

MANAGING EXTREMES

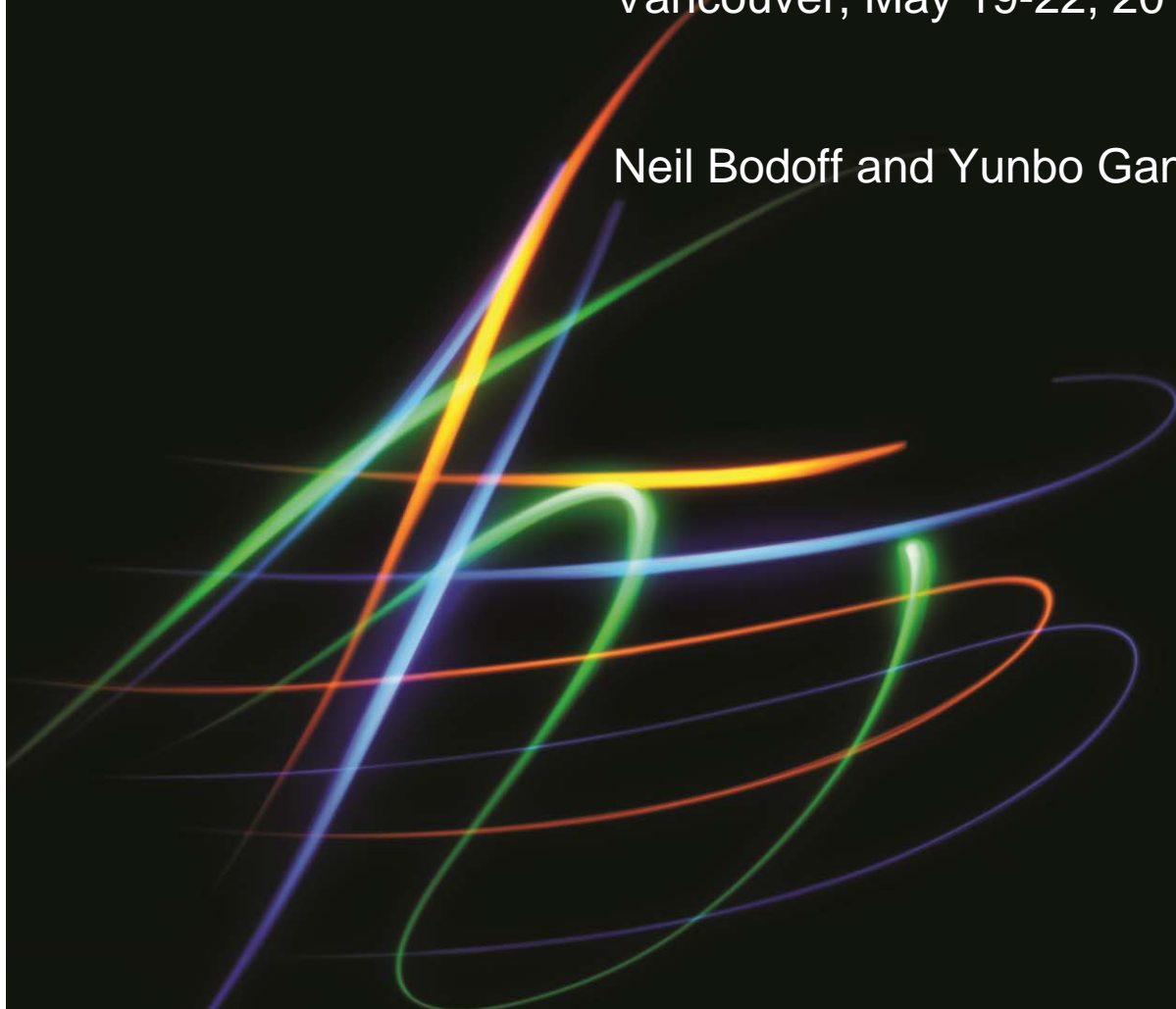
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# AN ANALYSIS OF THE MARKET PRICE OF CAT BONDS

CAS Spring Meeting

Vancouver, May 19-22, 2013

Neil Bodoff and Yunbo Gan



# Agenda

- Goal for today
- Background & motivation
- Proposed model
- Analysis and discussion
- Areas for future research
- Conclusion

# Goal for today

- Choice #1:
  - Identify precise parameter values for the spread % for cat bonds
- Choice #2:
  - Discuss general framework and approach

# Goal for today

- Choice #1:
  - Identify precise parameter values for the spread % for cat bonds
- Choice #2:
  - Discuss general framework and approach

No

Yes

# BACKGROUND & MOTIVATION

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# Background & motivation

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- What?
  - Cat bond
  - Forecast spread %
  - When issued
- Why?
  - Benchmarking
  - Guidance
  - Evaluate offered price
- Who?
  - Buyer
  - Seller
  - Advisor
- How?
  - ???

