Casualty Catastrophe Modeling

2014 CAS Reinsurance Seminar

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Agenda

- Evolution of catastrophe models
- Comparison of casualty vs. natural catastrophe models
- Casualty catastrophe modeling process
- The “evolution” in the evolution of casualty catastrophe models
- Case studies

Evolution of catastrophe models

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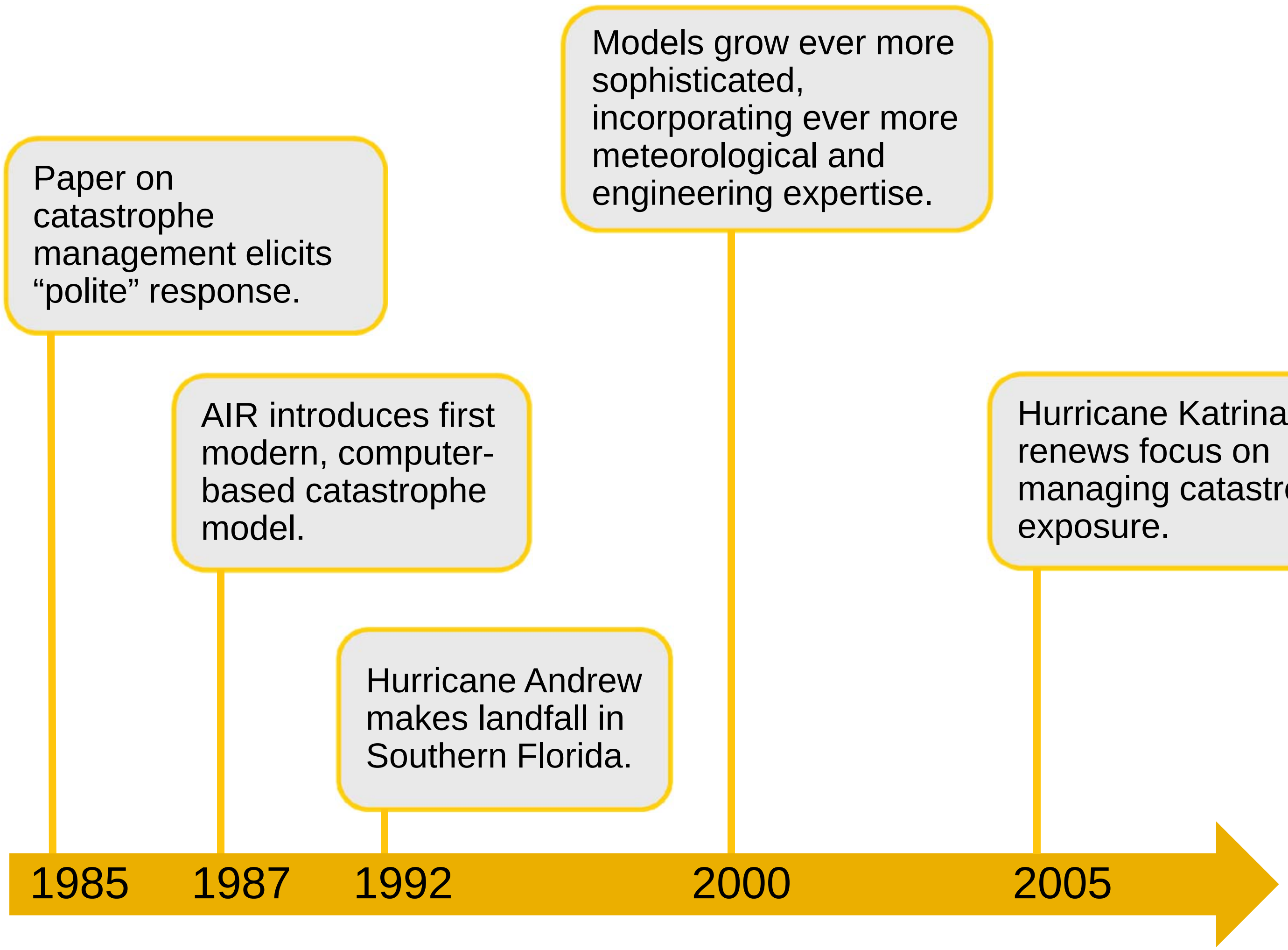
History of windstorm catastrophe models



Major catastrophe events have provided the catalyst for increased sophistication in natural and man-made catastrophe modeling and their use

Event	Year	Insured Loss*	Model
Hurricane Andrew	1992	26	Windstorm
Northridge Earthquake	1994	21	Earthquake
WTC	2001	24	Terrorism
Thailand Floods	2011	12	Flood (fresh water)
Japan Earthquake	2011	35	Tsunami

*2011 prices in $billions. Source Swiss Re, Sigma No 02/2012.

"[Andrew] awakened some larger companies to the fact that their reinsurance protection against catastrophes was far from adequate. It's only when the tide goes out that you learn who's been swimming naked."

Warren E. Buffet, Berkshire Hathaway Inc. 1992 Annual Report, page 10.

What will be the watershed event for casualty catastrophe modeling?

But two of the top three most costly insurance events were casualty catastrophes

Top 10 Most Costly Insurance Events (1970 – 2011)

Insured Loss ($bn) *	Year	Event
75	2005	Hurricane Katrina
71	1975	U.S. Asbestos
36	1990	U.S. Pollution
35	2011	Japan Earthquake
26	1992	Hurricane Andrew
24	2001	WTC
21	1994	Northridge Earthquake
21	2008	Hurricane Ike
15	2004	Hurricane Ivan
14	2005	Hurricane Wilma
338		**Total**
107		**Casualty Total**

So why isn't casualty catastrophe modeling more widespread?

*Sources:
Natural /man-made catastrophes — Swiss Re, Sigma No 02/2012, 2011 prices.
Casualty catastrophes — Towers Watson analysis of financial statement data compiled by A.M. Best and SNL, undiscounted ultimate losses.

What makes a casualty catastrophe, anyway?

- Hard to get a concrete definition
- Common response: "I know it when I see it"
- Example A
  - A mass tort must be caused by a specific type of event or product and typically involves multiple defendants, multiple insureds or class action lawsuits. A newly identified type of claim will be considered a mass tort if the insurer's expected ultimate loss and expense exceeds $50 million
- Example B
  - Any claim covering multiple general liability policies
- The specific cause of a mass tort will almost never repeat itself
- Large underlying costs (actual damages and legal fees combined) result from:
  - Large exposed population ...
  - ...who develop a serious problem that can be associated with the exposure ...
    - – with latency or inaction, exposed population grows before awareness
  - ... and who are inclined to sue for damages

Examples — Past, Present, Future (?)

