BLOWN AWAY: MONETARY AND HUMAN IMPACTS OF THE 2011 TORNADOES

Kevin M. Simmons, Ph.D.
Deadly Season
Analysis of the 2011 Tornado Outbreaks

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from the American Meteorological Society and
the University of Chicago Press
Annual Tornado Fatalities 1875-2010
Killer Tornadoes of 2011

- Average annual number of killer tornadoes 2000-2010
  - 21
- Number of killer tornadoes 2011
  - 59
Tornado Fatalities

- Average annual number of fatalities
  - 50-60
- This year?
  - 552
Joplin MO May 22, 2011
Street in Joplin – Before
Google Street Level
Same Street in Joplin - After
## Comparing Peak Tornado Fatality Seasons

<table>
<thead>
<tr>
<th>Year</th>
<th>Fatalities</th>
<th>Recent Average</th>
<th>Recent Maximum</th>
<th>Ratio of Fatalities to Average</th>
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## Estimated Property Damage 2011

<table>
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<tr>
<th>Month</th>
<th>Insured Losses</th>
<th>Total Losses</th>
</tr>
</thead>
<tbody>
<tr>
<td>April</td>
<td>$9.6 Billion</td>
<td>$16.2 Billion</td>
</tr>
<tr>
<td>May</td>
<td>$5.5 Billion</td>
<td>&gt;$7 Billion</td>
</tr>
<tr>
<td>Total</td>
<td>$15.1 Billion</td>
<td>&gt;$23.2 Billion</td>
</tr>
</tbody>
</table>

Source: NOAA’s National Climatic Data Center
## Partial List of Insured Losses Reported as of July 1

<table>
<thead>
<tr>
<th>Company</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allstate Corp</td>
<td>$2 Billion</td>
</tr>
<tr>
<td>State Farm</td>
<td>$1.75 Billion</td>
</tr>
<tr>
<td>Travelers Companies</td>
<td>$1.05 Billion</td>
</tr>
<tr>
<td>Chubb</td>
<td>$310 Million</td>
</tr>
<tr>
<td>Zurich Financial</td>
<td>$295 Million</td>
</tr>
<tr>
<td>Cincinnati Financial</td>
<td>$290 Million</td>
</tr>
<tr>
<td>MetLife</td>
<td>$180 Million</td>
</tr>
<tr>
<td>State Auto Financial</td>
<td>$135 Million</td>
</tr>
<tr>
<td>Hanover Insurance</td>
<td>$85 Million</td>
</tr>
<tr>
<td>Validus</td>
<td>$75 Million</td>
</tr>
<tr>
<td>Assurant</td>
<td>$75 Million</td>
</tr>
<tr>
<td>PartnerRe</td>
<td>$70 Million</td>
</tr>
<tr>
<td>Aspen Insurance</td>
<td>$60 Million</td>
</tr>
<tr>
<td>Hiscox</td>
<td>$56 Million</td>
</tr>
<tr>
<td>Hannover Re</td>
<td>$45.6 Million</td>
</tr>
<tr>
<td>Montpelier Re</td>
<td>$35 Million</td>
</tr>
<tr>
<td>Flagstone Re</td>
<td>$30 Million</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$6.56 Billion</strong></td>
</tr>
</tbody>
</table>

Source: Company statements (Reporting by Ben Berkowitz, Editing by Bernard Orr and Lisa Von Ahn)
Question to Consider

- What drove the damages/casualties, extreme weather or extreme vulnerability?
Extreme Vulnerability?

- Three areas of known vulnerability
  - Location
    - Mobile Homes
  - Timing
    - Nocturnal Tornadoes
  - Geography
    - Dixie Alley
Extreme Vulnerability?
Fatality Distribution – By Location

Source: National Weather Service
Since 1996, mobile homes account for 43% of all fatalities.

Even though they are only about 7.5% of the housing stock.

In 2011 they account for about 20% of the fatalities.
Extreme Vulnerability?
Nocturnal Tornadoes

- Overnight tornadoes are a known vulnerability
- Our models suggest that a tornado that occurs overnight will have fatalities double that of a similar afternoon tornado
Of the 59 killer tornadoes, only 6 occurred overnight with 7 fatalities.
94% of the fatalities came from states colored red or yellow

86% came from red or counties bordering a red state
Extreme Vulnerability? Dixie Alley

- Hard to ignore the fact that so many of the fatalities occurred in the southeast.
- But much of the southeastern effect is driven by:
  - Disproportionate share of deaths from
    - Mobile Homes
    - Nocturnal Tornadoes
    - Off Season Tornadoes
Extreme Weather?

