MANAGING EXTREMES Willis Re

AN ANALYSIS OF THE MARKET PRICE OF CAT BONDS

CAS Spring Meeting

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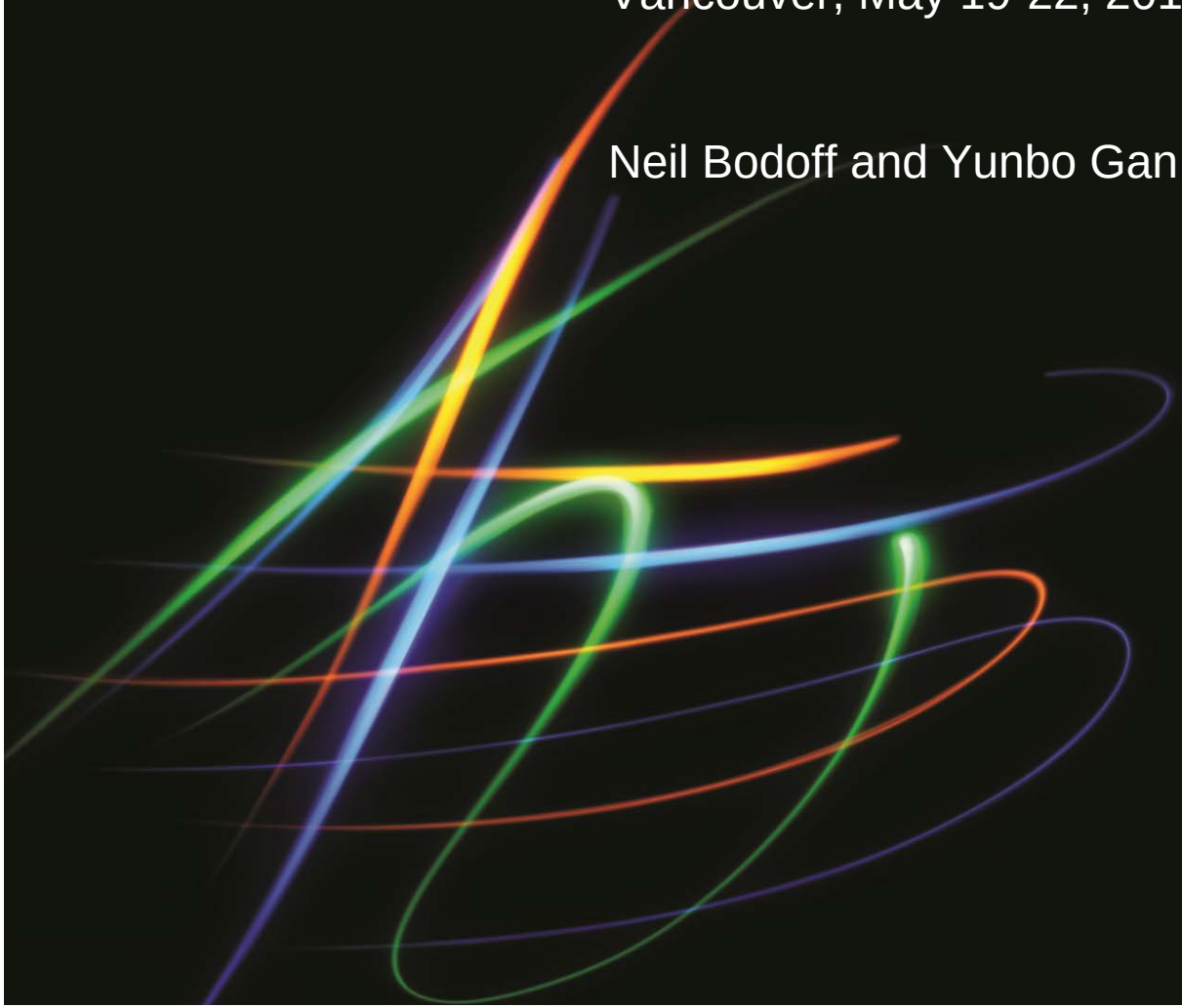

Agenda

- 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

No

- Choice #2:
  - Discuss general framework and approach

Yes

BACKGROUND & MOTIVATION

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Background & motivation

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

Background & motivation

- Banker model
  - Practitioner model
  - Spread = Multiple * expected loss
- Reinsurance / actuarial model
  - Kreps, 1998
  - Spread = Expected loss + multiple * standard deviation
- Academic finance model
  - Beta, systematic risk
  - Spread = Expected loss + credit spread puzzle
- ASTIN actuarial model
  - Lane, 2000
  - Spread = Expected loss + 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

