MULTIFACTOR SPREAD MODELS FOR CAT BONDS IN THE PRIMARY AND SECONDARY MARKET

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CONTENT

I. Introduction

II. Preliminary Review of Models

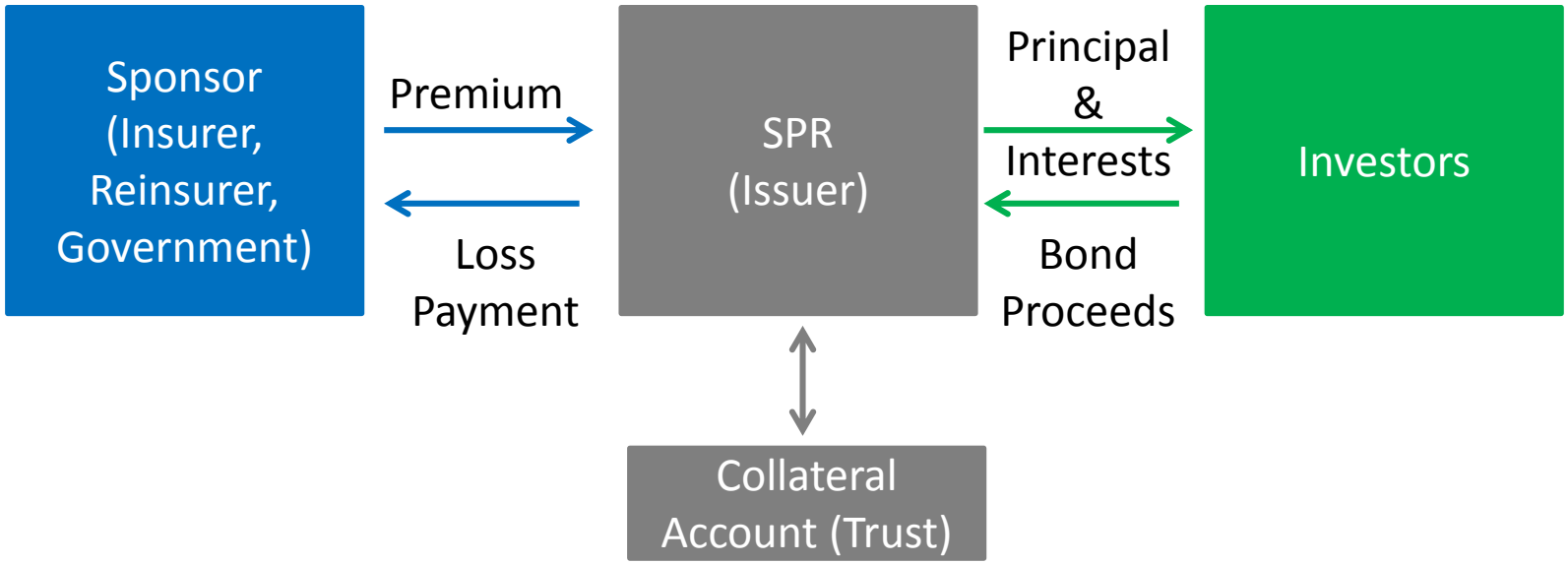
III. Multifactor Spread Models

IV. Conclusions and further research

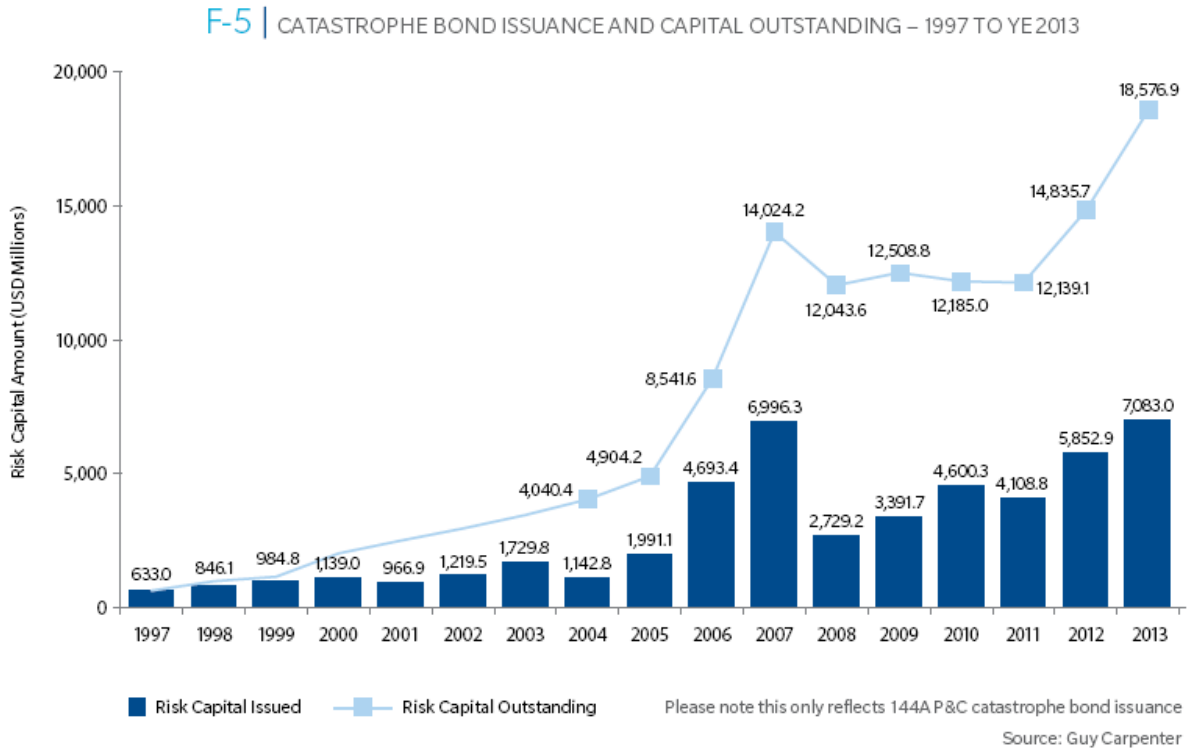
I. INTRODUCTION

Catastrophe Bonds:
Collateralized securities, with contingent payments upon the occurrence of a defined catastrophic event.

Structure of a Cat Bond:



Risk Capial Issued Quarterly



Historical Returns

Index	Annual Returns (2002-2012)	Volatility
Swiss Re Cat Bond Total Return Index (SCATTRR)	7.98%	2.79%
Dow Jones Credit Suisse Hedge Fund Index	6.38%	5.91%
S&P 500 Index	1.06%	16.24%
Dow Jones Corporate Bond Index	1.19%	6.70%
Private Equity Total Return Index	-2.26%	30.23%

II. PRELIMINARY REVIEW OF MODELS

Categories of Cat Bond Models according to *Galeoti et al (2013):*

Bond Pricing	Indifference Pricing	Premium Calculation Model
• Cat Bond as a portfolio consisting of a variable interest bond and an option whose exercise will depend on a catastrophic event	• Utility function, in which the indifference price is that for an agent with the same expected utility level between exercising a financial transaction and not doing so.	• the price which is also referred to as spread consists of the expected value of loss plus a load for risk margin and expenses.

Conclusions on each Cat Bond Models categories:

Bond Pricing

- A portfolio replicating a cat bond payment structure is hard to found, leading to Incompleteness which causes that a unique price cannot be derived.
- The modeling of the catastrophic event remains a challenge.
- Cash flows of the Cat Bond are considered to depend only on catastrophe risk variables, which is not necessarily true

Indifference Pricing

- Since the market for Cat Bonds lacks transparency for those privately placed bonds, and every contract is individually designed, it is almost impossible to verify the use of the pricing models by empirical analysis.

Premium Calculation Model

- it focuses on determining the spread paid to investors, which is ultimately the variable were risk and return converge.
- has a comprehensive vision, in which assumes that the spread depends not only on the expected loss but on a risk premium, which is open for the authors to define how it is measured.

