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A Multiple Decision-Maker Approach to Allocating Resources for Disruptive Events

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Resource allocation models in emergency preparedness and response

- Mathematical / operations research models: assume single decision maker (Altay and Green 2006, Golany 2009, MacKenzie et al., 2016)
- Multiple decision makers
  - Qualitative studies (Heath 1995, Smith and Dowell 2000)
  - Game theory models (Coles and Zhuang 2011, Shan and Zhuang 2014)
  - Group dynamics (Chittaro and Sioni 2015)
- Allocating resources before a disruption versus after a disruption (Rose et al. 2009, Healy and Malhotra 2009, MacKenzie and Al Kazimi 2018)

Research goals

- Incorporate four decision makers with different responsibilities and objectives in a disaster context
- Combine decisions of separate entities into overall economic measure of production
- Quantify effect of shared decision making

Hurricane Katrina

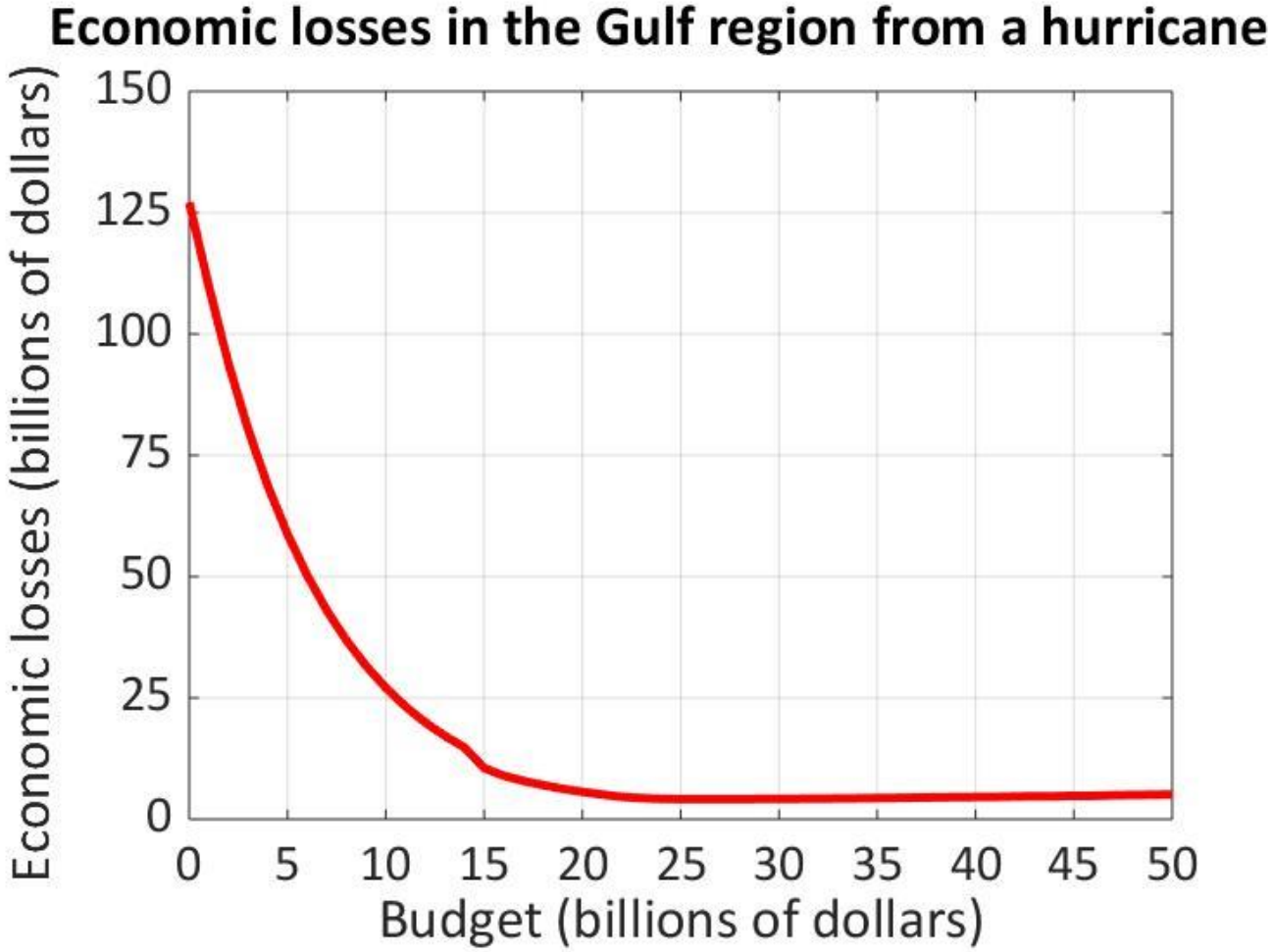
MacKenzie and Al Kazimi (2018) applies resource allocation model to determine resources that should be allocated before a hurricane and after a hurricane

