Economic Resilience

Adam Rose

Coordinator for Economics
Center for Risk and Economic Analysis of Terrorism Events
University of Southern California

Key Questions

- Is resilience a meaningful concept?

- Can resilience be rigorously defined?

- Can resilience be empirically measured?

- How effective has resilience been to date?

- Can resilience be enhanced or depleted?

Economic Resilience

- <u>Static</u>: Ability of a system to maintain function when shocked (efficient use of remaining resources at a given point in time).

- <u>Dynamic</u>: Speed of a system to recover from a shock (efficient use of resources over time for investment in repair and reconstruction).

Examples of Resilience

- Individual Business (and Household)
  - conservation of critical inputs
  - use of inventories
  - business relocation

- Market
  - efficient allocation of resources via price signals
  - non-interruptible service premia

- Regional Economy
  - importing scarce commodities
  - information clearinghouses

Consistent with Paradigm Shift

- Can't prevent all attacks, but can reduce some losses after the attack occurs

- Business interruption losses as great as property damage
  - begin immediately after attack & continue thru recovery
  - have both behavioral & policy dimensions

- Customers have more resilience options than suppliers

- Resilience has cost advantages over mitigation
  - many inexpensive options
  - don't have to implement until event is know to occur

Features of the Definition

- Focus on <u>flows</u> after the initial shock

- Recovery has 2 aspects:
  - restoring loss of function
  - rebuilding the capital stock

- Two approaches to resilience
  - inherent (ordinary substitution, inventories)
  - adaptive (Draconian conservation, innovation)

Motivation for Resilience

- Individual and business survival

- Need/profit—New "business continuity" industry

- Acknowledgement of interdependence:

    "Companies have started to realize that they participate in a greater ecosystem, and that their IT systems are only as resilient as the firms they rely on to stay in business."—IBM Executive

Resilience Example: 9/11 Relocation

- 95% of WTC area firms relocated after 9/11

- If all of firms in the WTC area went out of business, direct business interruption (BI) loss would = $58.4B

- If all relocation were immediate, then there would have been no BI

- All businesses relocated within 8 months => $16.1B

- Resilience: $42.3/$58.4 = 72%

Mathematical Definition: Direct Economic Resilience

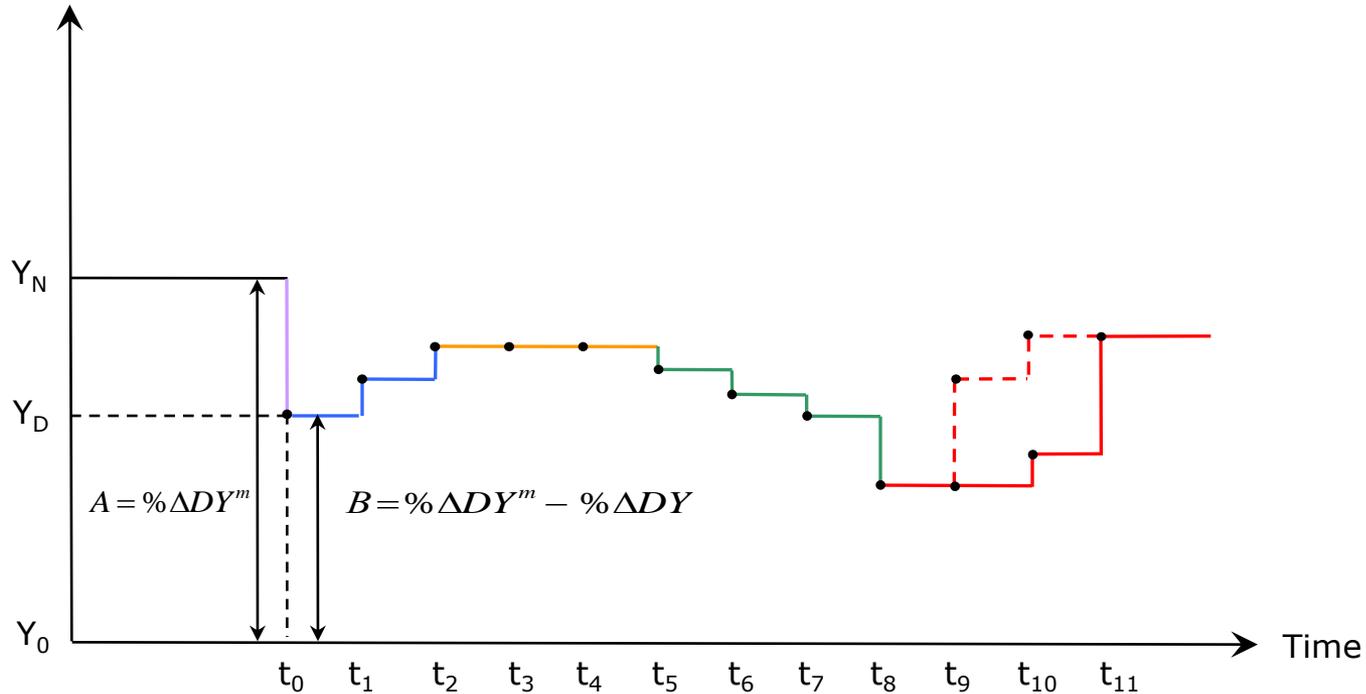$$DER = \frac{\%\Delta DY^m - \%\Delta DY}{\%\Delta DY^m}$$