Contribution of our research:

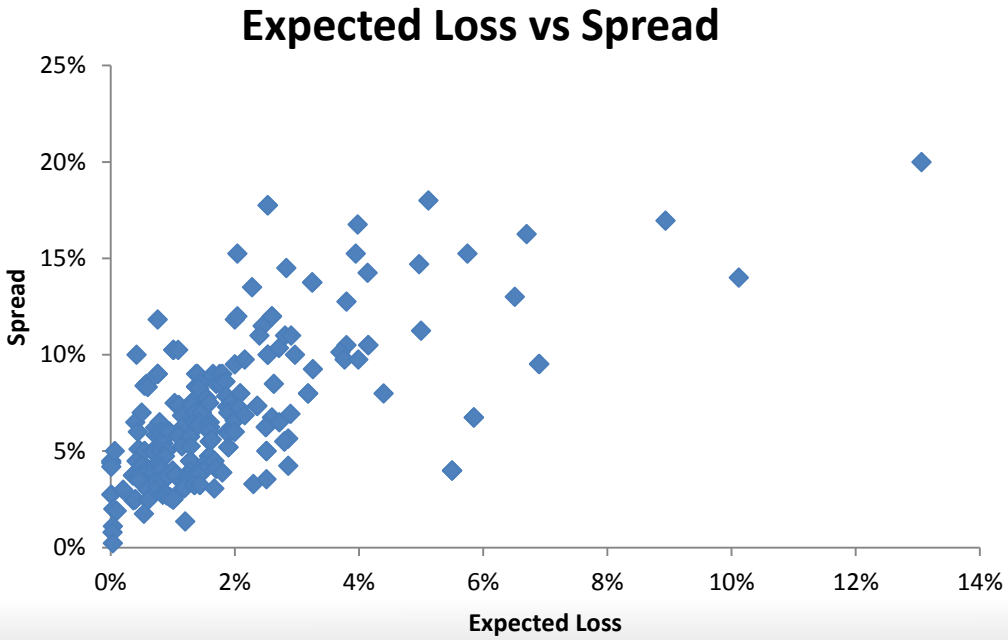
	Previous Authors	Multifactor Spread Model
Primary Market	Focused on Expected Loss	12 Significant Variables. Most relevant: Expected Loss
Secondary Market	Focused on Probability of ocurrence of Cat events	5 Significant Variables Most Relevant: Time to maturity Factor

*High Accuracy
*General application to P&C and Life

III. MULTIFACTOR SPREAD MODELS

SPREAD IN THE PRIMARY MARKET

- Between 1997 and 2013, 248 new Cat Bonds were issued to the market. ⟶ Database: 194 registers
- Cross checked data. Descriptive information.
- Coupon: Floating interest rate, based on a Risk Free Rate. Libor taken as proxy.



Explanatory Variables:

Internal	*External*
1) Expected Loss 2) Zones covered* (USA, Europe, Mexico, Japan, and Multizone) 3) Perils Covered* (Earthquake, Wind, Mortality, Multi-peril, and Others) 4) Triggering Type* (Indemnity, Industry Loss Index, Modeled Loss Index, Parametric Index, and Hybrid) 5) Credit Rating * (Investment Grade [rated above or on BBB-], Non-Investment Grade [rated below or on BB+] and Not Rated)	6) BB- Bonds Index 7) Interest Rate (Libor) 8) Rate on Line (ROL) Index