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
- Data
  - Spreads when issued
  - By tranche
  - By peril & zone
- Practitioner knowledge
  - Reinsurance market
  - Real world
  - Complements data

Proposed model: ideal qualities

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

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	Banker's "multiple"
1. Return on capital for bearing risk 2. Generates "multiple" that is larger when layer loss cost is smaller	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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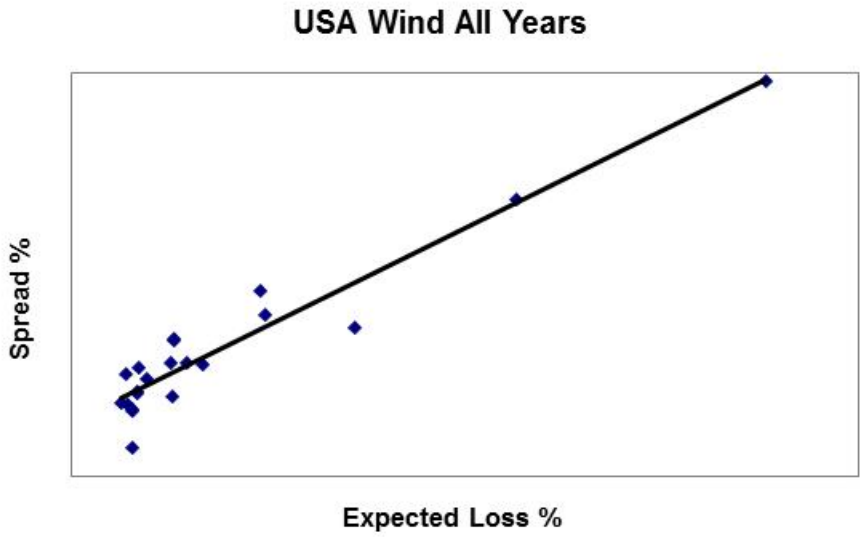
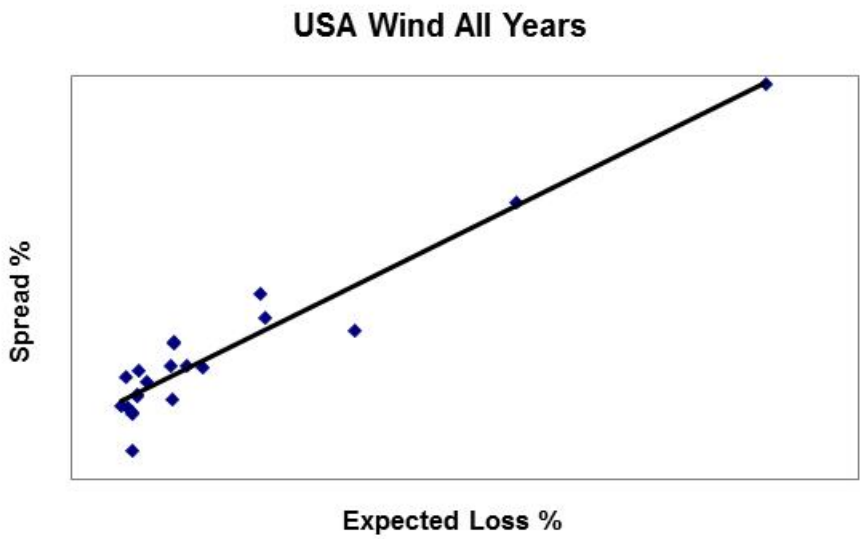
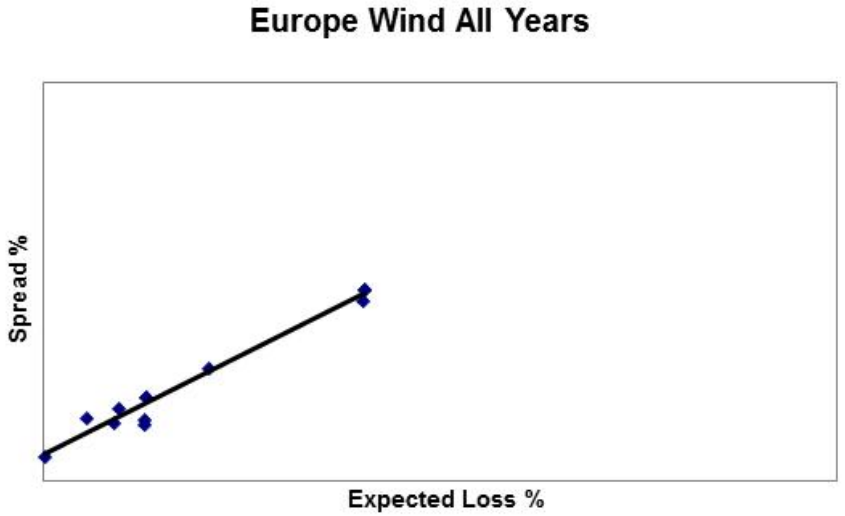
USA wind all years