# Background & motivation

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- Banker model

- Practitioner model
- $\text{Spread} = \text{Multiple} * \text{expected loss}$

- Reinsurance / actuarial model

- Kreps, 1998
- $\text{Spread} = \text{Expected loss} + \text{multiple} * \text{standard deviation}$

- Academic finance model

- Beta, systematic risk
- $\text{Spread} = \text{Expected loss} + \text{credit spread puzzle}$

- ASTIN actuarial model

- Lane, 2000
- $\text{Spread} = \text{Expected loss} + \text{exponentiation of probability, conditional severity}$

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All of these models have significant advantages



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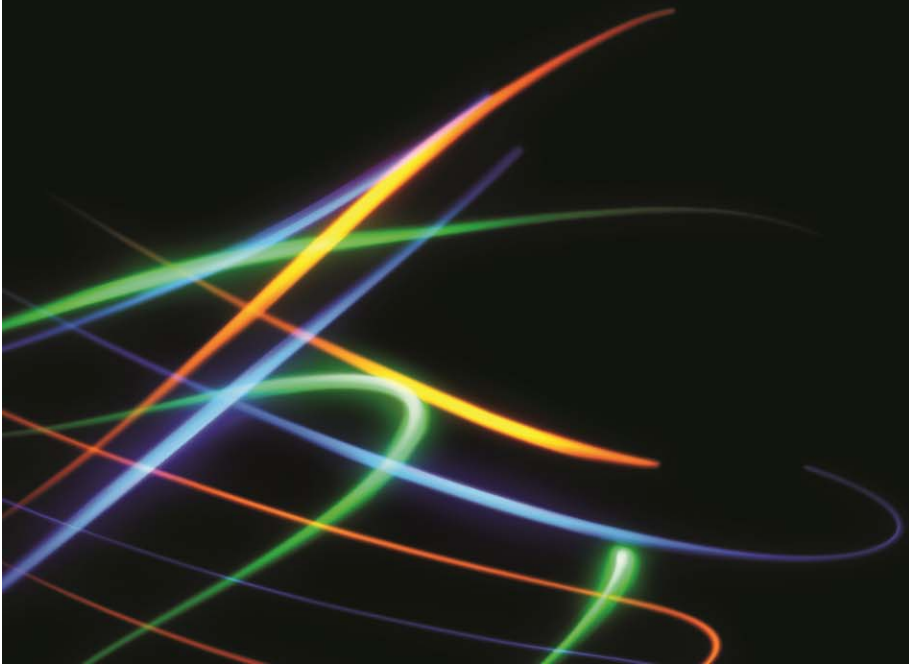
All of these models have significant advantages

All of these models have significant disadvantages

# PROPOSED MODEL

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# Proposed model

Choose model for cat bonds that incorporates

- Models

- Corporate bond spreads
- Asset pricing
- Reinsurance pricing

- Literature

- Finance: fixed income
- Finance: portfolio theory
- Actuarial science

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Choose model for cat bonds that incorporates

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- Finance: portfolio theory
- Actuarial science

- Data

- Spreads when issued
- By tranche
- By peril & zone

- Practitioner knowledge

- Reinsurance market
- Real world
- Complements data

# Proposed model: ideal qualities

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Attribute	Precedent
Practical	Banker model
Expected loss + margin	Corporate bond model
Portfolio risk, not standalone	Asset pricing, Markowitz, CAPM
Cat risk based on peril and zone	Reinsurance pricing
No arbitrage: prices are additive	Actuarial (Venter), finance

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# Proposed model

Spread = Expected loss + peril-specific-margin

Data

1. Spread = peril-specific-margin + peril-specific-multiplier \* expected loss
2.  $y = a + bx$
3. Spread = constant + loss multiplier \* expected loss

# Proposed model

Spread = constant + loss multiplier \* expected loss

Venter's no arbitrage rule: layer prices ought to be additive

Peril specific: accentuates real world risk in a diversified reinsurance portfolio

Practical

Bond market's additive spread

1. Return on capital for bearing risk
2. Generates "multiple" that is larger when layer loss cost is smaller

Banker's "multiple"