where

$\%\Delta DY^m$ is the maximum percent change in direct output
$\%\Delta DY$ is the estimated percent change in direct output

In essence, *DER* is the % avoidance of a maximum disruption to a given shock

Static & Dynamic Resilience

Regional Economic Output (y-axis), Time (x-axis)

Y_N, Y_D, Y_0

$A = \%\Delta DY^m$

$B = \%\Delta DY^m - \%\Delta DY$

t_0, t_1, t_2, t_3, t_4, t_5, t_6, t_7, t_8, t_9, t_{10}, t_{11}

Initial drop in customer output due to electricity outage

Productivity improvements by customers

Upper limit of customer resilience

Erosion of customer resilience

Repair & reconstruction of electricity system

Sample Research Results

- A 2-week outage of *electricity* in Los Angeles County would result in losses of $20.5 billion if resilience is non-existent and $2.8 billion if resilience is maximized

- A 2-week outage of *water* in Los Angeles County would result in losses of $20.7 billion if resilience is non-existent and $2.3 billion if resilience is maximized

Individual Resilience Options

Resilience Factor	Water	Electricity
Conservation	1.0	6.1
Adaptive Substitution	1.6	3.9
Inventories/Storage	3.0	—
Alternative Sources	—	28.1
Importance	58.7	28.7
Production Rescheduling	75.5	79.4
Total	91.0	89.6

Changing Resilience

- Enhancement
  - investment
  - information dissemination
  - planning & drills

- Erosion with size & duration of disaster
  - difficulty in sustaining resilience
  - interdependent infrastructure
  - finite capabilities

Resilience in Face of Catastrophes

Action	Example	Ordinary Effectiveness	Effectiveness in Catastrophe
Inherent Resource Substitution	bottled water for piped water	minor	lowered because substitutes less available
Adaptive Resource Substitution	drilling new water wells	minor to moderate	lowered by limited substitution options
Inherent Import Substitution	importing bottled water	minor	lowered if transport network damaged
Adaptive Import Substitution	importing trucked water	moderate	lowered if transport network damaged
Adaptive Conservation	using less water by recycling	minor to moderate	weakened by property damage
Resource Inventories	using stored water	minor	weakened by property damage
Production Rescheduling	making up lost production afterward	moderate to immense	weakened by property damage

Modeling / Empirical Estimation

- Input substitution: elasticities / surveys

- Conservation: productivity parameters / surveys

- Business relocation: loosen constraints / surveys

- Inventories: optimal stock / econometrics

- Tech change: recalibration / synthesis of literature

- Import substitution: elasticities / econometrics

- Production recapture: loosen constraints / simulation

- Pricing: inherent feature / surveys & simulations

Alternative Definitions

- <u>DHS Lexicon</u>: Ability to resist, absorb, recover from or successfully adapt to adversity or change in conditions.

- <u>NIPP</u>: Capability of an asset, system or network to maintain its function or recover from a terrorist attack or any other incident.

- <u>NHERP</u>: Ability of social units (e.g., organizations, communities) to mitigate risk, contain the effects of disasters, and carry out recovery activities in ways that minimize social disruption.

Considerations for All Definitions

- Stocks (property damage) vs. flows (business interruption)
- Behavioral and policy dimensions
- Static (efficient resource allocation at point in time) vs. dynamic (efficient investment in capacity change)
- Multiple levels (micro, meso, macroeconomic)
- Contextual nature—need for a point of reference
- Inherent (ordinary ability) vs. adaptive (ingenuity)
- Supply-side (provider) vs. demand-side (customer)
- Cost of implementation
- Equity implications

Conclusion

- Resilience is a worthy *second line of defense*

    - it is effective

    - it is low cost

    - it is self-motivated

- Resilience applies to both producers & consumers

- Resilience is yet another way we can *all* contribute to reducing the threat of terrorism

GAO Resilience Directive 7/11/08

- In 2006, the Homeland Security Advisory Council's Taskforce on Critical Infrastructure recommended DHS: "promulgate CI resiliency as the top level strategic objective to drive national policy & planning."

