

Financial black swans driven by ultrafast machine ecology

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ABSTRACT

Society's drive toward ever faster socio-technical systems¹⁻³, means that there is an urgent need to understand the threat from 'black swan' extreme events that might emerge⁴⁻¹⁹. On 6 May 2010, it took just five minutes for a spontaneous mix of human and machine interactions in the global trading cyberspace to generate an unprecedented system-wide Flash Crash⁴. However, little is known about what lies ahead in the crucial sub-second regime where humans become unable to respond or intervene sufficiently quickly^{20,21}. Here we analyze a set of 18,520 ultrafast black swan events that we have uncovered in stock-price movements between 2006 and 2011. We provide empirical evidence for, and an accompanying theory of, an abrupt system-wide transition from a mixed human-machine phase to a new all-machine phase characterized by frequent black swan events with ultrafast durations (<650ms for crashes, <950ms for spikes). Our theory quantifies the systemic fluctuations in these two distinct phases in terms of the diversity of the system's internal ecology and the amount of global information being processed. Our finding that the ten most susceptible entities are major international banks, hints at a hidden relationship between these ultrafast 'fractures' and the slow 'breaking' of the global financial system post-2006. More generally, our work provides tools to help predict and mitigate the systemic risk developing in any complex socio-technical system that attempts to operate at, or beyond, the limits of human response times.



Royal Institute of Technology

Master's Thesis

Analysis and Optimization of a Portfolio of Catastrophe Bonds

Fredrik Giertz



Abstract

This Master's Thesis in mathematical statistics has the two major purposes; (i) to model and measure the risk associated with a special type of reinsurance contract, the catastrophe bond, and (ii) to analyze and develop methods of portfolio optimization suitable for a portfolio of catastrophe bonds. Two pathways of modeling potential catastrophe bond losses are analyzed; one method directly modeling potential contract losses and one method modeling the underlying contract loss governing variables. The first method is simple in its structure but with the disadvantage of the inability to introduce a dependence structure between the losses of different contracts in a simple and flexible way. The second modeling method uses a stochastic number of stochastic events representation connected into a multivariate dependence structure using the theory of copulas.

Results show that the choice of risk measure is of great importance when analyzing catastrophe bonds and their related risks. As an example, the measure Value at Risk often fails to capture the essence of catastrophe bond risk, which in turn means that portfolio optimization with respect to the same might lead to a systematic obscurity of risk. Two coherent risk measures were investigated, the spectral risk measure and the Expected Shortfall measure. Both measures provides good representation of the risk of a portfolio consisting of catastrophe bonds.

This thesis extends and applies a well-known optimization method of Conditional Value at Risk to obtain a method of optimization of spectral risk measures. The optimization results show that expected shortfall optimization leads to portfolios being advantageous at the specific point at which it is optimized but that their characteristics may be disadvantageous at other parts of the loss distribution. Portfolios optimized for the spectral risk measure were shown to possess good characteristics across the entire loss distribution. Optimization results were compared to the popular mean-variance portfolio optimization approach. The comparison shows that the mean-variance approach handles the special distribution of catastrophe bond losses in an over-simplistic way, and that it has a severe lack of flexibility towards focusing on different aspects of risk. The spectral risk measure optimization procedure was demonstrated to be the most flexible and possibly the most appropriate way to optimize a portfolio of catastrophe bonds.

SEASONALITY MODELLING FOR CATASTROPHE BOND PRICING

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Abstract:

During the last decades, a new category of assets whose return is linked to insurance claims have appeared. Those assets, called catastrophe bonds, are primarily designed by insurers and reinsurers to transfer their risks to other categories of investors, looking for diversification. This paper proposes a method to price such bonds, when the claims arrival process is under the influence of a stochastic seasonal effect. The arrival process is modeled by a Poisson Process whose intensity is the sum of an Ornstein Uhlenbeck process and of one periodic function. The size of claims is assumed to be a positive random variable, independent of the intensity process. In this paper, we show that the expected number of claims can be inferred from the probability generating function and propose a pricing method of the fair coupon based on the Fourier Transform. To illustrate the tractability of our model, we price insurance bonds on claims resulting from tornadoes in the US.