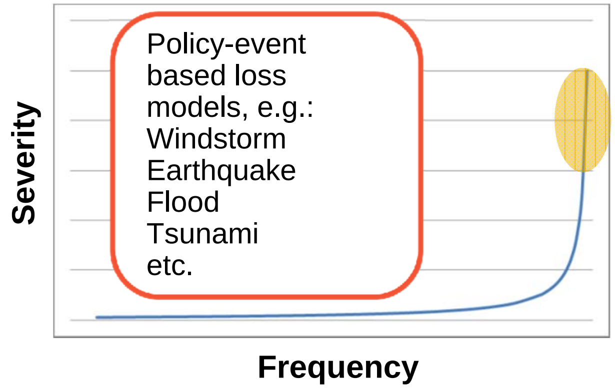
- Agent Orange
- Asbestos
- Avian influenza pandemic (aka bird flu)
- Bed bugs/Cimex Lectularius
- Bisphenol A (BPA)
- BP Oil Spill
- Carpal tunnel
- Cell phones
- Chemicals — Benzene, formaldehyde
- Chinese Drywall
- Construction defect
- DES including third generation claims
- EMF (electromagnetic fields)
- Environmental/pollution/hazardous waste sites
- Fire retardant plywood
- Food contamination, recall
- Formaldehyde in FEMA trailers from Hurricane Katrina
- Global warming
- Hand guns
- Hearing loss, noise induced
- HIV-tainted blood products
- Indoor air quality — sick building syndrome
- Latex gloves
- Lead paint
- Lead in toys
- Lung — white lung, black lung, baker's lung, farmer's lung, popcorn packer's lung
- Mad cow disease
- Mold
- Nanotubes
- Petroleum products — MTBE
- Perfluorooctanoic Acid (PFOA)
- Pharmaceuticals and medical devices
- Polybutylene systems
- Repetitive motion — carpal tunnel
- SARS (severe acute respiratory syndrome)
- Sexual molestation
- Silica
- Silicone breast implants
- SUV rollover
- Tires
- Tobacco
- Thimerosol vaccine
- Trans fats
- Welding rods
- WTC first responders
- Y2K

In some respects, casualty catastrophe modeling has been with us for a while now

Natural/Man-Made Catastrophe Models

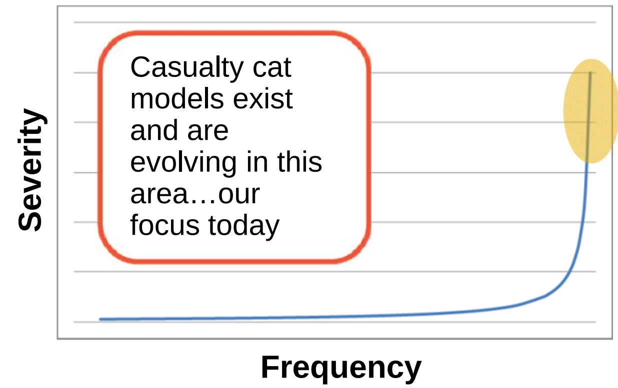
Casualty Catastrophe Models

Underwriting Risk

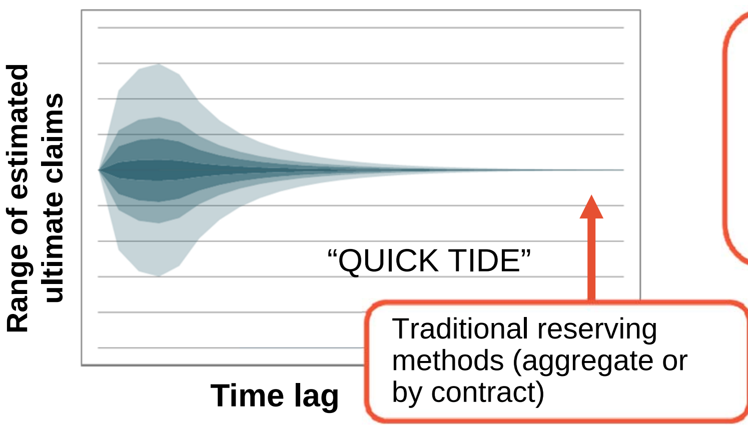


Andrew focused insurers on the premium loading for tail events for property lines.

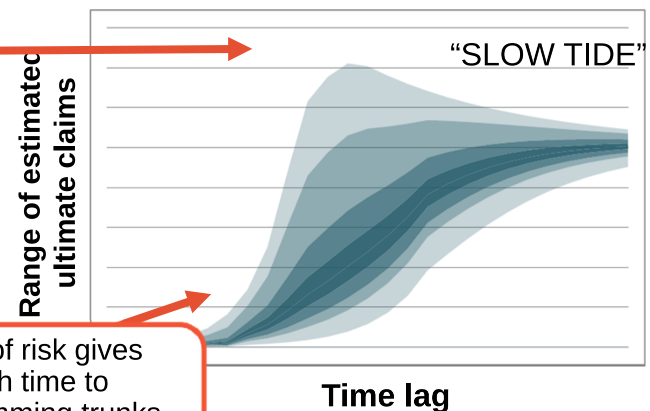
To what extent are the tail events allowed for in casualty premiums?



Reserving Risk



Policy-event based loss models, e.g.:
Asbestos
Pollution
Credit crisis
etc.



Slower "velocity" of risk gives companies enough time to borrow some swimming trunks perhaps…??

Comparison of casualty vs. natural catastrophe models

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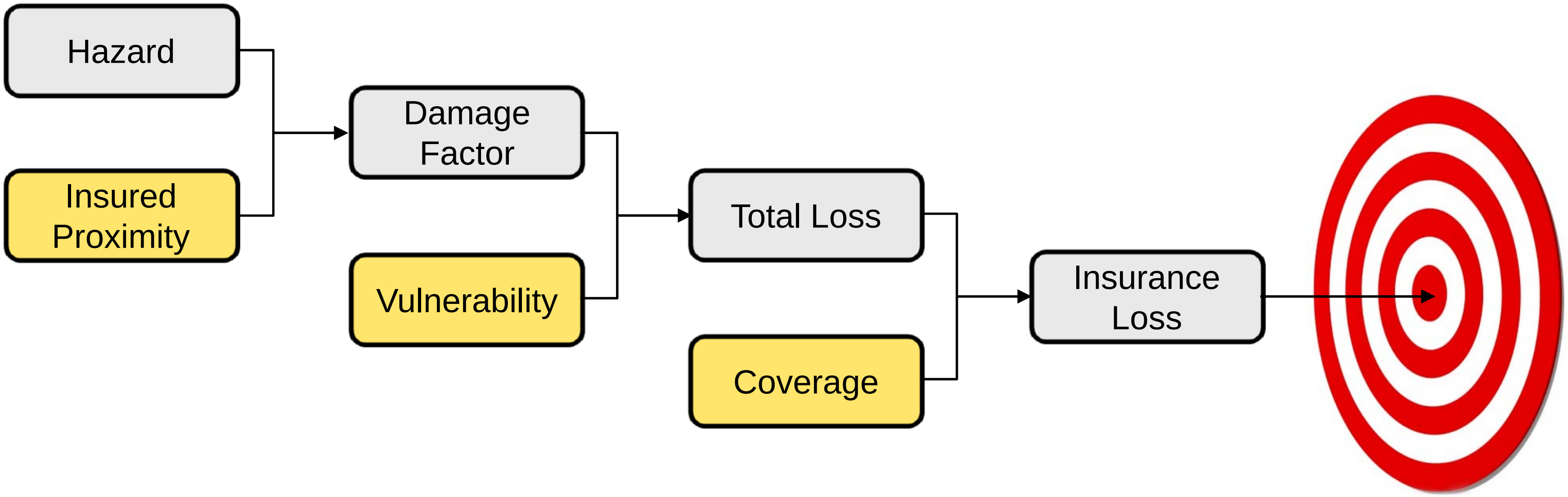
General Catastrophe Model

- A catastrophe model is made of various calibrated **modules** and **policy data**



- The challenges are similar for natural, man-made and casualty catastrophe models:
  - Limited data
  - Sensitivity to assumptions
  - Accuracy
  - Precision
  - Transparencies
  - External processes and data

"The actuarial literature does not deal with firewall movement in off-center automobile crashes, the relationship of central pressure to windspeed in Atlantic hurricanes, the demographics of drywall installers, or the migration of contaminant plumes in groundwater."