1. Puzzle to bond market model
2. Needed to fit the data
3. Needed for uncertainty in the loss cost?

# ANALYSIS AND DISCUSSION

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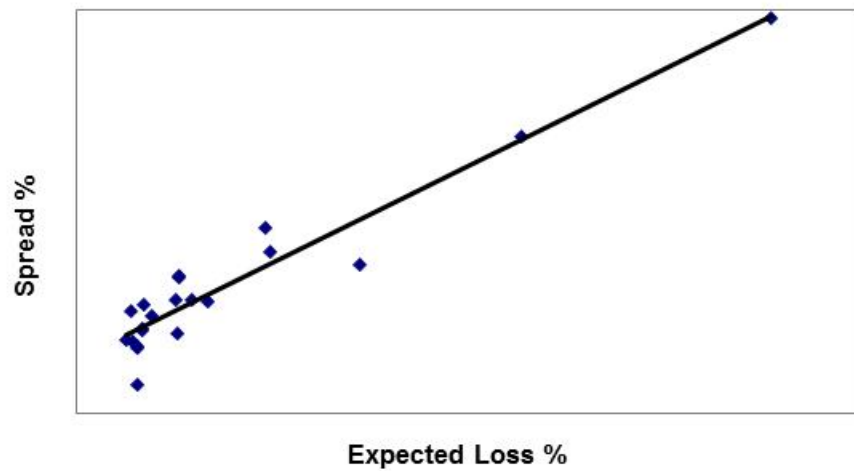
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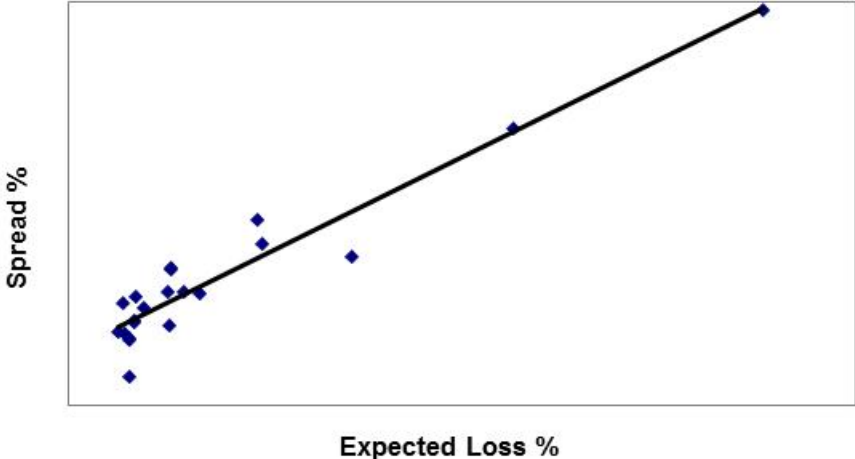
# USA wind all years