Four decision makers

American Red Cross

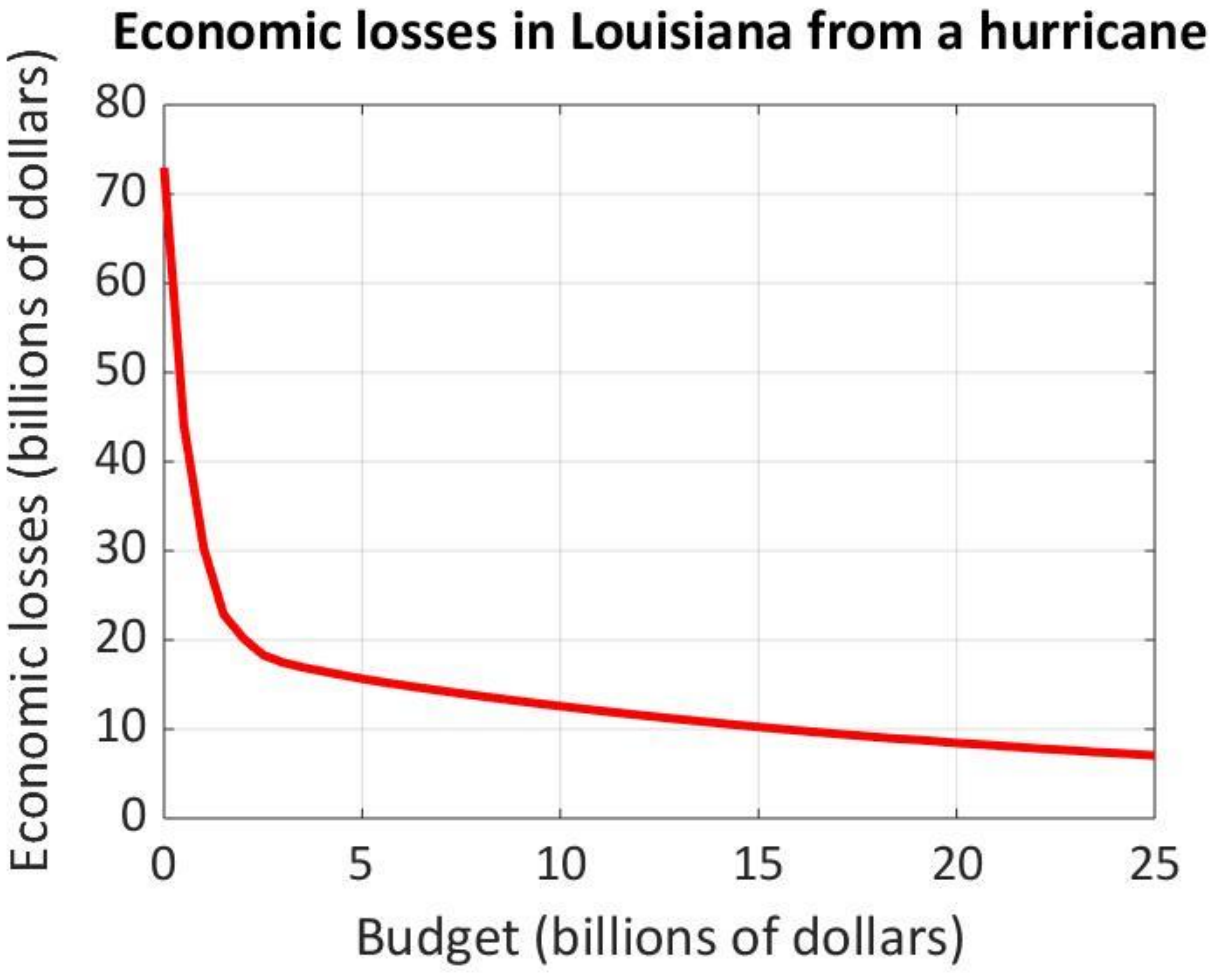
Federal government's resource allocation model

- Minimize expected economic losses in a region (5 states)
- Allocate pre-disruption resources to prepare for a disruption
- Allocate post-disruption resources to help individual economic sectors recover from a disruption
- Budget constraint