Dummy Variables
Base Category

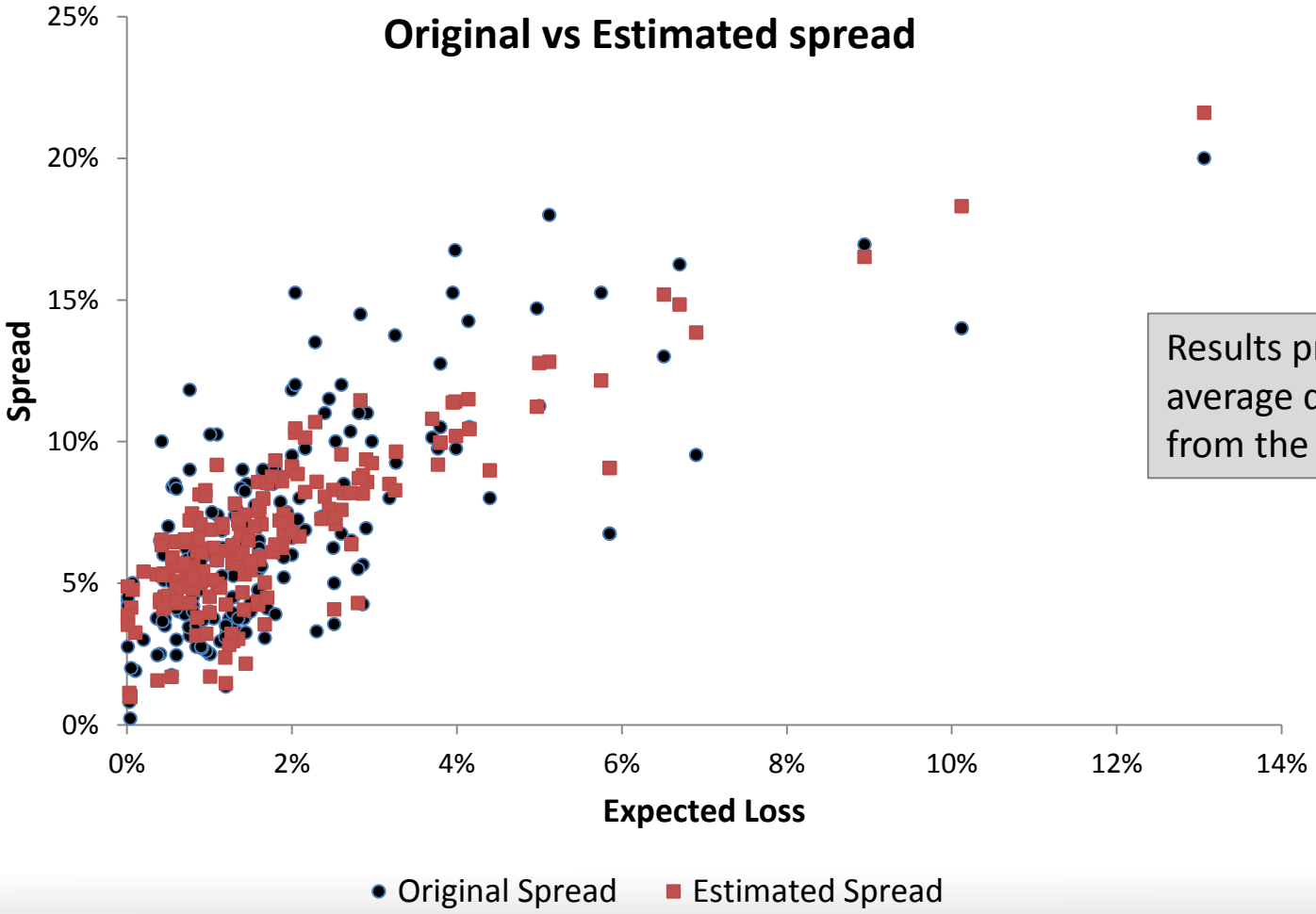
Multifactor Spread Model:

$$Spread_i = \alpha + \beta_{EL} * EL_i + \beta_{EUR} * EUR_i + \beta_{JP} * JP_i + \beta_{Mort} * Mort_i + \beta_{MP} * MP_i + \beta_{Ind} * Ind_i + \beta_{IL} * IL_i + \beta_{ML} * ML_i + \beta_{Inv} * Inv_i + \beta_{HY} * HY_i + \beta_{Libor} * Libor_i + \beta_{ROL} * ROL_i + e_i$$

Variable	Coefficient	Std. Error	
Constant	0.03555	0.015	
Exp. loss	1.23032	0.092	
Europe	-0.02467	0.005	
Japan	-0.01277	0.006	
Mortality	-0.04188	0.010	
Multiperil	0.01698	0.004	
Indemnity	0.00996	0.005	
Industry_Loss	0.01622	0.004	
Modeled_Loss	0.01672	0.007	
Investment	-0.01136	0.006	*
High_Yield	-0.00003	0.000	
Libor	-0.00188	0.001	*
ROL	0.00011	0.000	