From "Disability Income to Mega-Risks: Policy-Event Based Loss Estimation," Bouska

Hurricane Catastrophe Model

- The **key areas** of a hurricane model are based in **physical** science (meteorological, engineering)

Hazard / Insured Location

Damage Factor / Vulnerability

Total losses / Coverage

Casualty Catastrophe Model

- Features of casualty models can feel **less tangible**

Hazard / Insured Location

Damage Factor / Vulnerability

Total losses / Coverage

Casualty Catastrophe Model – Hazard Module

We have developed a proprietary **benchmark database** of **over 300** casualty catastrophes over the past 50 years

- Studying the features of historical casualty catastrophes yields clues about the characteristics of the next industry-changing catastrophic event.

DATABASE

Events categorized by:

- Type of loss
- Loss size
- Loss drivers
- Etc.

*Though not necessary for hazard module, vents trended to present day environment

CASUALTY CAT DNA

Event characteristics become the **DNA**

For example:

- Size of loss
- No. of insureds
- Insurance trigger
- Class actions
- Latency

EVENTS FOR SIMULATION

Permutations of event DNA become the basis of events for simulation.

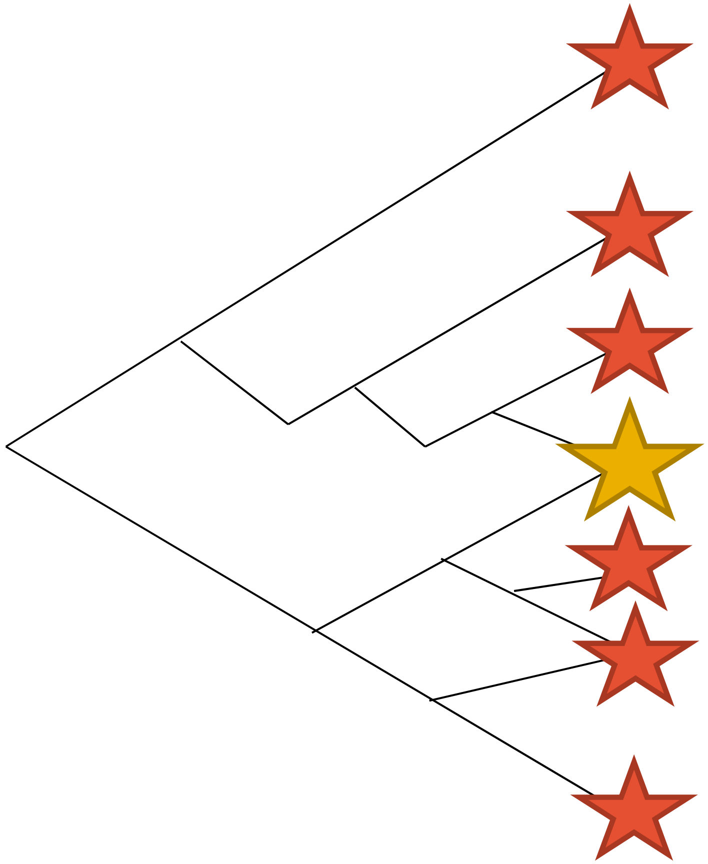
Gives the ability to analyze **reference events** and similar events.

Casualty Catastrophe Model – Hazard Module (cont.)

Let's use asbestos as an example.

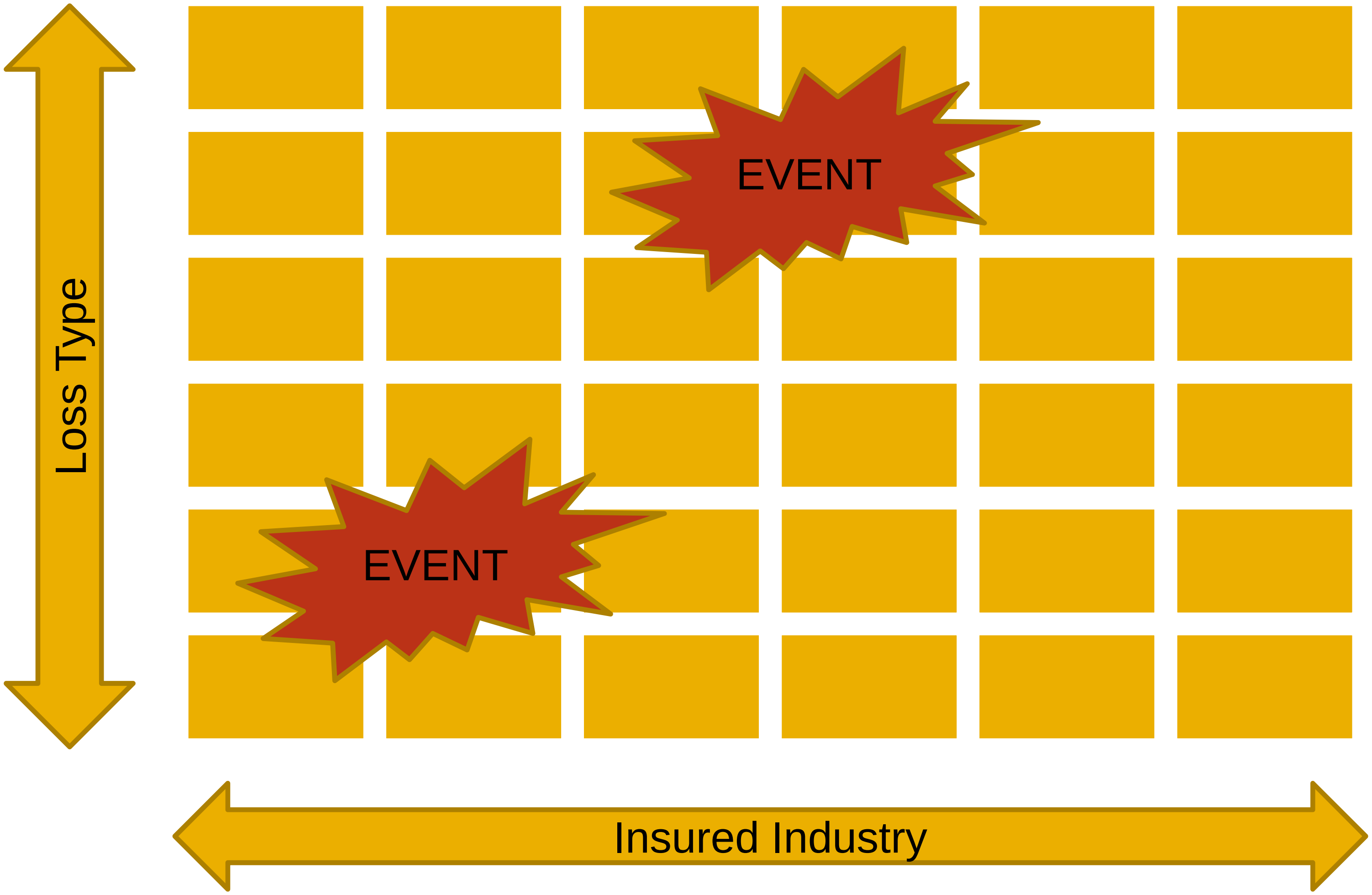
Here's what we know:

