What’s ground breaking about this study?

This study looks at the risk of economic output from catastrophes
• Not just how catastrophes damage property

It analyses cities as urban economic systems
• Compiled profiles of the economies of 301 of the world’s leading cities

We have analyzed a wide range of catastrophe threats
• Developed assessments of the likelihood of 18 threat types impacting each city
• In some cases, pioneered analysis of previously un-modelled threats

Developed metrics for economic consequences of catastrophe
• GDP@Risk

Provided a framework for thinking about this problem
• Identifying which cities and threats are most important
Cities and Economies

A city economy is a system

People

Physical Assets

Utilities

Connections
301 Cities that drive the world’s economy

- Includes the largest cities in the 50 largest economies in the world
- Includes all 34 of the UN designated ‘Megacities’
- Includes all cities over 3m population in the world
- Consist of half of the world’s capital cities
The world’s economy is increasingly urbanized

For example...

London economic region has increased its share of UK output from 15% in 1960s to 45% today
Cities, GDP & Projected Growth Rates

Growth Rates and GDP Size

- Africa
- China
- Eastern Europe
- Latin America
- Middle East
- North America
- Oceania
- SE Asia
- Western Europe
- Indian Subcontinent
- Japan
Towards the Knowledge Economy

Old

New

Cities economies categorized by type

G: Agriculture with Industry & Service

E: Industrial-Oriented Economy

A: Service-Dominated Economy

- Agriculture
- Industrial
- Service

39% 37% 24%

33% 63% 4%

22% 77%
Earthquake

Event: Great Hanshin earthquake, 1995
Location: Kobe, Japan

Economic cost: $150bn, two-thirds in infrastructure and property damage and one-third in economic disruption.

Description: A magnitude 6.9 earthquake struck 20 kilometres from the city of Kobe, 16 kilometres below its epicentre, on 17 January 1995.

Damage: More than 6,400 people died and 15,000 were injured. Around 82 hectares of urban land was devastated by fire. The city’s subway system and stations were damaged, along with 400,000 buildings, and its supply lines interrupted by damage to regional trunk roads, monorails, railway lines and stations. Liquefaction wrecked all but six of the 187 shipping berths in Kobe’s container port.

Insight: Domestic insurers covered about $3bn, and the

“In California, take up of earthquake insurance is only about 12%. In lieu of these covers being made compulsory, the industry needs to work harder at promoting the value of and driving the take up of these products, so that disaster risk financing is in place when the ‘Big One’ happens.”
Economic development hasn’t all been smooth sailing

The 301 cities have experienced many catastrophes over the past 50 years

- Lost more than a million of their citizens to earthquakes
- Half of them have suffered a serious flood
- Suffered more than 1,000 terrorist car bombs in city centres
- Seen a third or more of their economic capital wiped out by stock market crashes 5 times
- A quarter of them have been flooded more than 5 times
- Financial crisis of their governments defaulting on sovereign debts on 50 occasions
- Experienced thousands of cyber attacks
- 32 cities have had to cope with a volcanic eruption less than 100 km away
- Had to combat the outbreak of a previously unknown disease five times
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18 Threat Types

Finance and Trade

Market crash
Sovereign default
Oil price shock

Geopolitics and Society

Terrorism

Natural Catastrophe and Climate

Earthquake
Wind storm
Tsunami
Flood
Volcanic eruption
Drought
Freeze
Heatwave

Technology and Space

Nuclear accident
Power outage
Cyber attack
Solar storm

Health and Humanity

Human pandemic
Plant epidemic
18 Threat Types – **Manmade** and **Natural**

**Finance and Trade**
- Market crash
- Sovereign default
- Oil price shock

**Geopolitics and Society**
- Terrorism

**Natural Catastrophe and Climate**
- Earthquake
- Wind storm
- Tsunami
- Flood
- Volcanic eruption
- Drought
- Freeze
- Heatwave

**Technology and Space**
- Nuclear accident
- Power outage
- Cyber attack
- Solar storm

**Health and Humanity**
- Human pandemic
- Plant epidemic
18 Threat Types - **Emerging**

**Finance and Trade**
- Market crash
- Sovereign default
- Oil price shock

**Geopolitics and Society**
- Terrorism

**Natural Catastrophe and Climate**
- Earthquake
- Wind storm
- Tsunami
- Flood
- Volcanic eruption
- Drought
- Freeze
- Heatwave

**Technology and Space**
- Nuclear accident
- Power outage
- Cyber attack
- Solar storm

**Health and Humanity**
- Human pandemic
- Plant epidemic
Impact of 1995 Earthquake on Economy of Kobe, Japan

- Great Hanshin earthquake January 17, 1995, Magnitude 7.3
- Death toll 6,400; Direct damage costs $100 billion
- The port of Kobe, one of the world's busiest, was destroyed
- Kobe Steel Ltd, major steel maker, heavily damaged
- 80% of shoe factories damaged
- 50% of the region's sake breweries put out of action
- Kobe’s economic output halved in 1995, reducing Japan’s total industrial output by 2.6 percent
Analysis of Economic Loss in a Catastrophe

Supply Shock
- Destruction of Physical Assets
- Disruption of Labour Availability
- Flight of Capital
- Inability to Export

Demand Shock
- Consumer Confidence
- Shortage of Private Capital
- Share Price Reduction
- Inability to Import

Catastronomics Model

Government Recovery Stimulus

Inflation: increased cost of inputs
What if a severe earthquake hits Taipei in 2018?