USA Wind All Years

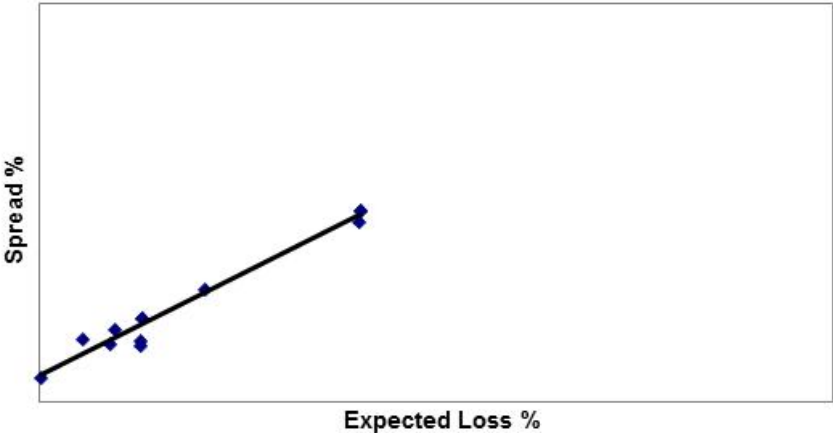


# USA wind vs. Europe wind

USA Wind All Years

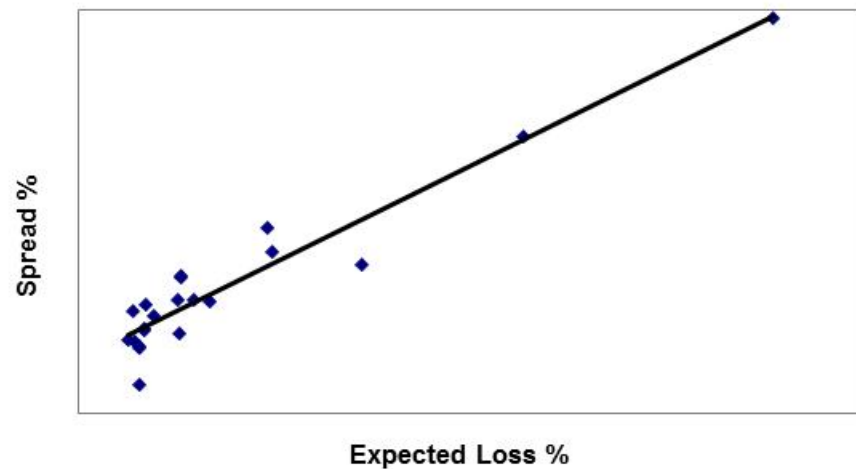


Europe Wind All Years

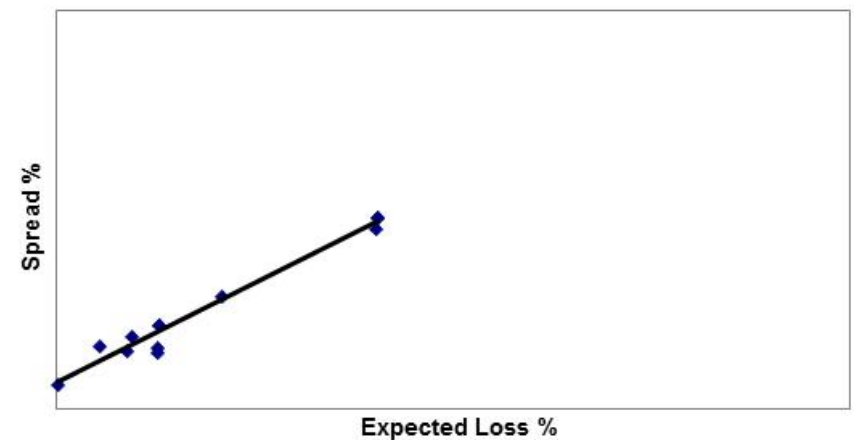


# USA wind vs. Europe wind

USA Wind All Years



Europe Wind All Years

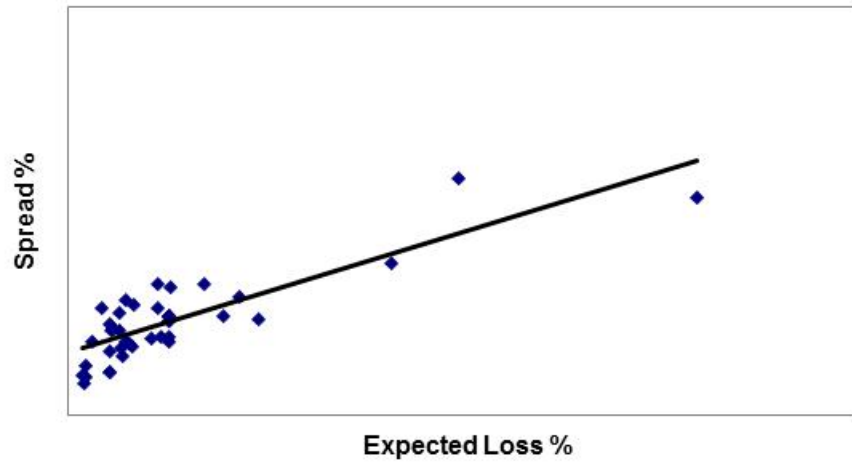


Constant (i.e. the intercept): higher for USA wind, lower for Europe wind

Loss Multiplier (i.e. the slope): very similar for USA wind and Europe wind

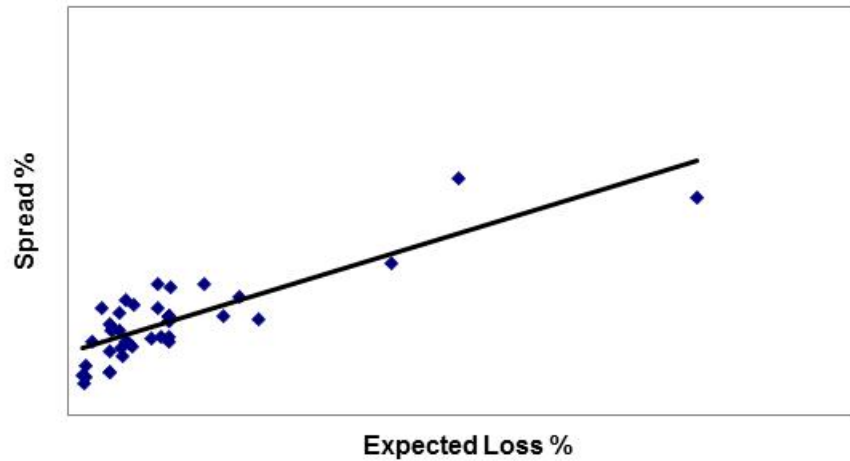