* Significant at a 10% confidence level

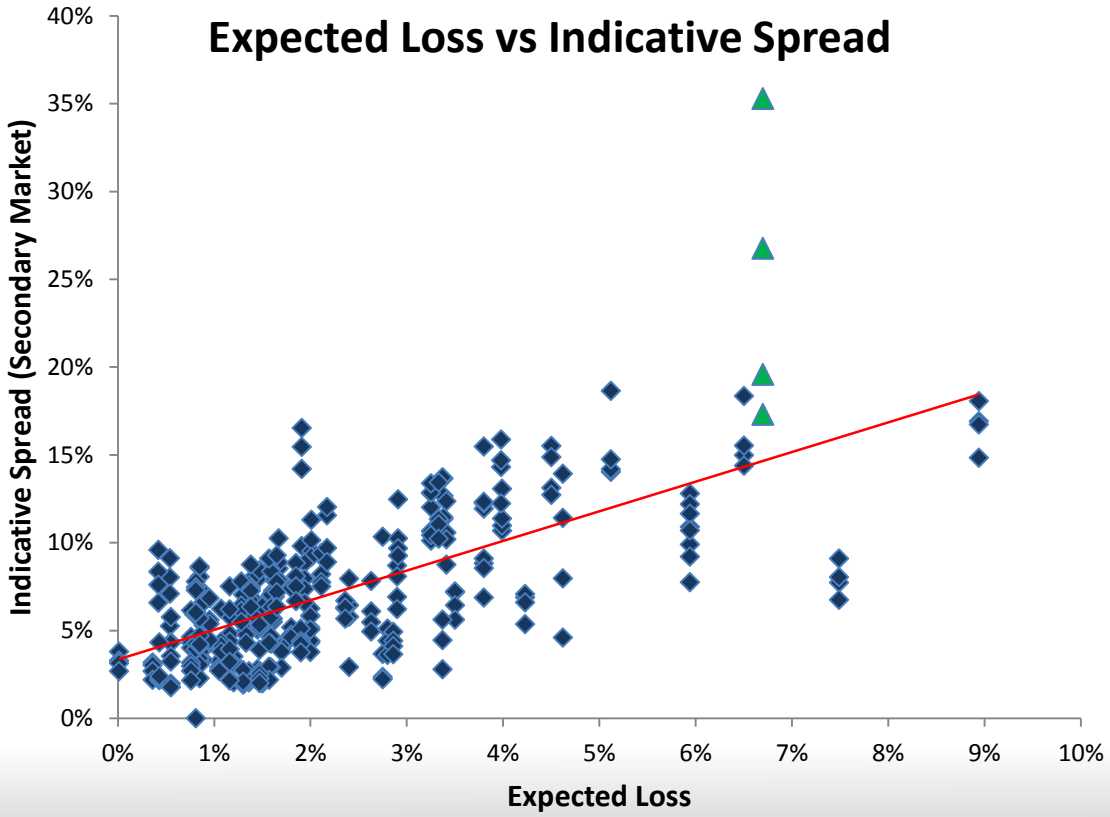
Fitness of the Regression:



Results proved an absolute average deviation of **1.54%** from the original spread.

SPREAD IN THE SECONDARY MARKET

- Lane Financial: Average market indication of every bond's spread on a Quarterly basis
- 81 Cat Bonds outstanding (June 2012 - March 2013) → Data Base: 324 observations



Methodology:

Panel Data:

Multi-dimensional data in which variables are observed for each individual, across several points in time. A panel has the following form:

$$X_{it} \quad i = 1, \ldots, N \; t = 1, \ldots, T$$

Where i is the individual dimension and t is the time dimension.

Panel Data and Cat Bonds

- Tao (2011), and Cummins and Weiss (2009), proved Cat Bonds as a zero beta security, by developing a comparative analysis with other financial securities, using panel data.

- Gürtler et al (2012) explores the impact of the financial crisis on Cat bonds, in a dynamic stage using panel data.

Panel data for assessing the spread of Cat bonds in the secondary market has not been explored yet.

Explanatory Variables:

Internal	*External*
1) Spread at Issue 2) Expected Loss 3) Credit Rating* (Investment Grade [rated above or on BBB-], Non-Investment Grade [rated below or on BB+] and Not Rated). 4) Time to Maturity Factor: $\frac{1}{(T-t)}$	5) BB- Bonds Index 6) Interest Rate 7) Swiss Re Cat Bond Total Return Index (SCATTRR)

Dummy Variables
Base Category

Preliminary Assesments:

Stationarity:	• Evaluated for: Indicative spread, Time to Maturity Factor, BB- Bond Index, Libor and SCATTRR. • Levin, Lin & Chu Unit Root test for panel data. All p-values<= 0.05
Unobserved heterogeneity:	• Breusch-Pagan test with p-value = 0.000
Fixed Effects or Random Effects?:	• Hausman test with a p-value = 0.9993 ↓ Random Effects