Keywords: catastrophe bonds, doubly stochastic processes, Fast Fourier Transform.

1. INTRODUCTION.

During the last two decades, we have attended to the emergence of a new category of assets, primarily developed to hedge the costs of insuring natural catastrophes. In this context, catastrophe insurance derivatives have been introduced at the Chicago Board of Trade in the early nineties. The value of these securities is directly related to indexes that account the total insurance losses due to natural catastrophes in US, by regions. Reinsurers have also started to propose a wide range of insurance bonds, based upon the mechanism of securitization. Those products offer two advantages. Firstly, they transfer a part of insurance risks from the reinsurers to other potential investors and allow them to increase the reinsurers' volume of transactions. Secondly, insurance derivatives are efficient tools of diversification for institutional investors, that are not exposed in their core business to

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THE DISASTER GAP

HOW INSURERS AND THE
CAPITAL MARKETS CAN
HARNESS BIG DATA TO
CLOSE THE GAP.



BNY MELLON

THE DISASTER GAP: HOW INSURERS AND THE CAPITAL MARKETS CAN HARNESS BIG DATA TO CLOSE THE GAP

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FOREWORD: A LEAP OF FAITH

The time has come for the insurance industry to acknowledge “alternative capital” (capital from outside the insurance industry which is now backing insurance risk; for example from endowments, pension funds or hedge funds) is here to stay, and as a consequence, the debate must move to one which explores how the industry and society can benefit from this capital.

BNY Mellon acts as trustee, paying and collateral agent on both public and private insurance-linked securities (ILS) structures. For example, in the public catastrophe (cat) bond market we act as the trustee on more than 65%¹ of issues. Issuers and structurers like our credit rating, our deep experience and expertise, and our independence.

We believe that within five years public cat bond debt outstanding will have reached the \$50bn mark. Total ILS will be a multiple of that.

ILS is an efficient mechanism for the capital markets to gain exposure to the insurance industry. The low interest rate environment has encouraged investors to look more closely at ILS. We believe that even when interest rates normalise, allocations of institutional investors such as pension funds in ILS will continue to increase because of returns over the London Interbank Offered Rate (Libor) and for reasons of diversification.

Insurers must shift their mindset that returns are only generated by deploying their own capital. We think the tipping point will come when big data (loosely defined as the exploitation of voluminous, fast changing and unstructured data) allows insurers to deploy their own capital and third party capital against new risks. Anticipating the location and size of future earthquakes is still an inexact science, however big data can capture the fragility of buildings and identify areas at risk from future earthquakes and shaking damage.

¹68% market share of CAT bonds issued in 2012, BNY Mellon data matched against market data from Artemis.bm

At the 2013 annual Asia Pacific Risk and Insurance Association (APRIA) Conference, held in New York, BNY Mellon moderated a panel on the role of cat bonds. The conference was attended by more than 200 delegates from 23 countries. Eighty percent of the audience said they believed that ILS, through partnership between nation states, insurers and the capital markets, offers the financial services industry an opportunity to demonstrate its positive contribution to society.

Never has the experience of the insurer been needed more. Deploying capital against much needed cover over non-modelled exposures requires deep underwriting and technical expertise. It is unlikely that the capital markets would provide this cover in the absence of insurers' expertise and the comfort that comes from seeing the insurer also deploying its capital against these previously uncovered risks.

Invariably, there will also be further innovation in the various structures or special purpose vehicles. Here, we urge caution. It would be unfortunate if both issuer and investor understood the risks and returns on offer, only to fall foul of a shortcoming in vehicle design. For example, you may remember at the time of the financial crisis a handful of bonds were impacted by having Lehman Brothers as a total return swap counterparty. Consequently, the investment of the collateral tends to be more straightforward these days.

