portfolios’ efficient frontier upwards
- Special risk-return-characteristic
  - High returns for investors despite being “zero-beta” assets
  - Outperformance of Treasury bills and equally rated corporate bonds

“The historical evidence suggests the addition of cat exposures to investment portfolios is equivalent to a free lunch for investors and insurance consumers alike.” Froot et al. (1995)
Warren Buffett Predicted in his 1997 Chairman’s Letter:

“Catastrophe bonds may well live up to their name!”

- The word “bond” is an Orwellian misnomer.
- Truly outsized risks will exist in these contracts if they are not properly priced. Mispricing may remain undiscovered for a very long time.
- Risk assessment of natural catastrophes is fuzzy.

Goal of Presentation: Investors have to be aware of risks and characteristics of catastrophe bonds
Traditional Risk Securitization Structure

1. **Highly-Rated Short Term Investments**

2. **(Re)Insurer as Cedent**
   - Premium
   - Contingent Claim Payment
   - Cat XL-Reinsurance Contract

3. **Special Purpose Reinsurer**
   - Investment Earnings
   - Principal + Premium
   - Principal
   - Principal + Premium + Interest – Contingent Claim Payment

4. **SWAP Counterparty**
   - Scheduled Interest (e.g., LIBOR)
   - Fix Payment
   - Event-Dependent Payment

5. **Investors**
   - Investment Earnings
Risk Securitization Structure after Lehman Brothers (†)

Highly-Rated Short Term Investments

(Re)Insurer as Cedent

Investment Earnings

Premium

Contingent Claim Payment

Cat XL-Reinsurance Contract

Principal + Premium

Investors

Principal

Premium + Interest − Contingent Claim Payment

Fix Payment

Event-Dependent Payment

Premium
Investors’ Situation at a first Glance

- Highly tailored investment products
- Classical insurer risks connected with holding catastrophe bonds:
  - Acceptance of a fix premium upfront for the coverage of an uncertain loss amount later
    → Investors bear underwriting risk
  - Investment of premium and principal
    → Investors bear investment risk (market, credit, liquidation value risk)
- Investment risk by embedded options (e.g. optional extension periods, call options)
- Investment risk by overestimating outperformance and underestimating correlation
The underwriting risk of catastrophe bond investors consists of the uncertainty whether the calculated premium is enough to cover the upcoming claims expenditures.

Investors’ underwriting risk is specified by
- errors in the risk assessment before investing,
- changes in the risk’s behaviour,
- and the random character of insurance events during the holding period in the context of low frequency-high severity risks.
High uncertainty (epistemic and aleatory) in the assessment and prognosis of catastrophe risks
→ Caution with the results of catastrophe models
→ Possible risk assessment in favor of cedents

Appearing misestimations may cause price adjustments

Excess-of-loss contracts as instruments to transfer the risk of high random deviations

⇒ In summary, catastrophe bond investors carry the risk of a pure accidental, catastrophic, and difficult to assess reinsurance claim. This exceeds their premium by far and happens coincidentally in their holding period.
Briys et al. (1998):
- Standard deviation as inadequate risk measure for highly-skewed return distributions
- Past performance of highly-non stationary investments as inappropriate estimator for the future one
- Catastrophe bonds have a relatively high interest rate sensitivity

Blum et al. (2002) argue that the joint distribution of insurance and financial risks is unlikely to be elliptical
→ Linear correlation coefficient is inappropriate to model dependency. Underestimates dependency in extreme scenarios
→ Classical portfolio theory is generally not suitable to justify the usefulness of ILSs for investors
Diekmann (2011) shows a significant correlation between catastrophe bond returns, consumption rates, and traditional asset classes. This diversification effect is present but limited. Catastrophes could bring investors to their subsistence level.

Gürtler et al. (2012) discover a positive dependency between corporate credit spreads and catastrophe bond premiums. This dependency rises significantly in extreme market conditions.

Assumptions about outperformance and diversifying effect ("zero-beta" asset) have to be interpreted with care.
Catastrophe Bond Investors’ Wealth Process

- The classical risk reserve process \((U(t))_{t \geq 0}\) is defined as

\[
U(t) = u + ct - \sum_{i=1}^{N(t)} X_i, \quad t \geq 0,
\]

where \(u \geq 0\) stands for the initial capital of an insurance company, \(c > 0\) for its premium income rate, and \(\sum_{i=1}^{N(t)} X_i\), as a compound Poisson process, for the insurer’s random aggregate claim amount of the single claims \(X_1 + \cdots + X_{N(t)}\) up to time \(t\).

- Redefining \((U(t))_{t \geq 0}\) as wealth process for catastrophe bond investors

- Subexponential distributions (e.g. log-normal and Pareto) for modeling heavy-tailed risks
Assume the claims $X_i$ to be subexponentially distributed. Then the wealth process of catastrophe bond investors has following characteristics:

- Comparable high probability for a total loss
- Total loss by one extreme event
- Extreme events happen “out of the blue”
Conclusion

- Individually tailored investments
- High underwriting risk and uncertainty in the correct premium
- Investment risks and interest rate sensitivity
- Highly-skewed return distribution
- Key for successfully long-term investing is the ability to estimate fair premiums
References I