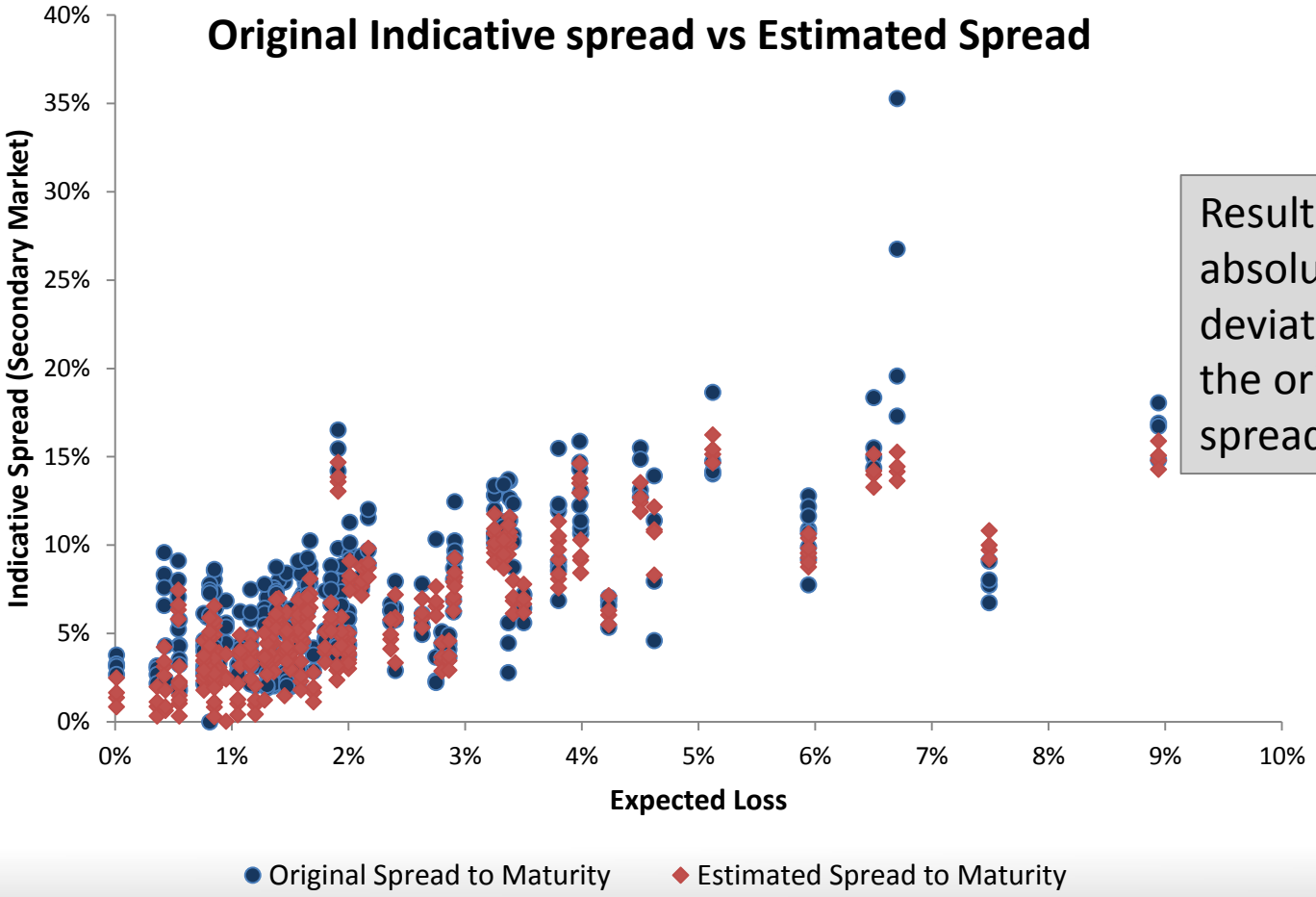
Multifactor Spread Model:

$$Spread_i = \alpha + \beta_{Spread} * Spread_i + \beta_{EL} * EL_i + \beta_{Maturity} * TTMFactor_{it} + \beta_{HY} * HY_{it} + \beta_{SCATTRR} * SCATTRR_{it} + C_i + U_{it}$$

Indicative Spread	Coefficient	Standard Error
Constant	0.1679	0.0728
Spread at Issue	0.8669	0.0780
Expected Loss	0.3800	0.1595
Time to Maturity Factor	-1.6966	0.5711
High_Yield	0.0003	0.0001
SCATTRR	-0.0023	0.0007

Source: Stata regressions results

Fitness of the regression modeled:



Results proved an absolute average deviation of **1.75%** from the original indicative spread.