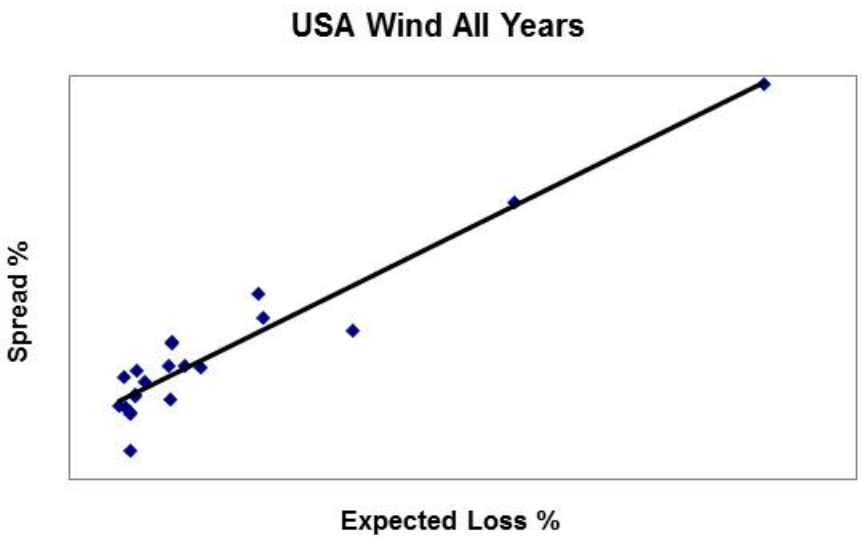


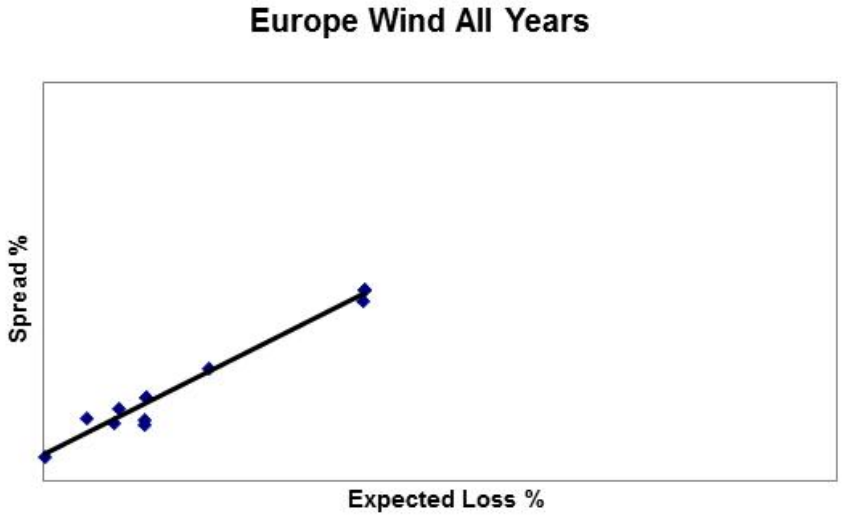
USA wind vs. Europe wind





USA wind vs. Europe wind

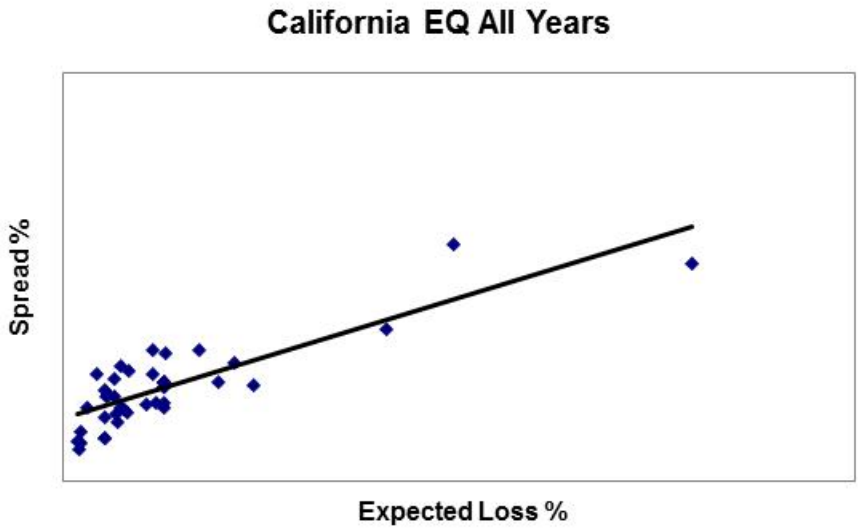




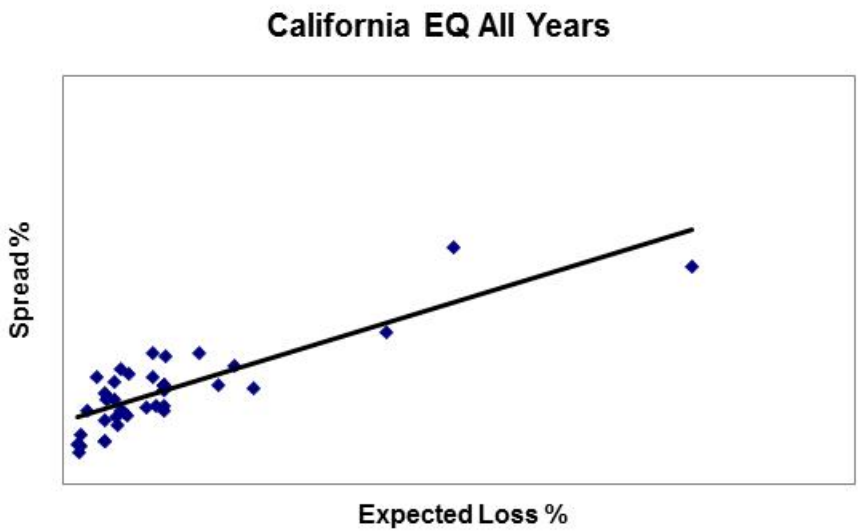