# California EQ all years

California EQ All Years

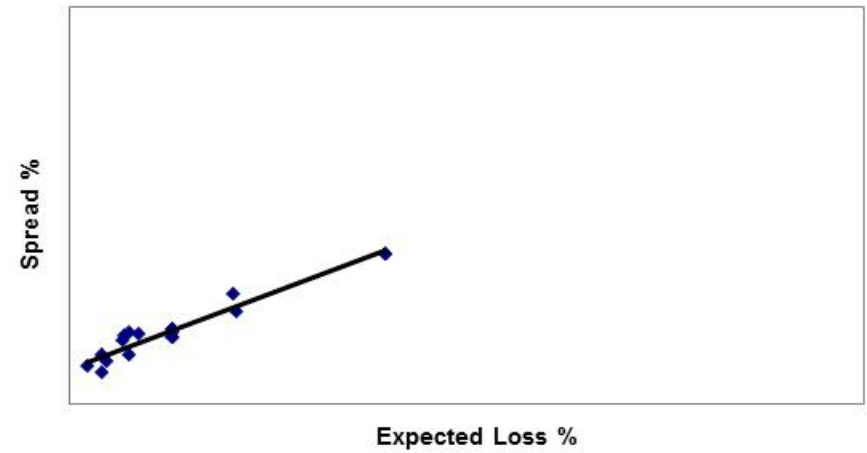


# California EQ vs. Japan EQ

California EQ All Years

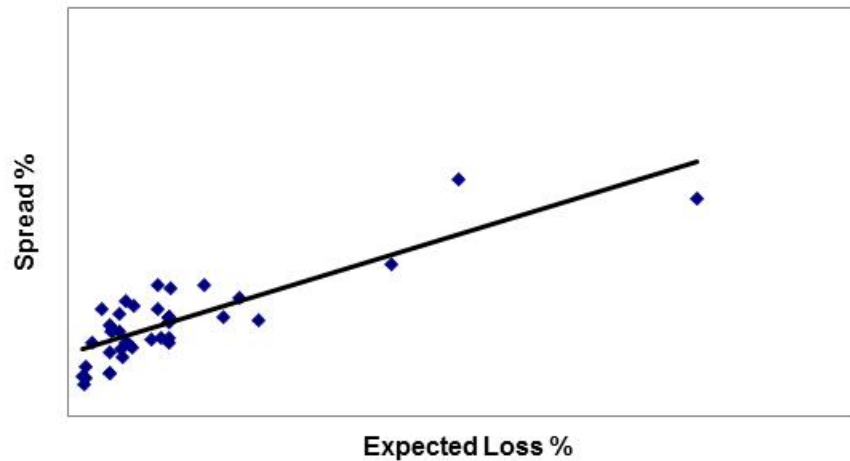


Japan EQ All Years

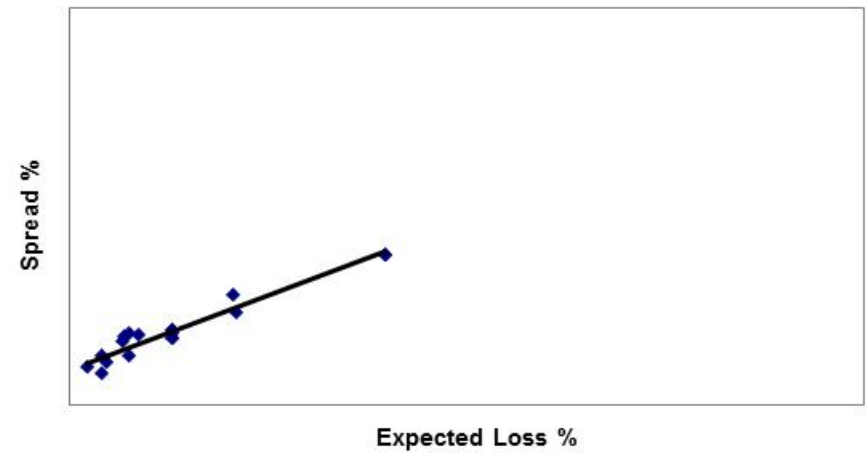


# California EQ vs. Japan EQ

California EQ All Years



Japan EQ All Years

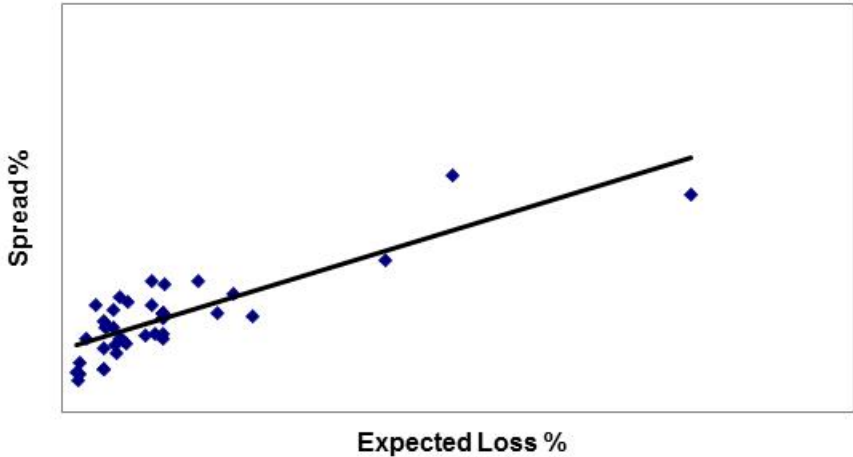


Constant (i.e. the intercept): higher for California EQ, lower for Japan EQ

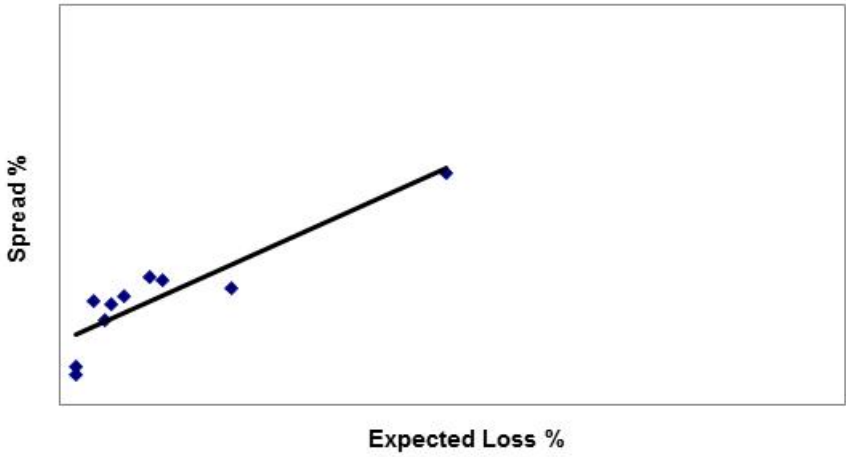