IV. CONCLUSION AND FURTHER RESEARCH

Conclusion:

➢The **Expected Loss** is the single most important determinant factor in the spread of a Cat Bond in the **primary market**.

➢**Time to maturity** proved to be the most relevant factor in the **secondary market**.

➢Although in the secondary market the **Expected Loss** remained significant, is no longer the most relevant factor.

➢The sign and magnitude of the **High Yield Index** is equal both in the primary and secondary market.

➢Our proposed models show to have a **high accuracy** on replicating the spread of Cat Bonds. Furthermore, our models have a **general application**, relevant both for the P&C and Life market of Cat Bonds.

Areas for further research:

✓To identify additional factors impacting the spread of Cat Bonds in the secondary market.

References:

- A.M. Best Company, Inc. 2012. *Rating natural catastrophe bonds*. Accessed on January 2014. Available at: http://www3.ambest.com/ambv/ratingmethodology/OpenPDF.aspx?rc=197662
- AON Benfield. 2012. *Insurance-Linked Securities 2012: Second Quarter Update.* Accessed on March 2014. Available at: http://thoughtleadership.aonbenfield.com/Documents/201207_ab_securities_ils_quarterly_update_q22012.pdf
- AON Benfield. 2013. *Though Leadership. Insurance Linked Securities*. Accessed on November 2013. Available at: http://thoughtleadership.aonbenfield.com/Pages/Home.aspx?ReportCategory=Insurance-Linked%20Securities
- Aon Benfield. 2013. *The Aon Benfield Aggregate. Results for the year ended December 31, 2013.* Accessed on June 2014. Available at: https://www.abconnect.aonbenfield.com/ABConnect/Pages/MarketReView/MarketReView.aspx?bc=25
- Artemis. 2014. *Deal Directory*. Accessed on January 2014. Available at http://www.artemis.bm/deal_directory/
- Baryshnikov Y., Mayo A. and Taylor, D. R. 2011. Pricing of CAT Bonds. *Statistical Tools for Finance and Insurance*. Vol. 1, pp. 371-391.
- Bodoff, N. M., and Gan, Y. 2009. An analysis of the market price of Cat Bonds. *Casualty Actuarial Society E-Forum*. Spring, 2009.
- Braun, Alexander. 2012. Pricing in the primary market for cat bonds: new empirical evidence. *Working papers on risk management and insurance.* Vol. 116.
- Burnecki, Krzysztof, Grzegorz Kukla, and David Taylor. 2011. Pricing of catastrophe bonds. *Statistical Tools for Finance and Insurance*. Springer Berlin Heidelberg, 2011. 371-391.
- Cox, S. H., and Pedersen, H. W. 2000. Catastrophe risk bonds. *North American Actuarial Journal*. Vol 4, No.4, pp. 56-82.
- Cummins, J. D. 2008. CAT bonds and other risk-linked securities: State of the market and recent developments. *Risk Management and Insurance Review*. Vol. 11, pp. 23-47.
- Cummins, J.D. and Geman, H. 1995. Pricing Catastrophe Insurance Futures and Call Spreads: An Arbitrage Approach. *Journal of fixed Income*. March, pp. 46-57.
- Cummins, J. David, & Weiss, M. A. 2009. Convergence of Insurance and Financial Markets: Hybrid and Securitized Risk-Transfer Solutions. *Journal of Risk and Insurance.* Vol. 76, No. 3, pp. 493-545.
- Dieckmann, S. 2008. By force of nature: explaining the yield spread on catastrophe bonds, Working Paper, Wharton School, University of Pennsylvania, Philadelphia.
- Finken, Silke, and Christian Laux. 2009. Catastrophe Bonds and Reinsurance: The Competitive Effect of Information-Insensitive Triggers. *Journal of Risk and Insurance*. Vol 76, No. 3, 579-605.
- Galeotti, M., Guertler, M., and Winkelvos, C. 2013. Accuracy of Premium Calculation Models for Cat Bonds – An Empirical Analysis. *Journal of Risk and Insurance*. Forthcoming.
- Gomez, L. and Carcamo, U. 2014. A Multifactor Spread Model for Cat Bonds in the Primary Market. *North American Review of Finance*. Vol 14 (2), Forthcoming.
- Gomez, L. and Carcamo, U. 2014. A Multifactor Pricing Model for Cat Bonds in the Secondary Market. *Journal of Business, Economics & Finance*. Vol 3(2), p 247-258.