- Exposure
  - Widespread use
  - Involvement in multiple industries
  - Large population exposed
  - Decades of exposure
  - Extensive exposure of insurance policies
- Cause of loss
  - Signature disease, mesothelioma
  - Long latency
- Legal Environment
  - High propensity to sue, union organization

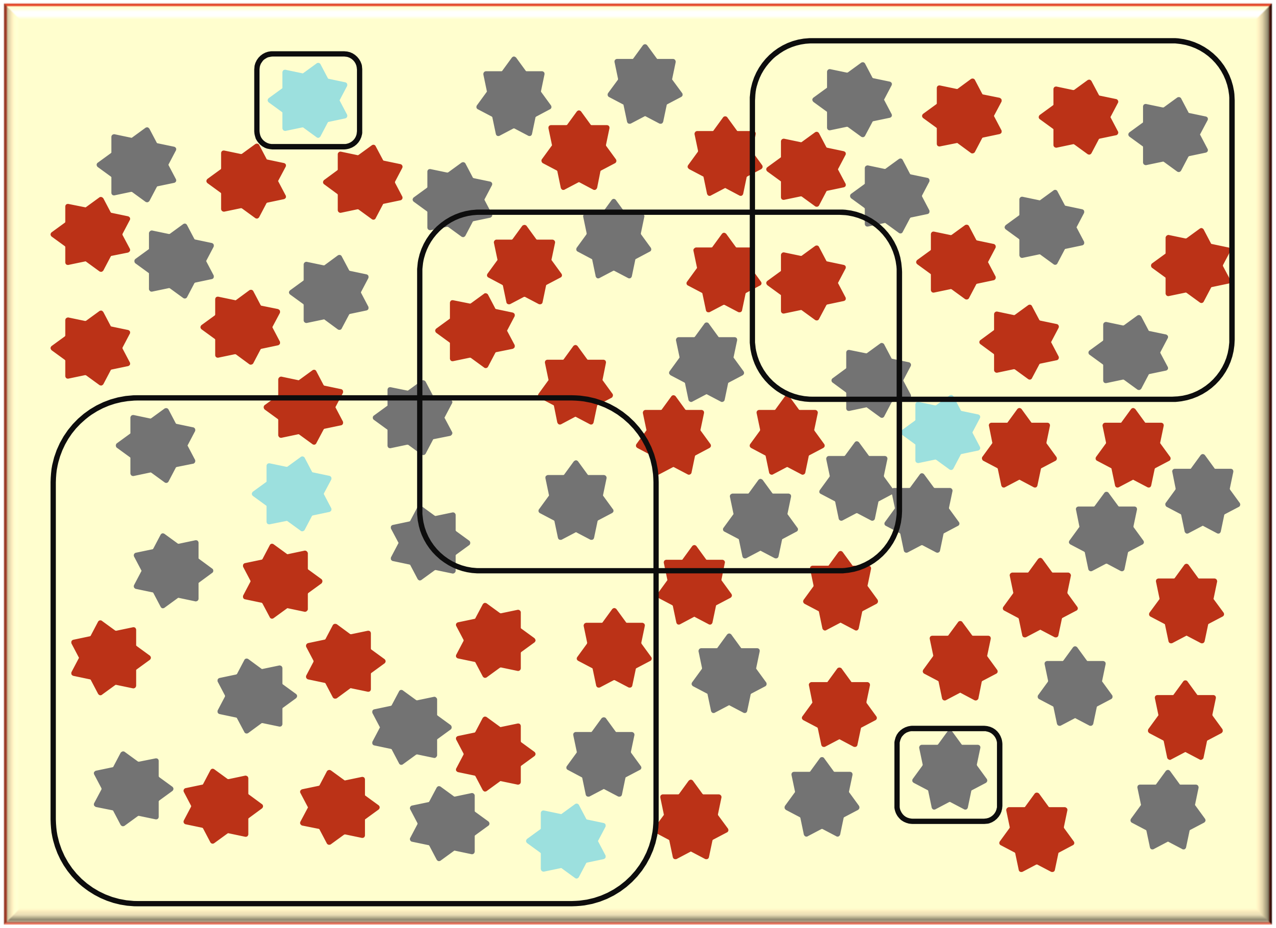


These characteristics form the basis of our simulation event set. "New" events are created by re-arranging the DNA.

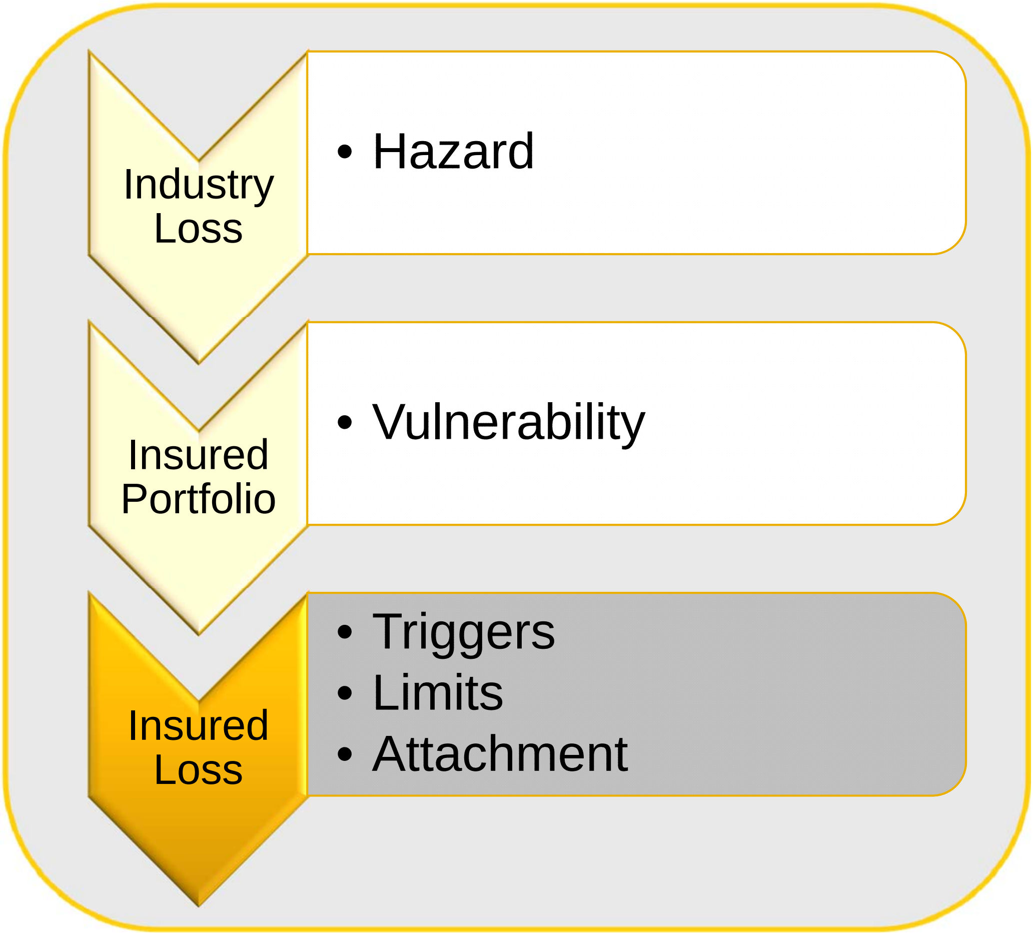
Casualty Catastrophe Model – Vulnerability Module