Loss Multiplier (i.e. the slope): similar to each other, lower than wind

# Calif. EQ all years vs. Calif. EQ hard market years

California EQ All Years



California EQ Hard Market

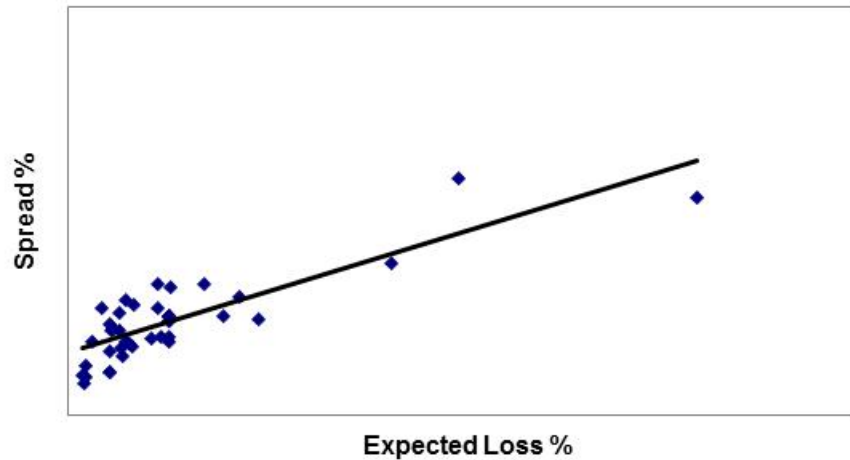


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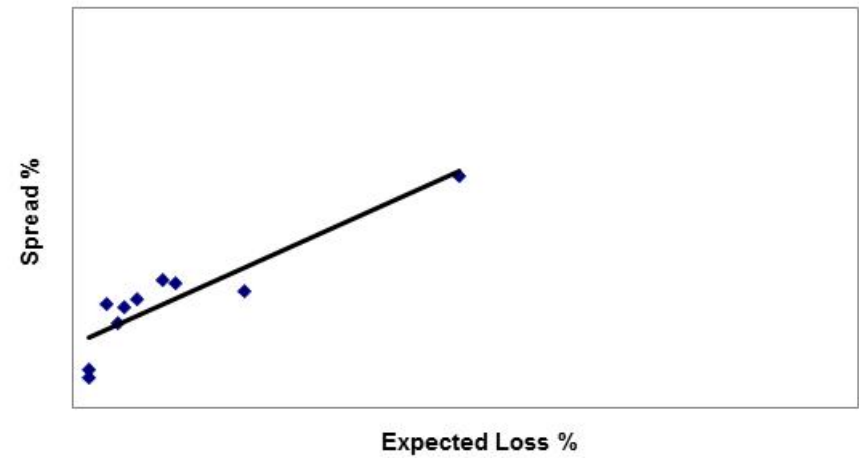
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California EQ All Years



California EQ Hard Market



How do the constant & loss multiplier differ when the market is different (2006-2007 hard market)?