- Taipei has a Threat Assessment Grading for earthquake of ‘Very high threat’ based on United States Geological Survey earthquake design code assessment of Taipei.
- An earthquake that would affect the city centre with shaking of PGA 400-600 cm/s² (MMI VIII) could be expected approximately once every 133 years (annual probability of 0.0075).

Taipei’s total lost GDP = $194 Bn
Mapping the Threat

- Solar storm
- Wind storm
- Oil price shock
- Earthquake
Putting them together into the City Risk Index

For each city:

• We assess the threat of all 18 threat types
  • i.e. how likely that city is to experience a number of representative scenarios of different magnitudes from that threat (3 representative scenarios)

• We model the economic consequences of each scenario for the city
  • We have modelled $301 \times 18 \times 3 = 16,254$ scenarios

• The GDP@Risk is the ‘expected loss’ – the loss x the probability

• We combine the GDP@Risk from the various threats and cities, assuming that the events are generally independent
### GDP@Risk metrics for a city – a risk profile

**Seoul**

**GDP@Risk: All threats**

$103.50bn

1. **Wind storm** $44.68bn
2. **Oil price shock** $12.72bn
3. **Market crash** $12.63bn
4. **Flood** $9.83bn
5. **Human pandemic** $7.61bn
6. **Drought** $6.08bn
7. **Cyber attack** $2.71bn
8. **Sovereign default** $2.02bn
9. **Freeze** $1.42bn
10. **Solar storm** $1.08bn
11. **Power outage** $1.01bn
12. **Volcano** $0.85bn
13. **Plant epidemic** $0.66bn
14. **Terrorism** $0.19bn
15. **Earthquake** $0.00bn
   - **Heatwave** $0.00bn
   - **Nuclear accident** $0.00bn
   - **Tsunami** $0.00bn

$11.50bn | $23.00bn | $34.50bn | $46.00bn
## Results – the world’s top 20 cities

How much of the world’s economy might be eaten up by catastrophes

This is also known as the ‘technical premium’ – if you could insure the economy of a city, here’s how much it would cost to insure against catastrophe loss.

A big city with a large economy will pay more than a city with a small economy for the same risk.

### GDP@Risk: Top 20 cities

<table>
<thead>
<tr>
<th>Rank</th>
<th>City</th>
<th>GDP at Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Taipei</td>
<td>$181.20bn</td>
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<tr>
<td>2</td>
<td>Tokyo</td>
<td>$153.28bn</td>
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<td>3</td>
<td>Seoul</td>
<td>$103.50bn</td>
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<tr>
<td>4</td>
<td>Manila</td>
<td>$101.09bn</td>
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<td>5</td>
<td>New York</td>
<td>$90.36bn</td>
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<td>6</td>
<td>Los Angeles</td>
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<td>7</td>
<td>Istanbul</td>
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<td>8</td>
<td>Osaka</td>
<td>$79.32bn</td>
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<td>Shanghai</td>
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<td>Hong Kong</td>
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<tr>
<td>11</td>
<td>Lima</td>
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<td>Tehran</td>
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<td>13</td>
<td>Sao Paulo</td>
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<td>20</td>
<td>Jakarta</td>
<td>$48.23bn</td>
</tr>
</tbody>
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Overall conclusions

• In this study we have made a first-order assessment at how catastrophes impact the economy of the world
  • Where the risk is most severe
  • What the threat drivers are in each location

• Globalization is boosting city hubs as generators of economic growth

• The nature of the economies is changing in these engines of growth

• Managing the risks of economic disruption requires different thinking to protecting physical assets

• This study provides the first step to understanding and managing the risks of economic catastrophe
Technical resources to help understand this

http://cambridgeriskframework.com/wcr

Special Methodology Seminar
Lloyd's City Risk Index - Methodology and Usage of City Economy Risk Analysis
Tuesday 6 October 2015
16:30-18:30, at Lloyd's, London

Registration: http://www.risk.jbs.cam.ac.uk/
Lloyd’s City Risk Index 2015–2025

301 cities
18 threats
US$4.56trn at risk

Lloyd’s City Risk Index 2015-2025 analyses the potential impact on the economic output (GDP@Risk) of 301 of the world’s major cities from 18 manmade and natural threats.

Based on original research by the Cambridge Centre for Risk Studies at the University of Cambridge Judge Business School, the Index shows that governments, businesses and communities are highly exposed to systemic, catastrophic shocks and must do more to mitigate...