Casualty Catastrophe Model – Vulnerability Module (cont)

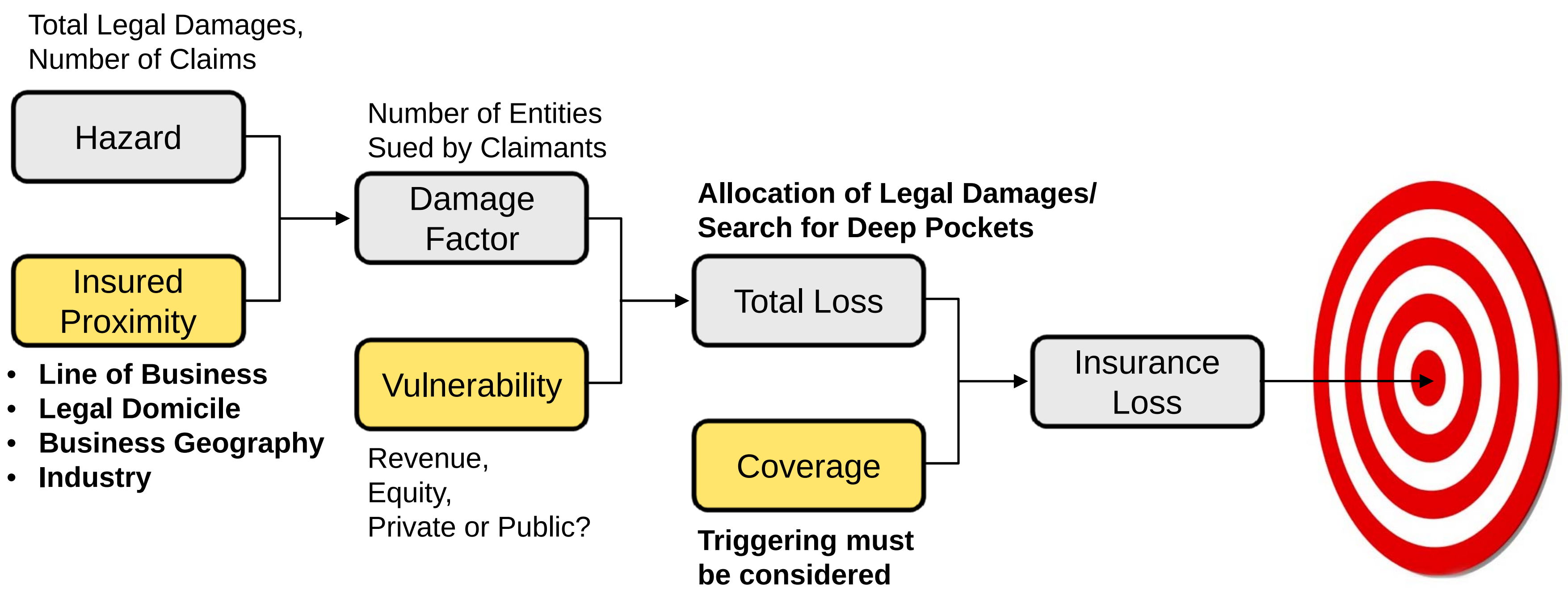


Casualty Catastrophe Model – Loss Module



Casualty Catastrophe Model

- While the structure is similar to other catastrophe models, the relative size and complexity of the various modules are different



Casualty catastrophe modeling process

How to create a casualty catastrophe model

1. Gather historical information on casualty catastrophe events
2. Adjust the ultimate cost of historical events to a common future point in time
3. Parameterize the frequency and severity of historical casualty catastrophes by line of business
4. Simulate future casualty catastrophes by line of business using a frequency-severity approach
5. For each simulated casualty catastrophe, allocate the industry-level ultimate losses to policy year and insurer
6. Review the results in total and along various dimensions
7. Conduct sensitivity testing of the model's assumptions and parameters, and compare with other empirical estimates from expert judgment

We have developed a proprietary benchmark database of over 300 casualty catastrophes over the past 50 years

Number of Events: **291**
Estimated Costs: **$542 billion**

Types of Allegations/Causes

- Antitrust
- Asbestos
- Automobile accident
- Breach of contract
- Collapsed structure
- Director negligence
- Discrimination
- Drugs for mothers, infants or children
- Explosion
- Fire
- Firm causes financial damages
- Negligent care
- Oil spill
- Plane crash
- Poisoning/contamination
- Pollution/chemical exposure
- Product causes medical damage
- Product causes property damage
- Product unsafe
- Securities fraud
- Securities negligence
- Train collision
- Vehicle unsafe

Lines of Business

- Aviation
- Directors and Officers
- Employment Practices Liability
- Errors and Omissions
- General Liability — Excluding Products
- Marine
- Medical Malpractice
- Pollution
- Products — Excluding Pharmaceuticals
- Products — Pharmaceuticals

- Towers Watson may not be able to predict what the next asbestos will be, but we are in a unique position to:
  - Understand the category of events your portfolio is more exposed to
  - Estimate the impact and volatility of these events related to your book of business
  - Establish a robust framework to parameterize economic capital models and provide underwriting guidelines

Adjusting Thalidomide: A case study in trending casualty catastrophe events into present day

Initial Estimate of Thalidomide's Worldwide Losses

Claims	Losses	Avg Loss	ALAE	Median Date of Sale	Trend	Length	Trended Losses and ALAE
15,000	30,000,000	2,000	12,000,000	1959	5%	53 years	557,547,844

Thalidomide, launched by Grünenthal on 1 October 1957, was found to act as an effective tranquilizer and painkiller, and was proclaimed a **"wonder drug"** for insomnia, coughs, colds and headaches. It was also found to be an effective antiemetic that has an inhibitory effect on morning sickness, so thousands of pregnant women took the drug to relieve their symptoms.

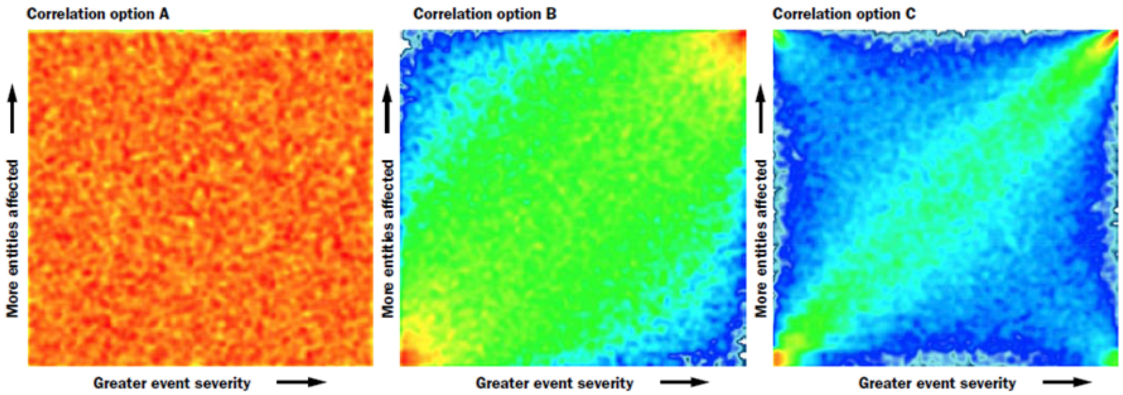
How much liability would this event produce if it occurred today?