Constant (i.e. the intercept): higher for USA wind, lower for Europe wind

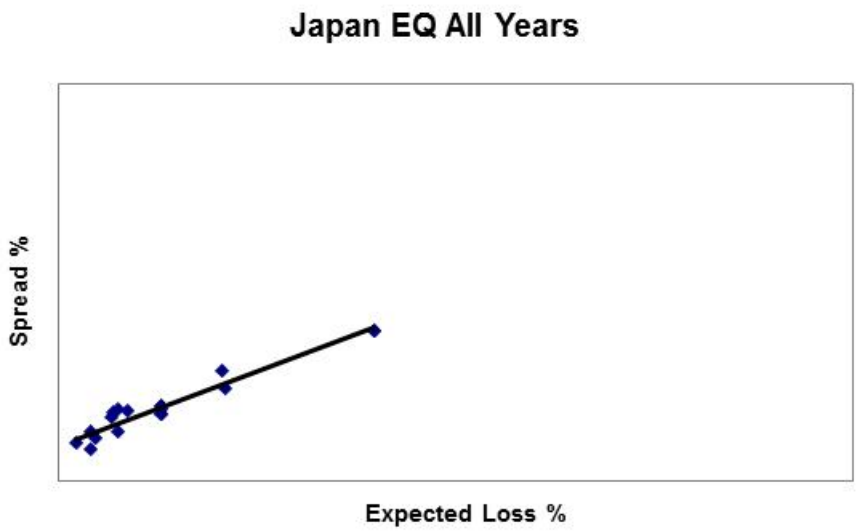
Loss Multiplier (i.e. the slope): very similar for USA wind and Europe wind