- GAO will now assess how DHS has taken action to:

  - define resiliency

  - establish & promote resiliency as a goal

  - assess how an emphasis on resiliency alters CI protection efforts, how lessons learned have been incorporated & communicated to stakeholders

Behavioral Linkages

- Off-site responses from behavioral changes (business, household, investor, worker, gov't)

- Emanates from social amplification of risk (media coverage, rumor)

- Fear feeds on itself and spreads

- Translates into direct and indirect BI losses

- Can be 2 to 3 orders of magnitude higher

Behavioral Linkage Examples

- 9/11 led to a 2-year reduction in air travel

- Workers fear of riding the subway/bus

- Business fear of staying open after dark

- Investor fear of taking high risk

- Household fear of spending

- Gov't premature shutdown or evacuation

Terrorism and the Diffusion of Fear
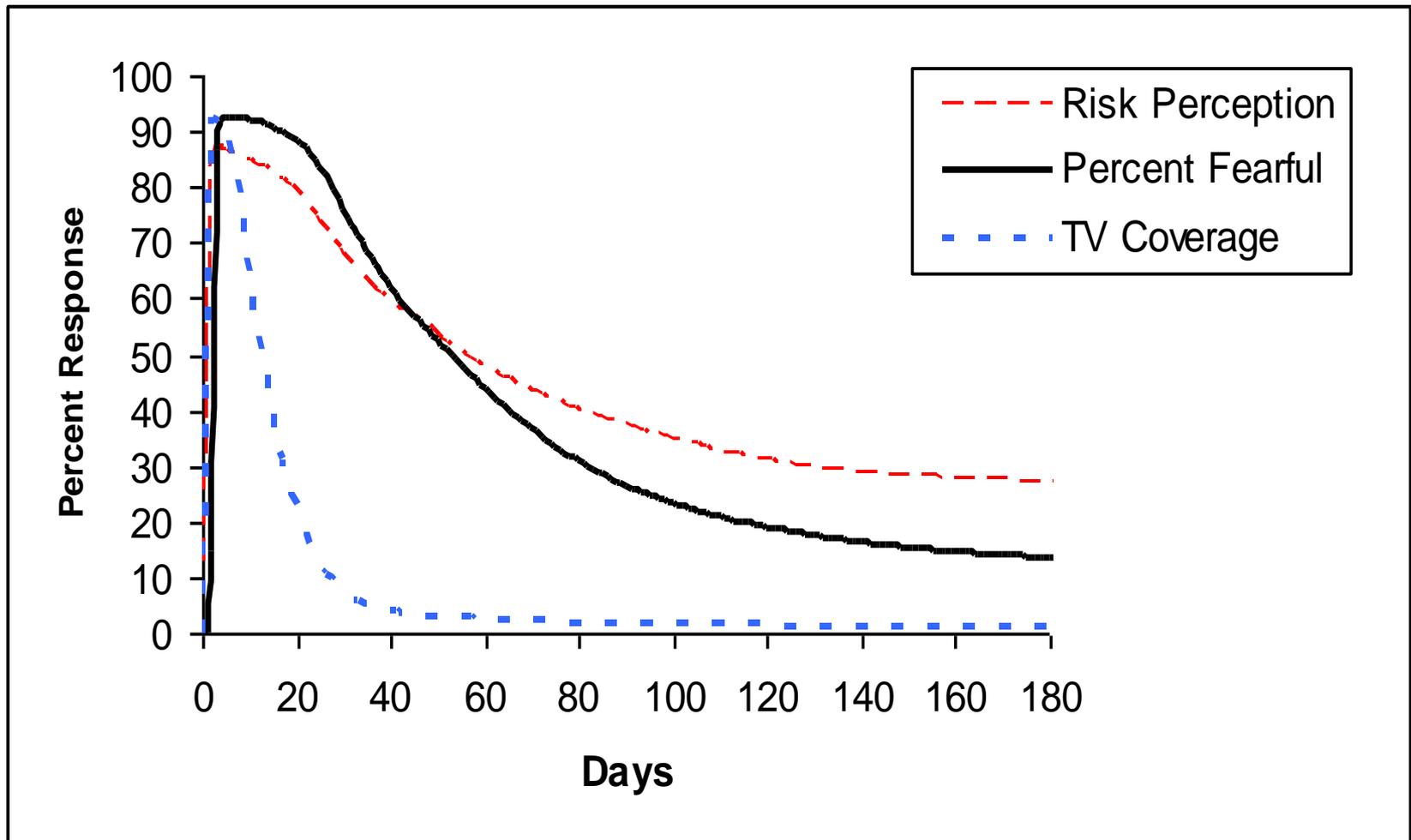
September 11 and the "Fear Factor"