- Has market for drug expanded since 1959, resulting in more claims now than before?
- What would the average settlement be today?
- Would the cases need to be more rigorously defended today, resulting in a higher ALAE load?
- Would the harmful effects of the drug have been noticed earlier, limiting the number of people exposed to the drug?

Very likely for Thalidomide.

	Claims	Present Day Avg Loss	Total Losses	ALAE	Trended Losses and ALAE
Present Day Population	30,000	26,550	796,496,921	318,598,768.25	1,115,095,689
Present Day Legal Environment	30,000	1,000,000	30,000,000,000	18,000,000,000	48,000,000,000
Effect Would be Discovered Sooner	5,000	500,000	2,500,000,000	1,500,000,000	4,000,000,000
FDA Would Block Drug	-	1,000,000	-	-	-
Best Estimate?	10,000	500,000	5,000,000,000	3,000,000,000	8,000,000,000

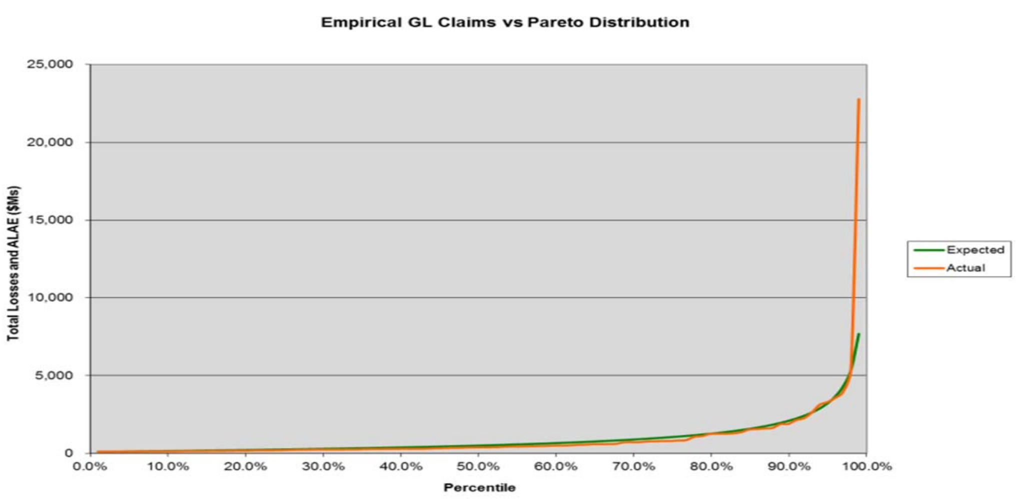
Parameterize model and simulate industry-wide losses



*Option A: no correlation; Option B: rank normal copula with 50% correlation; Option C: multivariate student's t copula with 50% correlation and one degree of freedom

Not Just Severity:

- Frequency
- Date of reporting
- Policy triggering
- Number of Entities



GL Claims Source: Towers Watson Casualty Catastrophe Database.

5. Allocate industry-level losses to policy year and insurer

Market-Share Approach

- Use market share of insurers by policy year
- Vary market share to fit a distribution of potential allocations

Policy-Level Approach

Simulate more details of the event. Some of which may be correlated.

- Number of claims
- Number of entities found liable
- Number of policies triggered
- Gross severity of each individual claim

Best practices

- Model results are sensitive to some assumptions. Resist the urge to over-parameterize and over-rely.
- Start collecting historical information now
- Set clear definitions early on
  - Catastrophe threshold
  - Events within definition (governmental liability, suits against insurance companies, suits against companies normally not insured?)
  - Claim/claimant/entity
  - Emergence on occurrence, reported or occurrence-reported basis
  - Emerge as nominal ultimate, discounted ultimate, or actuarial best estimate
- Be careful with exposure — it does not only relate to frequency

The “evolution” in the evolution of casualty catastrophe modeling

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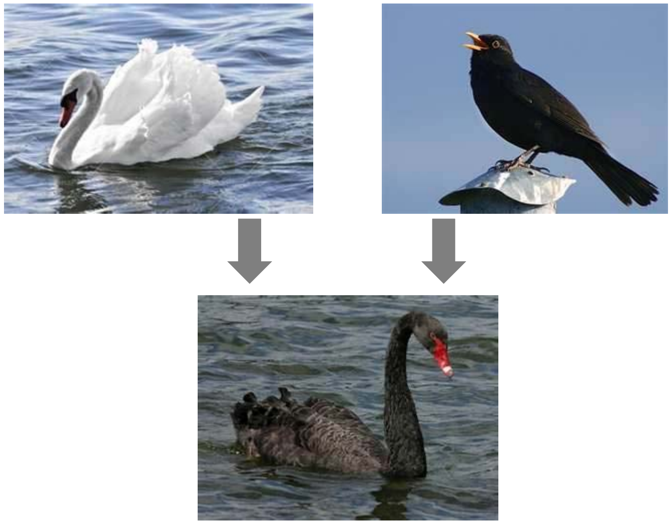
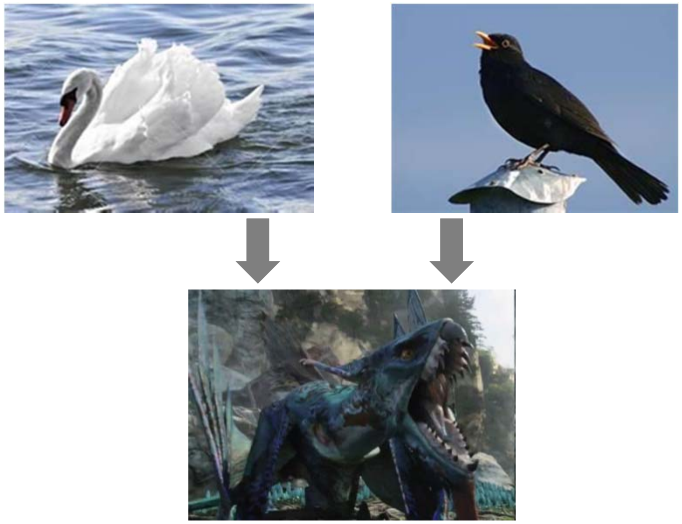
Can we predict black swans?