California EQ all years



California EQ vs. Japan EQ





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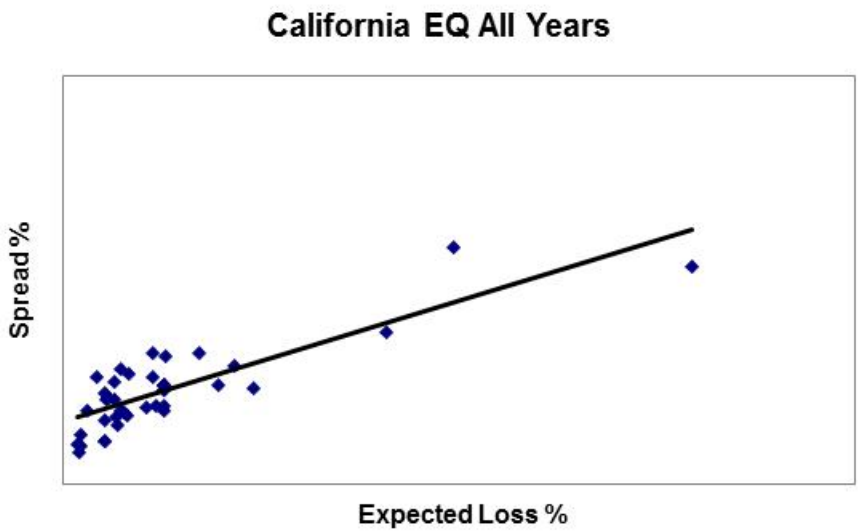
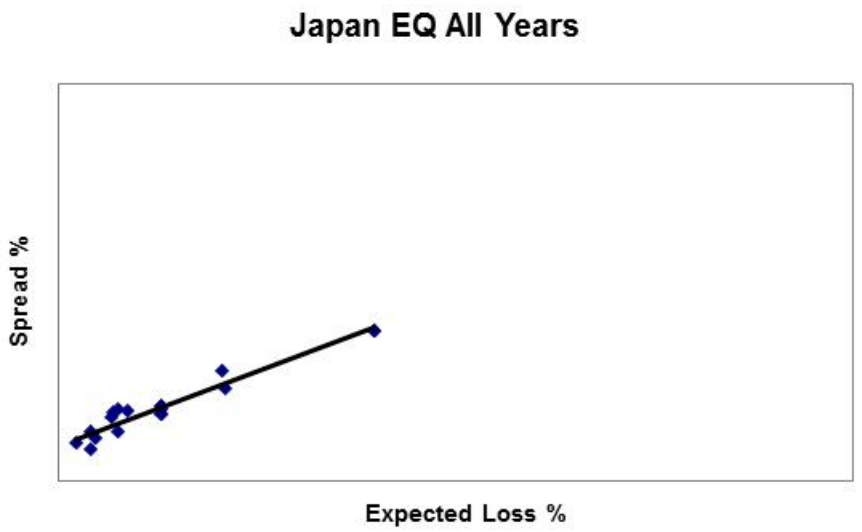
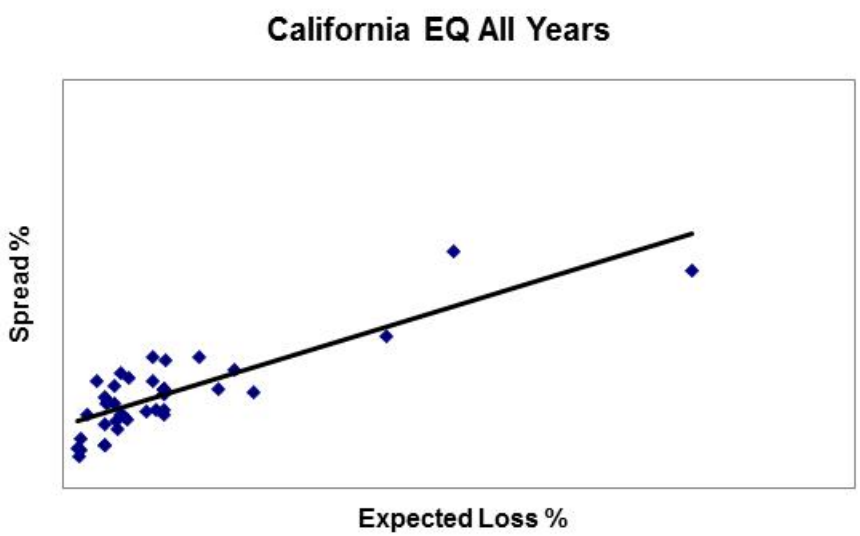