I am very grateful for the knowledge and insight that has been provided by our diverse range of contributors. I hope you enjoy this paper and that it informs your thinking as you prepare for the changes this new capital heralds.

Paul Traynor, Head of Insurance Segment, International, BNY Mellon



EXECUTIVE SUMMARY

- Convergence between the traditional reinsurance market and the market for ILS has now occurred. An estimated \$50bn of ILS will be in force by the end of this year and the cat bond industry is on track to break the previous 2007 issuance record of \$7.2bn.
- There is huge potential for the ILS sector and cat bond industry to become much bigger. BNY Mellon predicts ILS in force could grow to \$150bn by 2018, with the cat bond share of that total volume worth up to \$50bn.
- The “disaster gap” between economic losses and insured losses is getting wider, leaving governments and society on the hook for the cost of rebuilding. Climate change and urbanisation are expected to exacerbate future losses from catastrophes.
- At present, 75% of this alternative capacity is focused on US peak perils – mainly windstorm and earthquake.
- There is a real opportunity for insurers to properly embrace the cat bond sector, to innovate and become more global. At the same time it will fulfil an important social role in covering the cost of future catastrophes.
- There are numerous challenges to overcome, including the lack of historical data and sophisticated catastrophe modelling in some regions. Big data could be the answer, providing underwriters with tools to price and structure future deals; and investors the tools to assess the risks.
- Insurers must acknowledge alternative capital is here to stay. Insurers and the capital markets working together with big data should be able to deploy this new capital to cover new perils.

THE DISASTER GAP

The gap between the cost of a disaster and the level of insurance was the subject of Lloyd’s Global Underinsurance Report, which came out in 2012. It estimates the annual gap at just over \$168bn. The research, carried out by the Centre for Economic and Business Research defines this gap as the minimum levels of cover necessary and the actual levels that businesses and governments have set aside to rebuild and recover following major catastrophes.

The largest single gap in monetary terms is in China. With rapid economic growth and urbanisation the country’s exposure to earthquake, windstorm and flood losses is growing substantially. Yet only 1.4% of the losses between 2004 and 2011 were insured. One barrier to increasing insurance penetration in countries such as China is the role the government takes as insurer and reinsurer of last resort. “In China there is this attitude of government paternalism to the public when it comes to disasters,” says the World Bank’s Eugene Gurenko.

ABOUT BNY MELLON

BNY Mellon is a global investments company dedicated to helping its clients manage and service their financial assets throughout the investment lifecycle. Whether providing financial services for institutions, corporations or individual investors, BNY Mellon delivers informed investment management and investment services in 35 countries and more than 100 markets. As of September 30, 2013, BNY Mellon had \$27.4 trillion in assets under custody and/or administration, and \$1.5 trillion in assets under management. BNY Mellon can act as a single point of contact for clients looking to create, trade, hold, manage, service, distribute or restructure investments. BNY Mellon is the corporate brand of The Bank of New York Mellon Corporation (NYSE: BK). Additional information is available on www.bnymellon.com, or follow us on Twitter @BNYMellon.

The insurance industry is a key focus for BNY Mellon:

- Globally, clients include 78 of top 100 Life Insurers² and 68% of top 50 Non-life insurers²;
- We help Insurers manage and service their financial assets throughout the investment lifecycle. We maintain insurance assets under custody of more than \$2 trillion³;
- We are a top-5 manager by AUM globally, managing more than \$70 billion¹ in insurer assets;
- We help Insurers manage their liabilities:
 - by helping them issue ILS – we are the world’s largest catastrophe bond (cat) trustee; or
 - by using insurance trusts to marry-up assets and liabilities in a jurisdiction. We administer some 1,950² trusts with \$176 billion in assets.
- We were the first investment services firm in Europe to launch
 - a data management solution to meet the asset data reporting requirements arising out of Solvency II;
 - a Solvency II compliant Insurance Trust vehicle in Europe.

²BNY Mellon client data as matched against A.M. Best industry rankings publication as of December 2012

³As of 31 December 2012