- Time difference between future event and observation time point determines whether the event is a black swan or not*
  - Example: Internet technology in 1960s vs. 1990s
  - Biological evolutionary methods (e.g., phlyogenetics) can assist in identifying prior signals of events**



Possible



Unlikely

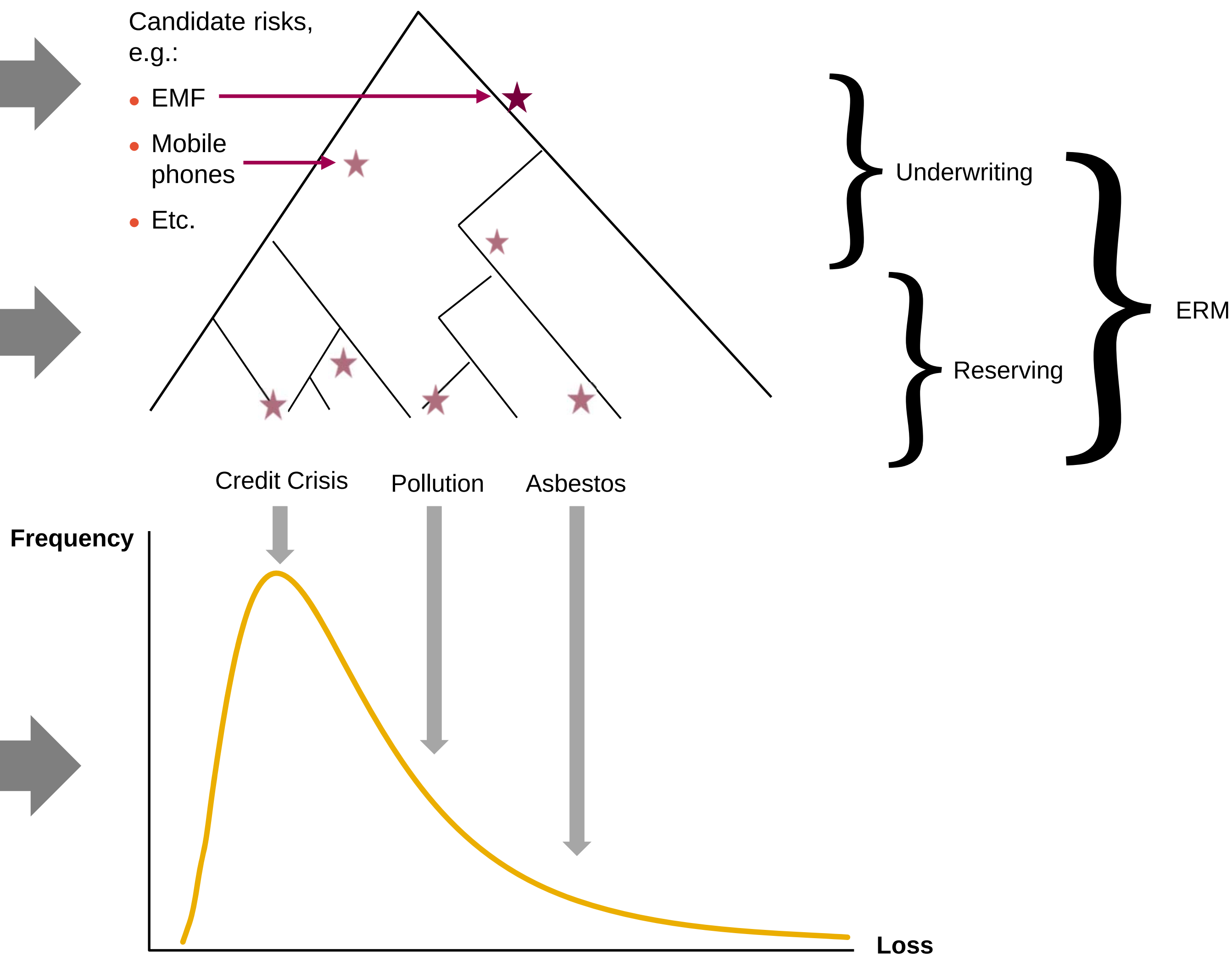
*Nassim Taleb, “The Black Swan,” 2007.
**“A review of the use of complex systems applied to risk appetite and emerging risks in ERM,” Allan et al.

The future of casualty catastrophe modeling

Overlay current environment

Casualty catastrophe database of historical characteristics or DNA of risks, e.g.:
- Size of loss
- No. of insureds
- Insurance trigger
- Class actions
- Latency

Evolutionary Risk Tree



Conclusions

Conclusions

- Casualty catastrophes have had major impacts on insurers historically
- Evolution in catastrophe modeling has been driven by major events: Hurricane Andrew, asbestos, pollution, WTC, etc.
- Casualty catastrophe reserving models have been around for a while now: asbestos, pollution, and other policy-event based loss estimation models
- Methods to quantify uncertainty for future casualty catastrophes exist and are evolving
- Uses of casualty catastrophe modeling: reserving, catastrophe risk management, scenario testing e.g RDS, economic capital modeling, ERM, underwriting...
  - ….catastrophe bonds?
- Further reading: “The Need for Casualty Catastrophe Models: A Way to Prepare for the ‘Next asbestos’”; Ball, Jing, Sullivan; http://www.towerswatson.com/newsletters/emphasis/6025

Case study 1 — Policy level modeling

Case study assumptions

- We created a simple fictitious company with the following base assumptions:
  - Two lines of business
    - General liability
    - Products liability
  - Began writing business ten years ago
  - Only writes primary, ground-up policies
  - Writes 25% of the entities in these industries
  - Business written with a 20% coinsurance share of the losses
- Then, some of the base assumptions were varied…

Case study results

Figure 2. Case study

Scenario	Policy terms	Share	Coverage period	Classes	Nmber of insureds per year	Number of enities in market	Mean in $millions	50th	90th	95th	99th	99.5th
1	Primary	20%	2001 – 2010	GL + Products	250	1,000	1,021	0.41	2.57	3.88	8.02	10.15
2	Primary	20%	2001 – 2010	GL + Products	500	1,000	2,042	0.55	2.39	3.45	6.37	8.46
3	10 x 10	20%	2001 – 2010	GL + Products	250	1,000	45	0.31	2.41	4.20	10.56	18.51
4	Primary	20%	2001 – 2010	GL	250	1,000	113	0.42	2.62	3.85	7.75	9.92
5	Primary	20%	2001 – 2010	Products Pharma	250	1,000	300	—	2.84	5.58	14.82	21.16
6	Primary	20%	1981 – 2010	GL + Products	250	1,000	1,203	0.40	2.53	3.84	8.32	10.67
7	Primary	100%	2001 – 2010	GL + Products	50	1,000	1,021	0.08	2.45	4.76	13.37	21.63