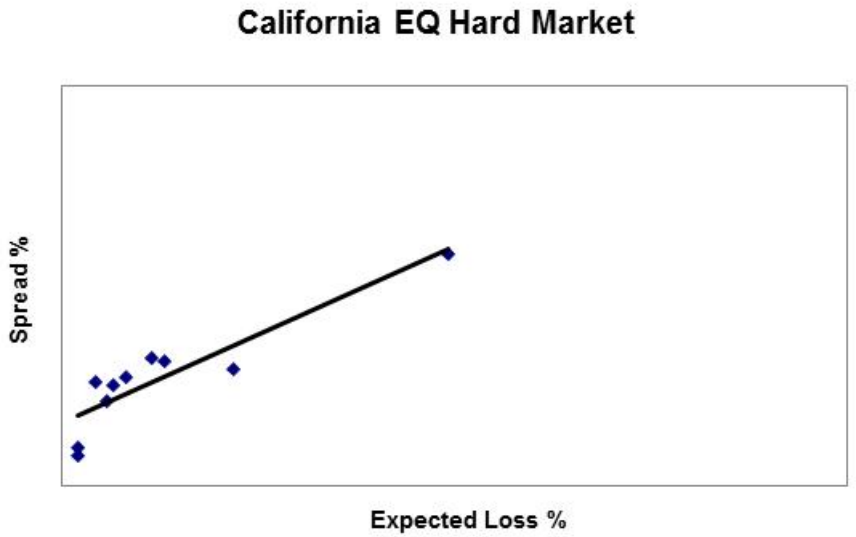


Constant (i.e. the intercept): higher for California EQ, lower for Japan EQ

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

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