- To address this question, we employ a casualty model we’ve developed over the last 10 years.
- If the range of fatality estimates from our model come close to the observed fatalities, then extreme weather is most likely the culprit.
Model

- Uses data from 1990-2010
- SPC tornado archive
- Census Bureau for socio-economic and demographic data
- Several important variables
  - Percent of mobile homes
  - Population Density
  - Tornado Intensity – F(EF) Scale
Model Limitations

- No single tornado in our data with fatalities in excess of 36
- Demographic data is at county level
Out of Sample Projections

- We used the model coefficients to estimate fatalities for the 2011 tornadoes
Results

- We run 4 variations of our casualty model
- The lowest estimated fatalities is 489
- The highest is 570 fatalities
- Average of the 4 models is 526 fatalities
Relative Measures of Lethality

- Deaths per damaged building
  - 335
- Deaths and injuries
  - 358
- Deaths and monetary damages
  - 401
Results

- This suggests that given the number of violent tornadoes, the fatality total of 552 is not unexpected.
Can it Happen Again? Fatalities

- Over the last 60 years, 85% of all fatalities are from Long Track Strong/Violent tornadoes
  - Defined as F2+ and a path of 5 or more miles

- This year saw 178

- 60 year average? 91

- Other years with large fatalities
  - 1953 LTSV Tor – 103 Fatalities - 515
  - 1965 LTSV Tor – 144 Fatalities - 301
  - 1974 LTSV Tor – 175 Fatalities - 348
Can it Happen Again?
Damage

Normalized Damage

What damage would have occurred if the tornadoes from a previous year happened in the same place but at a future date?

Adjustments must be made for changes in population and wealth.

We perform 3 ways to get at that adjustment and then scale previous years to 2011.
Can it Happen Again? Damage

- Over the last 60 years, 75% of all damage is from Long Track Strong/Violent tornadoes
  - Defined as F2+ and a path of 5 or more miles
- Other years with large damage
  - 1953 LTSV Tor – 103 Damages - $32 Billion
  - 1965 LTSV Tor – 144 Damages - $29 Billion
  - 1974 LTSV Tor – 175 Damages - $14 Billion
Tornado Losses Compared to Other Hazards

- Tornadoes 1950-2011
  $339 Billion Normalized Losses

- Earthquakes 1950-2011
  $150 Billion Normalized Losses

- Hurricanes 1950-2011
  $621 Billion Normalized Losses
Future Policy Considerations Limiting Fatalities

- Extended Lead Time
- Public Funding of Shelters
- Dissemination of issued warnings
- Warning Quality – False Alarms
Extended Lead Time

- Currently, average lead time is about 15 minutes
- This is triple the average lead time from 20 years ago
Extended Lead Time

- Our models show diminishing returns for lead time beyond 15 minutes
- Which begs the Question:
  - What will people do with the additional time?
Extended Lead Time

- Warn on Forecast could extend lead time measured in hours, not minutes.
- Evacuation?
Engineers at Texas Tech designed an indoor shelter that can withstand the winds of an EF-5 tornado.
Public Funding of Shelters
The Tradeoff

- Such a large event prompts discussion of public subsidies for saferooms.
- Several states, most notably Oklahoma have had such programs.
- If public funds are used, there exists a tradeoff on potential uses of the same money to save lives elsewhere.
- Value of Life estimates:
  - A common range is $5-$10 million
Our Approach

- For each state we have calculated a “Cost Per Avoided Fatality”
- Inputs to the calculation:
  - Average annual fatalities
  - Average shelter cost
  - Housing Units
  - Discount Rate
  - Estimated shelter life
Example: Alabama Permanent Homes

- Housing Units (2010 Census – Single Detached) 1,535,146
- Average Annual Fatalities (1950-2011) 3.07
- Shelter Cost $2,500
- Shelter Life 50 Years
- Discount Rate 3%
Example: Alabama Mobile Homes

- Housing Units (2010 Census) 291,373
- Average Annual Fatalities (1950-2011) 4.26
- Shelter Cost $2,500
- Shelter Life 50 Years
- Discount Rate 3%
Estimate Cost Per Avoided Fatality

- Permanent Homes
  $47.2 Million

- Mobile Homes
  $6.5 Million
Estimate Cost Per Avoided Fatality With Some Consideration for Peace of Mind

- Permanent Homes
  - $22.2 Million
- Mobile Homes
  - $3.0 Million
Observations on Public Funding

- There appears some merit for mobile homes given the increased vulnerability

- Permanent homes, however, are harder to justify
One way to examine the value of saferooms is to see if they affect the value of the property.

Study: Oklahoma County Residential Sales

We were looking for any premium to sales price if a shelter was present.
Private Mitigation Results

- The presence of a shelter added about 3.5% to the sales price of the home.
- For our sample that was an increase of $4,200 to the average home.
Continued Progress in Reducing Casualties

- Warning Dissemination
  - Nocturnal Tornadoes
    A lethal tornado at 2:00 a.m. will kill over twice as many people as the same tornado occurring at 2:00 p.m.

- Warning Quality
  - False Alarms
    Our research shows that there is a “cry wolf” effect.
Future Policy Considerations Limiting Damage

- Better Construction
  - Load path connections
Future Policy Considerations Limiting Damage

- IIBHS Fortified Program

- Tornadic Winds are different than hurricane wind forces
  - Wind speeds in an EF-5 tornado exceed 200 mph
  - Winds are not straight line creating special forces on the structure.
Future Policy Considerations
Limiting Damage

- Current study on the effect of enforced building on hail damage
- Study participants
  - Wharton Risk and Decision Analysis Center
  - Insurance Services Office
  - Travelers Insurance
- Research Question:
  - How much is good enforcement worth when a hail storm strikes?
- Result:
  - Damage is reduced by about 20%
Could it Have Been Worse?

- **1953**
  - Population of Affected Counties: 3.9 Million
  - Fatality Rate: 131.7 per million

- **2011**
  - Population of Affected Counties: 8.6 Million
  - Fatality Rate: 64.3 per million
Conclusion

- The tragic results of 2011 remind us that nature can be violent and unforgiving.
Thank You For Your Attention