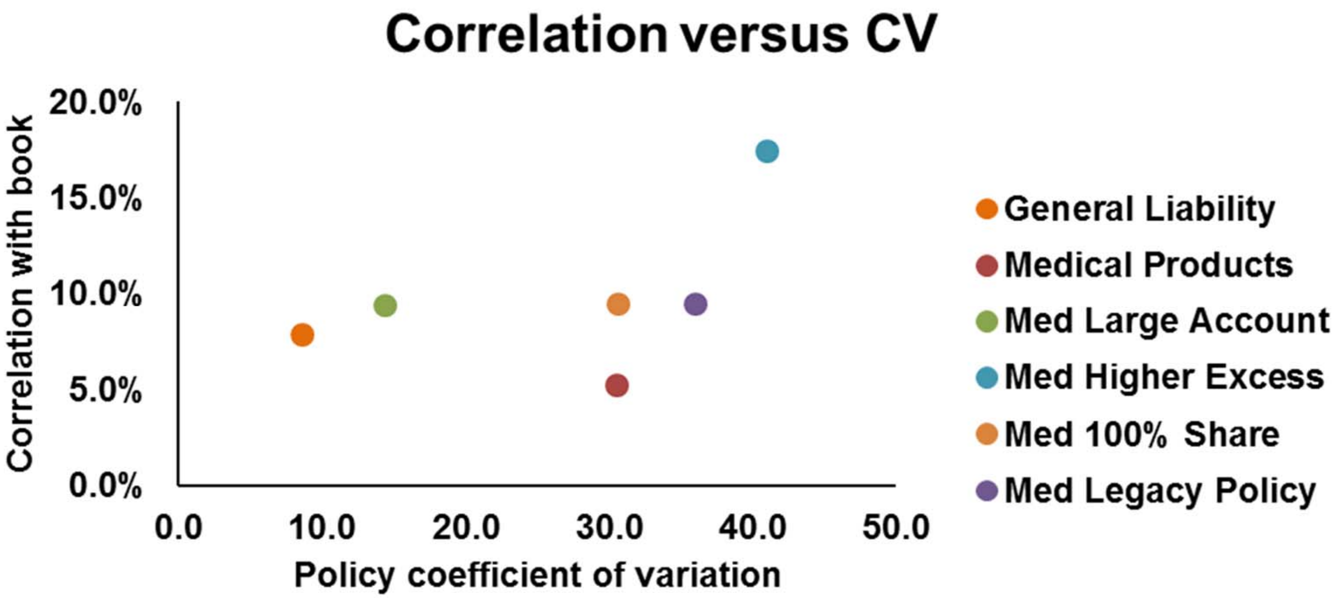
- Scenario 2 doubles the mean losses and “diversifies” the risk
- Excess layers in scenario 3 mean lower losses, but higher risk
- Scenarios 4 and 5 show effect of only writing different lines of business
- The longer history of policies in scenario 6 leads to slightly higher risks
- In scenario 7, by taking 100% of the share of losses, but writing fewer insureds, the insurer has accepted the same mean loss, but drastically increased the overall risk in extreme percentiles

Case study 2 — Portfolio optimization

Case study assumptions

- Six policy types:
  - Base: 4m xs 1m, 20% coinsurance share, written for 10 years, only GL
  - Large account policy with twice the average exposure for the market
  - Higher excess policy of 10 xs 5m
  - New policy only written for 1 year
  - 100% coinsurance share
  - Only medical products liability
- 30 policies of each type for a total of 180 policies
- Market assumptions the same as first case study

Policy-level approach can create variables needed for quantifying the policy's risk margin



- Identifies relative risk
- Facilitates the calculation of risk margins and allocation of capital to type

Case study 3 — Underwriting dashboard

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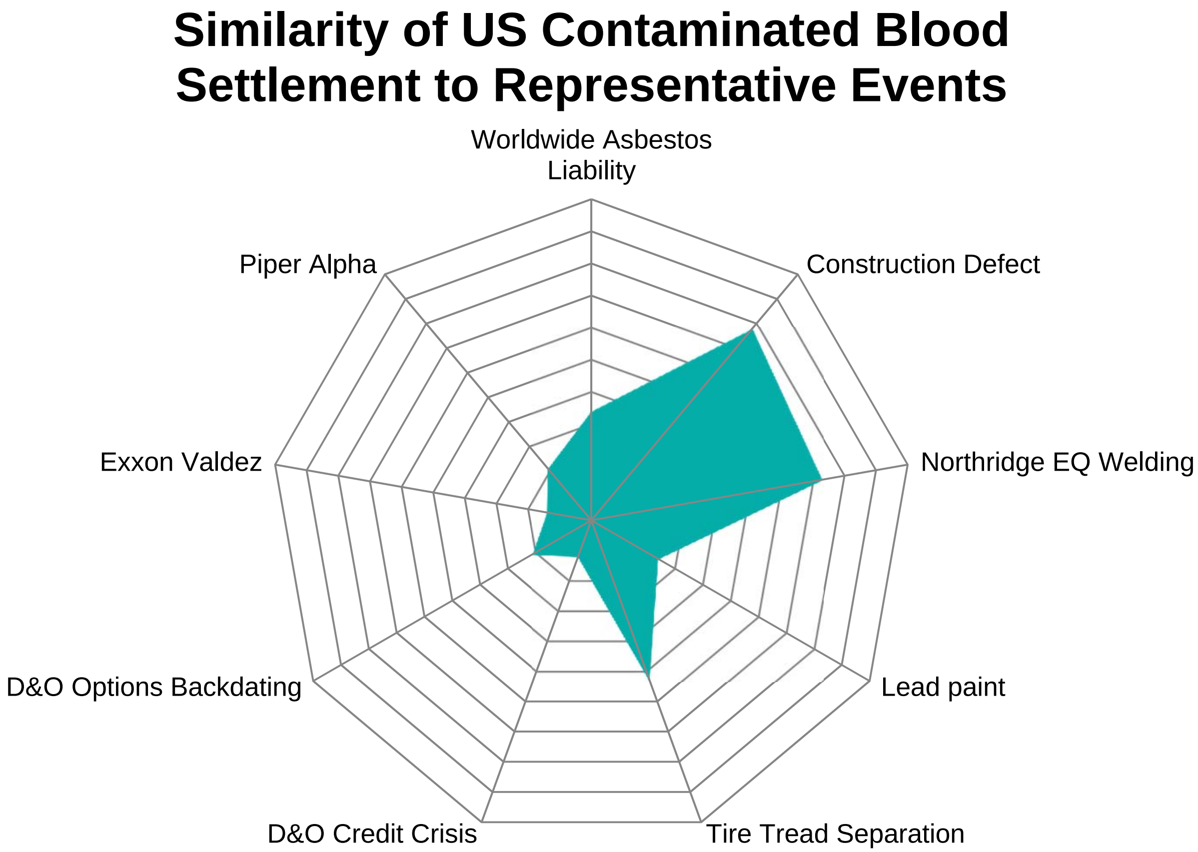
Why an underwriting dashboard?

- Every casualty catastrophe event has its own unique characteristics
  - Source of alleged damage or harm
  - Actions of insured leading up to event
  - Strategy of plaintiff law firm(s)
- On the other hand, there are some commonalities
  - Latency of damage or harm
  - Size of exposure
  - Type of damage or harm (medical, fiduciary, and so on)
  - Legal tractability of damage or harm to insureds
  - Specific actions of plaintiff law firms
- The commonalities allow a comparison of a potential future event to known historical events, allowing insurance companies to
  - Determine the range of most likely potential loss amount outcomes,
  - Classify the potential timing of the event, and
  - Identify the most similar historical events, thereby gaining insight into the potential future event.

Dashboard relies on and draws from our specialized casualty catastrophe event knowledge base and evolutionary biology techniques

- Database of casualty catastrophe events and characteristics
- Identification of key characteristics of events
- Categorization of each key characteristic
- Research into and understanding of life cycle of casualty catastrophes, including key legal events
- Classification of stages in life cycle
- Logic to objectively and consistently place events into stages in the life cycle
- Use of evolutionary biology techniques to measure “closeness” of potential emerging risks to historical events and therefore level of risk

Example output — risk “wagon wheel” illustrates relative closeness to other risks



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