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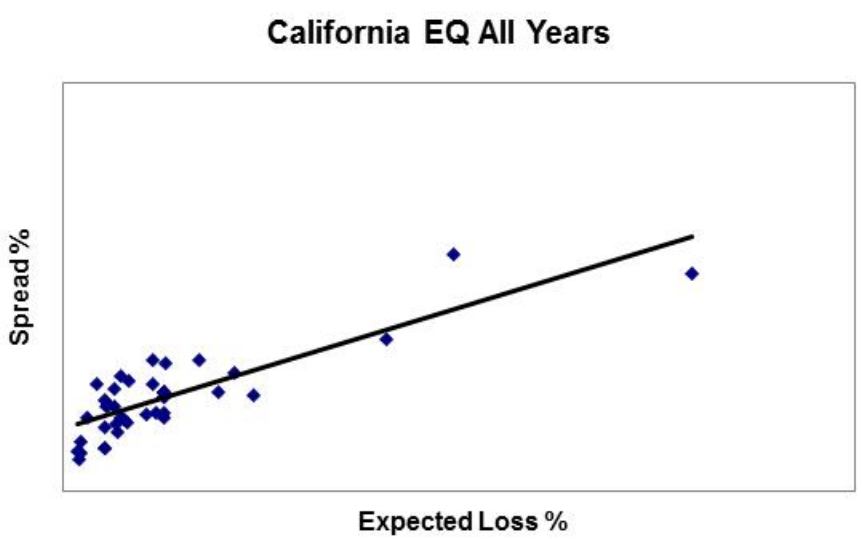
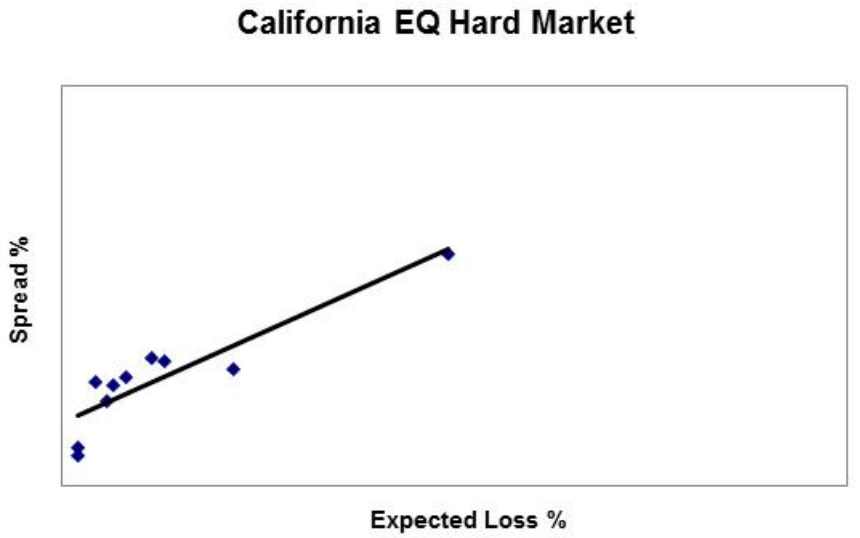
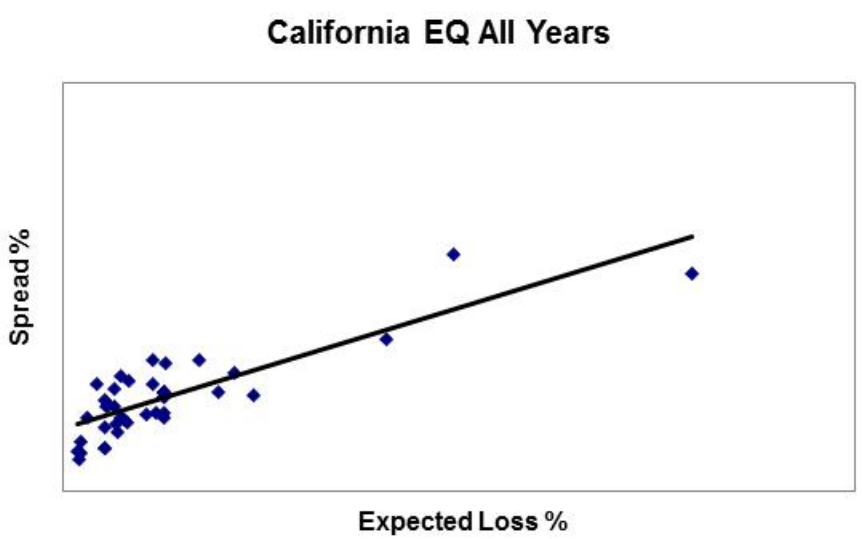
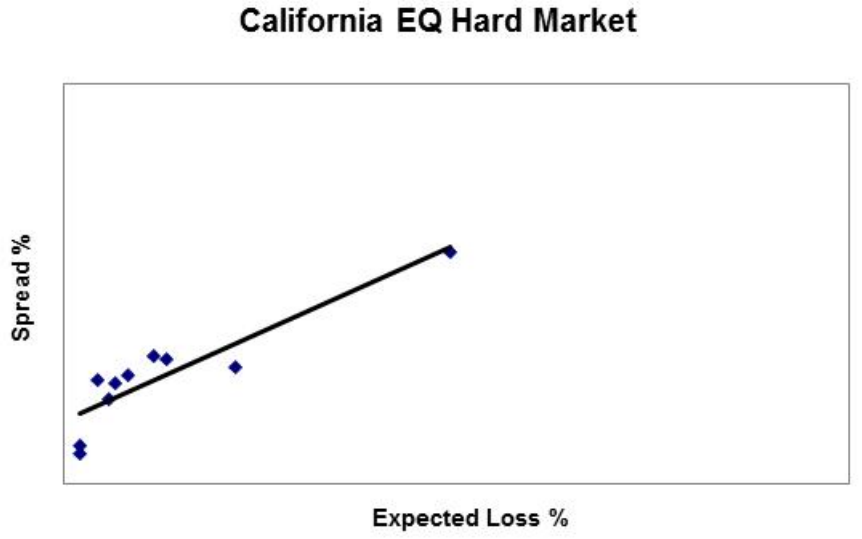