State government's resource allocation model

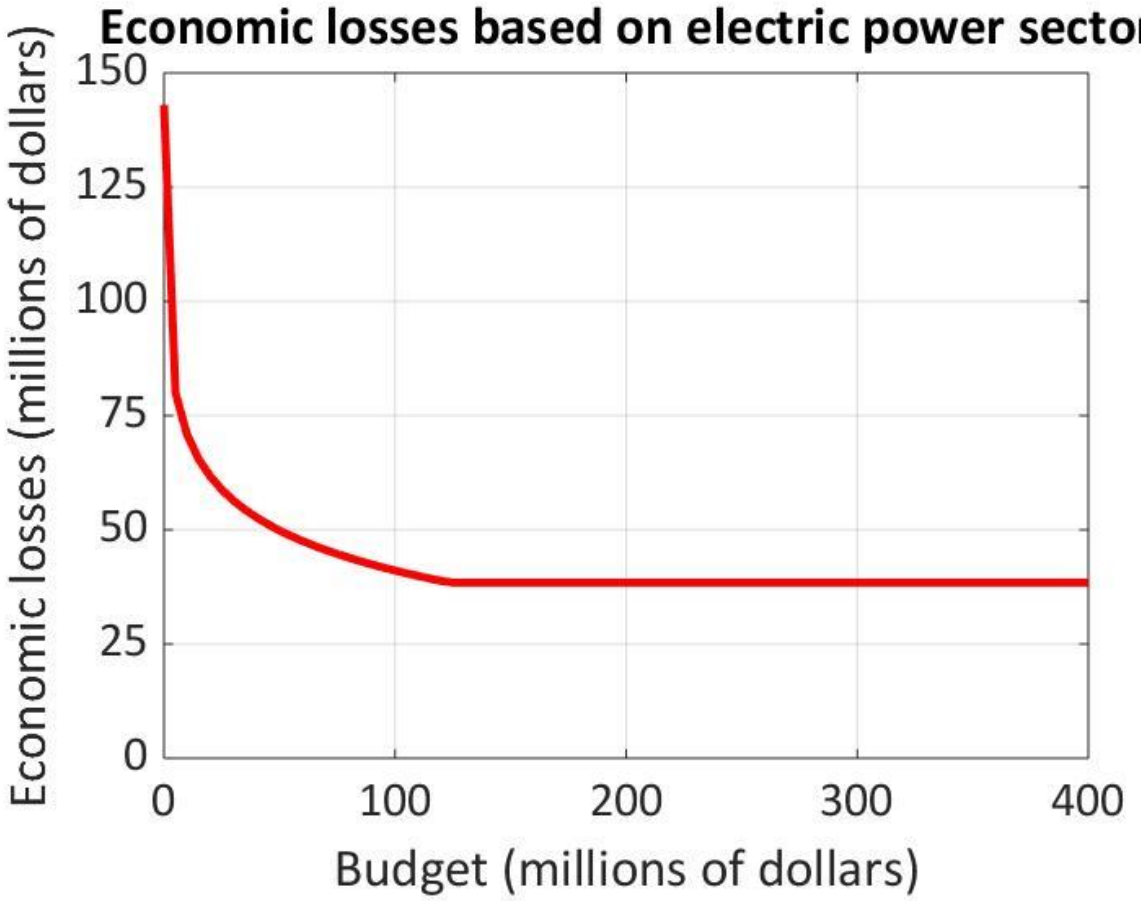
- Minimize expected economic losses in a state
- Allocate pre-disruption resources to prepare for a disruption
- Allocate post-disruption resources to help individual economic sectors recover from a disruption
- Budget constraint
- Assumption: state government's resources are more effective than federal government (Joumard and Giorono, 2002)



Private sector's decision model

- Maximize private sector's resilience to disruptive event (MacKenzie and Zobel 2016)
- Allocate resources for hardening (reduces initial impacts) and recovery (reduces time until full recovery)
- Budget constraint

→ Translate resilience to economic losses in private sector industry



Non-governmental organization (NGO) decision maker

- Maximize multi-objective utility function
  - Food
  - Shelter
  - Relief items
- Allocate resources for each item type before and after disruption
- Budget constraint

NGO results (millions of dollars)

Budget	Pre-disruption allocation		Post-disruption allocation		
	Food	Relief	Food	Relief	Shelter
300	16.5	5.8	43.9	33.8	0.6
350	22.7	1.4	48.8	43.8	0.6
400	29.0	7.1	56.8	46.4	0.6
450	32.1	1.3	73.3	51.9	0.6
500	37.2	20.1	73.1	51.8	0.6

Translate effect of NGO decisions to economic productivity
(using person-days of work)

Shared decision making

- Combine combined economic losses based on 4 decision-making models
- Budgets
  - Federal government = $10 billion
  - State government (Louisiana) = $2.5 billion
  - Electric utilities = $100 million
  - NGO (Red Cross) = $400 million
- Total production losses = $43.5 billion

- Budgets
  - Federal government = $7 billion
  - State government (Louisiana) = $5 billion
  - Electric utilities = $500 million
  - NGO (Red Cross) = $500 million
- Total production losses = $29.9 billion

Conclusions

- Operations research model of four different decision makers with different resources, objectives, effectiveness
- Allocating resources before a disruption (e.g., hurricane) and after a disruption
- Input-output economic model translates resource allocation decisions to economic losses from a disruption
- Combine four decision makers: economic production losses from a hurricane can be reduced by $13 billion if budget is divided differently

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