References:

- Guy Carpenter. 2013. *Capital Stewardship: Charting the course to profitable growth.* Accessed on January 2014. Available at: http://www.guycarp.com/content/dam/guycarp/en/documents/dynamic-content/Mid-Year-Market-Overview-Sept-2013.pdf
- Guy Carpenter. 2010. *GC Capital Ideas. Catastrophe Bond update*. Accessed on November 2013. Available at: http://www.gccapitalideas.com/2010/04/13/catastrophe-bond-update-first-quarter-2010-%E2%80%93-heavy-smoke-some-fire%E2%80%A6encouraging-conditions-persist/
- Guy Carpenter. 2013. *Mid-Year Market Overview. Capital Stewardship: Charting the course to profitable growth*. Accessed January 2014. Available at: http://www.guycarp.com/content/dam/guycarp/en/documents/dynamic-content/Mid-Year-Market-Overview-Sept-2013.pdf
- Gürtler, M.; Hibbeln, M. and Winkelvos, C. 2012. The impact of the financial crisis and natural catastrophes on CAT bonds. *Working Papers, Institut für Finanzwirtschaft, Technische Universität Braunschweig*, No.IF40V1.
- Jin-Ping, and Min-The. 2002. Pricing Default-Risky Cat Bonds with Moral Hazard and Basis Risk. *The Journal of Risk and Insurance.* Vol. 69 (1), 25-44.
- Jaeger, L., Müller, S., & Scherling, S. 2010. Insurance-Linked Securities: What Drives Their Returns?. *The Journal of Alternative Investments.* Vol 13(2), 9-34.
- Lane Financial LLC. 2013. *Soft Markets Ahead? Annual Review for the Four Quarters, Q2 2012 to Q1 2013*. Accessed on March 2014. Available at: http://www.lanefinancialllc.com/index.php?searchword=2006&option=com_search&Itemid=
- Lane Financial LLC. 2013. *Trade Notes. Annual Review for the four quarters, Q2 2012 to Q1 2013*. Accessed March 2014. Available at : http://www.lanefinancialllc.com/index.php?option=com_search&Itemid=99999999&searchword=lane&searchphrase=any&ordering=newest&limit=30&limitstart=65
- Lane, M., & Mahul, O. 2008. *Catastrophe risk pricing: an empirical analysis*. World Bank publications. Accessed December 2013. Available at: https://openknowledge.worldbank.org/bitstream/handle/10986/6900/WPS4765.pdf?sequence=1
- Loubergé et al. 1999. *Using Catastrophe-Linked Securities to Diversify Insurance Risk: A Financial Analysis of Cat Bonds*. Journal of insurance issues. Vol. 22, No. 2, pp.125-146.
- Risk Management Solutions (RMS). 2012. Cat Bonds demystified. RMS guide to the asset class. *Standard & Poor's. Credit Ratings Definitions & FAQs*.
- Standard & Poor's. Ratings. 2012. *Insurance Linked Securities*. Accessed November 2013. Available at http://www.standardandpoors.com/ratings/ils/en/us
- Standard & Poor's. 2013. *Rating Natural Peril Catastrophe Bonds: Methodology and Assumptions*. Accessed January 2014. Available at: http://www.standardandpoors.com/ratings/ils/en/us
- Tao, Z. 2011. Zero-Beta Characteristic of CAT Bonds, *BIFE '11 Proceedings of the 2011 Fourth International Conference on Business Intelligence and Financial Engineering*. pp. 641-644.
- Weber Christoph. 2011. Insurance Linked Securities. *Gabler Verlang*. Page 95.
- Young, V.R. 2004. Pricing in an incomplete market with an affine term structure. *Mathematical Finance.* Vol 14 (3), pp:359–381.