- CREATE Economic Impact Modeling Forum: Economic Impacts of WTC Attacks

  - property damage: $25 billion
  - loss of life: $15B
  - direct business interruption: $11B
  - indirect business interruption: $14B
  - reduced airline travel/tourism: $50B
  - indirect effects of fear factor: $60B

  Total of business interruption: $135B

Analytical Framework Overview
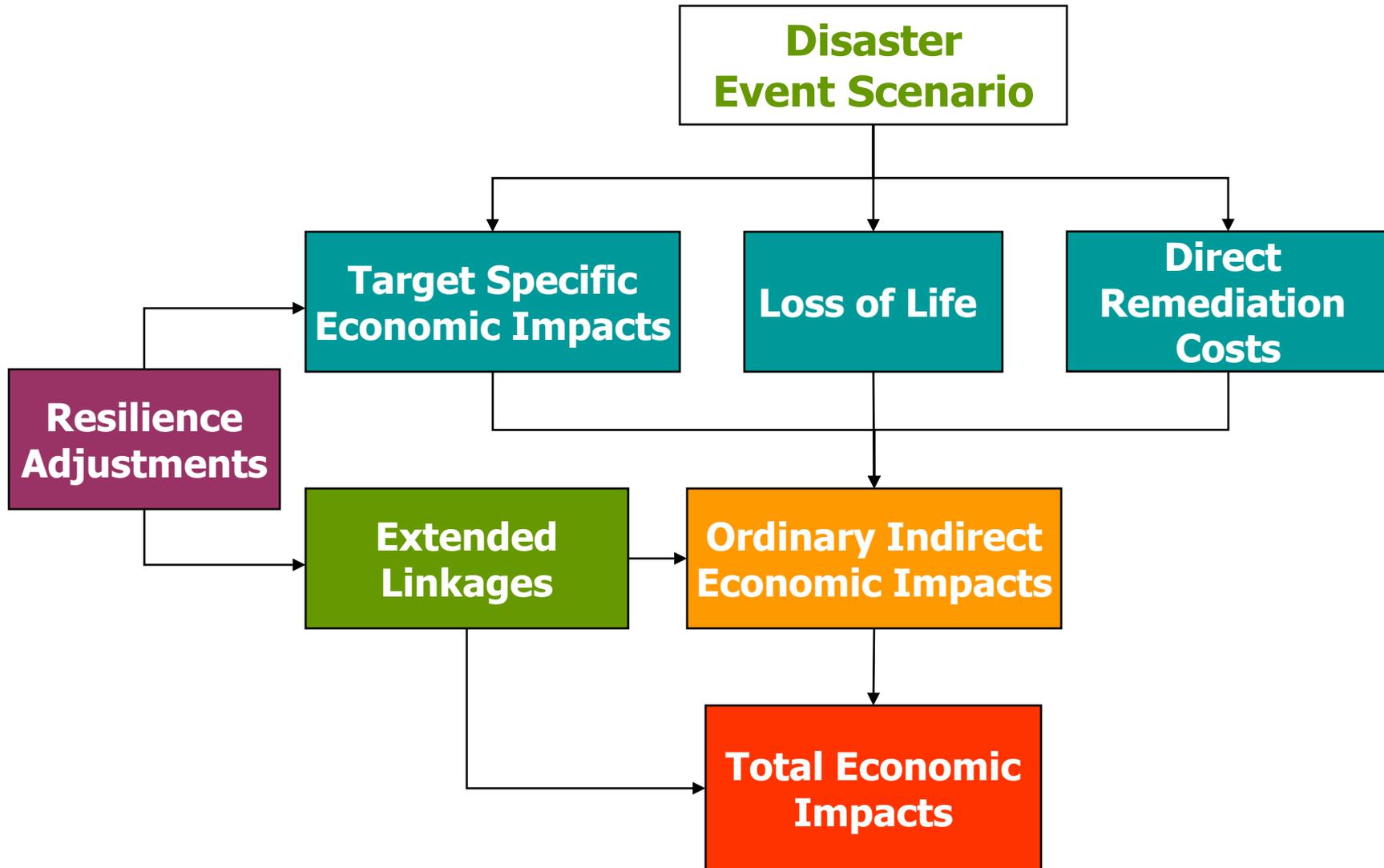
Reducing Losses

Three ways to reduce losses from terrorism:

1. Stop the terrorists before they strike
2. Protect the targets they plan to attack
3. Minimize the consequences of an attack
   - recover efficiently
   - recover quickly