How do the constant & loss multiplier differ when the market is different (2006-2007 hard market)?

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



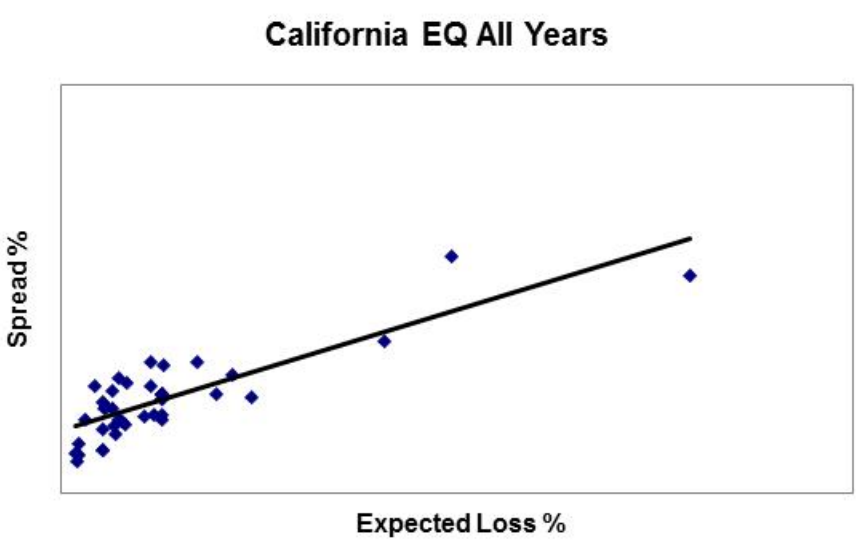


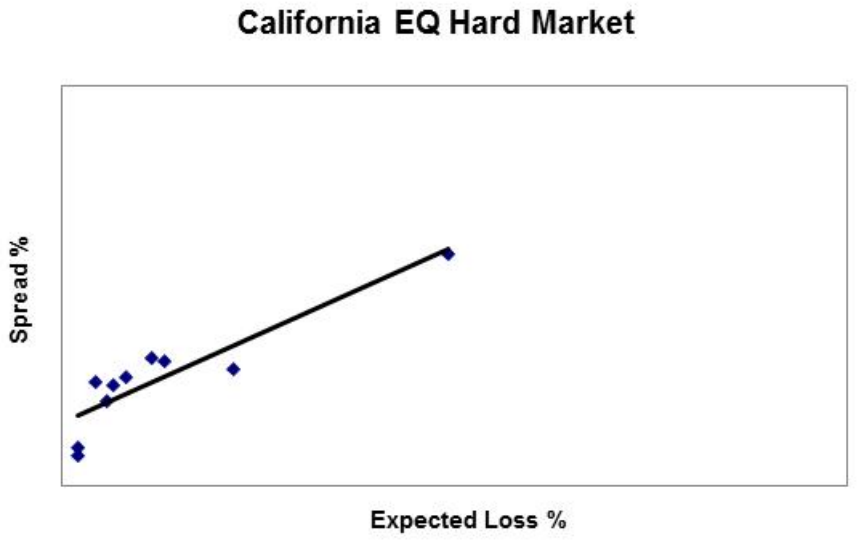
How do the constant & loss multiplier differ when the market is different (2006-2007 hard market)?

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





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

Spread % = $\text{Constant}_{\text{All}}$ %

+ Additional $\text{Constant}_{\text{Peak}}$ % * Peak Peril Indicator

+ Additional $\text{Constant}_{\text{Diversifying}}$ % * Diversifying Peril Indicator

+ $\text{Loss Multiplier}_{\text{EQ}}$ * $\text{Expected Loss}_{\text{EQ}}$ %

+ $\text{Loss Multiplier}_{\text{Wind}}$ * $\text{Expected Loss}_{\text{Wind}}$ %

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+ Additional $Constant_{Diversifying}$ % * Diversifying Peril Indicator

+ Loss $Multiplier_{EQ}$ * Expected $Loss_{EQ}$ %

+ Loss $Multiplier_{Wind}$ * Expected $Loss_{Wind}$ %

Peril	Zone	Years	Market Condition	Parameter Name	Parameter Value	Standard Error	Confidence Interval (95%) Lower Bound	Confidence Interval (95%) Upper Bound
All	All	All Years	Full Cyde	$Constant_{All}$ %	2.35%	0.25%	1.85%	2.85%
All	All	All Years	Full Cyde	Additional $Constant_{Peak}$ %	1.28%	0.27%	0.76%	1.81%
All	All	All Years	Full Cyde	Additional $Constant_{Diversifying}$ %	-1.09%	0.35%	-1.79%	-0.39%
All	All	All Years	Full Cyde	Loss $Multiplier_{EQ}$	1.60	0.10	1.40	1.81
All	All	All Years	Full Cyde	Loss $Multiplier_{Wind}$	2.29	0.10	2.10	2.48

Possible model for all perils and hard market years

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Peril	Zone	Years	Market Condition	Parameter Name	Parameter Value	Standard Error	Confidence Interval (95%) Lower Bound	Confidence Interval (95%) Upper Bound
All	All	2006 - 2007	Hard Market	$Constant_{All}$ %	2.20%	0.40%	1.38%	3.02%
All	All	2006 - 2007	Hard Market	Additional $Constant_{Peak}$ %	2.31%	0.38%	1.54%	3.08%
All	All	2006 - 2007	Hard Market	Additional $Constant_{Diversifying}$ %	-1.66%	0.45%	-2.56%	-0.76%
All	All	2006 - 2007	Hard Market	Loss $Multiplier_{EQ}$	1.87	0.13	1.60	2.14
All	All	2006 - 2007	Hard Market	Loss $Multiplier_{Wind}$	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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