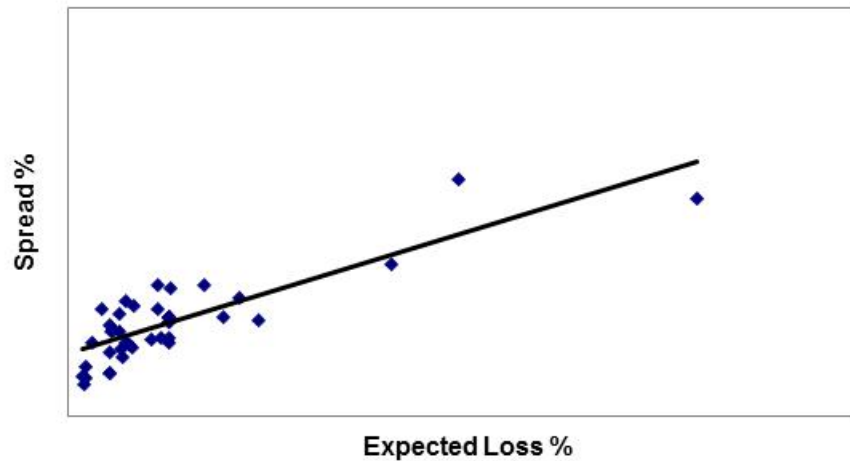


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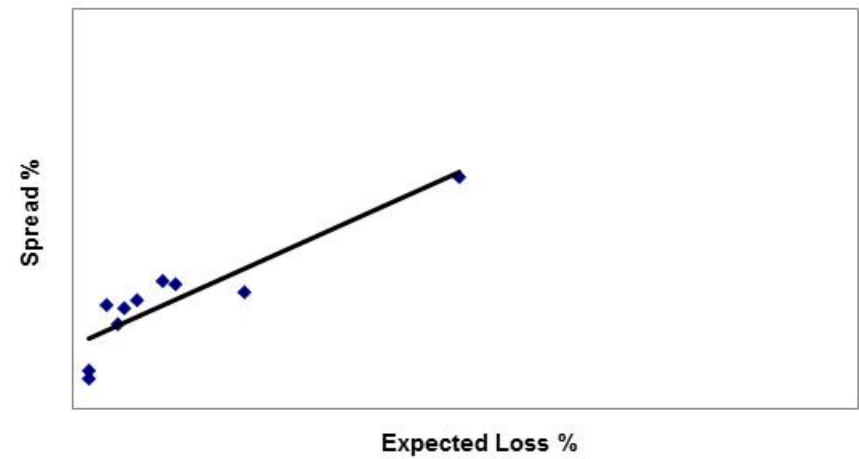
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California EQ All Years



California EQ Hard Market



How do the constant & loss multiplier differ when the market is different (2006-2007 hard market)?

Constant (i.e. the intercept): is higher

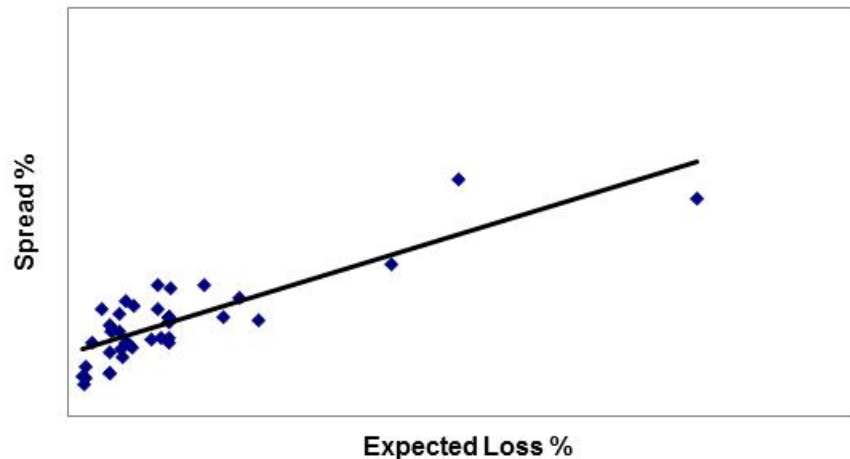
Loss Multiplier (i.e. the slope): is larger

# Calif. EQ all years vs. Calif. EQ hard market years

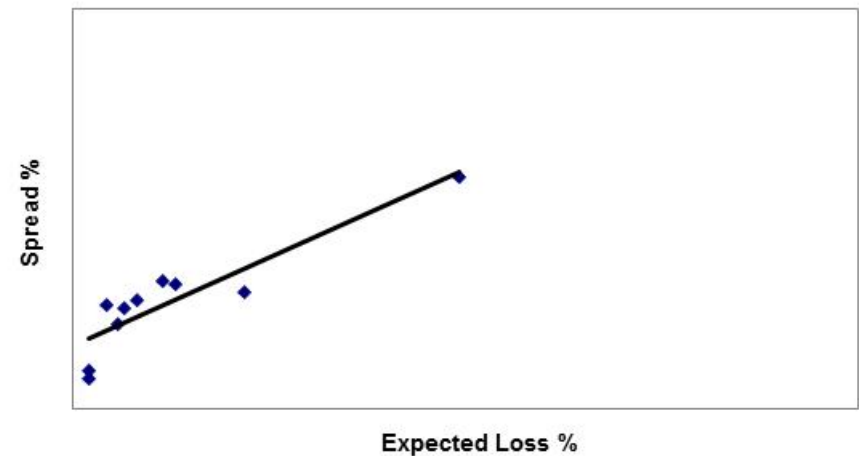
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How do the constant & loss multiplier differ when the market is different (2006-2007 hard market)?

Constant (i.e. the intercept): is higher

Loss Multiplier (i.e. the slope): is larger

Conclusion #1: model creates compact vocabulary for expressing changes in market conditions

Conclusion #2: time period & market conditions matter

# Possible model for all perils and all years

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Spread % = Constant<sub>All</sub> %

+ Additional Constant<sub>Peak</sub> % \* Peak Peril Indicator

+ Additional Constant<sub>Diversifying</sub> % \* Diversifying Peril Indicator

+ Loss Multiplier<sub>EQ</sub> \* Expected Loss<sub>EQ</sub> %

+ Loss Multiplier<sub>Wind</sub> \* Expected Loss<sub>Wind</sub> %

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Peril	Zone	Years	Market Condition	Parameter Name	Parameter Value	Standard Error	Confidence Interval (95%)	
							Lower Bound	Upper Bound
All	All	All Years	Full Cycle	Constant <sub>All</sub> %	2.35%	0.25%	1.85%	2.85%
All	All	All Years	Full Cycle	Additional Constant <sub>Peak</sub> %	1.28%	0.27%	0.76%	1.81%
All	All	All Years	Full Cycle	Additional Constant <sub>Diversifying</sub> %	-1.09%	0.35%	-1.79%	-0.39%
All	All	All Years	Full Cycle	Loss Multiplier <sub>EQ</sub>	1.60	0.10	1.40	1.81
All	All	All Years	Full Cycle	Loss Multiplier <sub>Wind</sub>	2.29	0.10	2.10	2.48

# Possible model for all perils and hard market years

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Spread % = Constant<sub>All</sub> %

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Peril	Zone	Years	Market Condition	Parameter Name	Parameter Value	Standard Error	Confidence Interval (95%)	
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All	All	2006 - 2007	Hard Market	Constant <sub>All</sub> %	2.20%	0.40%	1.38%	3.02%
All	All	2006 - 2007	Hard Market	Additional Constant <sub>Peak</sub> %	2.31%	0.38%	1.54%	3.08%
All	All	2006 - 2007	Hard Market	Additional Constant <sub>Diversifying</sub> %	-1.66%	0.45%	-2.56%	-0.76%
All	All	2006 - 2007	Hard Market	Loss Multiplier <sub>EQ</sub>	1.87	0.13	1.60	2.14
All	All	2006 - 2007	Hard Market	Loss Multiplier <sub>Wind</sub>	2.31	0.09	2.12	2.50

# Possible model for all perils all years vs. hard market years

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These parameters increased in absolute magnitude when fit to hard market data

These parameters did not change when fit to hard market data

# AREAS FOR FURTHER RESEARCH

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# Areas for further research

- Time series of fitted parameters
  - Slope & intercept by peril
  - Drift, patterns, relationships over time
- Unified model describing both reinsurance and cat bonds
  - How to deal with reinstatements?
  - Implications for reinsurance pricing
- Are all cat models' loss costs the same?



# CONCLUSION

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# Conclusion

- We propose a linear model with peril-specific parameters
  - Easy to use
  - Straightforward to explain
  - Fits the data
  - Creates compact vocabulary
  - Measures risk aversion across the cycle
  - Consistent prices when slicing into layers & tranches
  - Illuminates the “credit spread puzzle” in corporate bonds

Questions & comments?

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[neil.bodoff@willis.com](mailto:neil.bodoff@willis.com)

&

[yunbo.gan@willis.com](mailto:yunbo.gan@willis.com)

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