Self-Organizing Cooperative Dynamics in Government Extended Enterprises

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Research Task / Overview

- **Propose and evaluate a new, SoS-based theory of cooperation among autonomous government organizations**
  - Strong support for 3 hypotheses about 4 key forces, moderate support for hypothesis 4; proposed fifth hypothesis may not be needed
  - Important reinforcing and offsetting effects exist between: 1) pairs of forces, 2) each force and strategy, 3) sets of forces and strategy
- **Demonstrate a "laboratory" and process for further work**
  - See if the combination of the theory, simulation and coding process produced results that mirror reality
  - Determine whether model balances sensitivity with robustness to variance in input data

Goals & Objectives

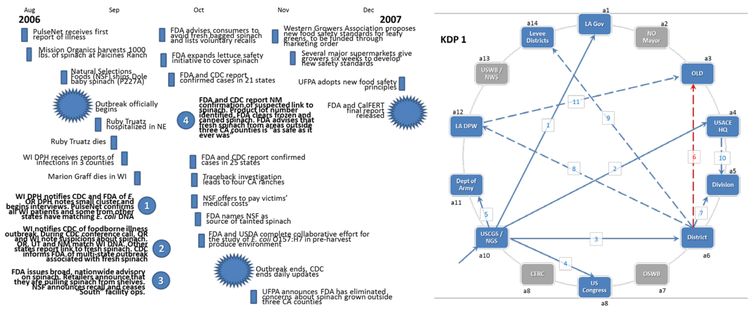
- Discover the **canonical forces** that influence an organization's willingness to be part of an extended enterprise, especially if the organizations are not motivated by economic forces
- Explain why networks of autonomous organizations often fail to achieve their public goals because their members fail to cooperate
- Develop and test **a useful theory** explaining the foundational forces supporting voluntary cooperation within SoS

Hypotheses: In a system of systems *S* with autonomous components a_1 through a_n, a_x's levels of Probability of Cooperation with a_y will be:

1. positively correlated with a_x's level of Sympathy with respect to a_y,
2. positively correlated with a_x's Trust with respect to a_y,
3. negatively correlated with a_x's level of Greed with respect to a_y,
4. negatively correlated with a_x's level of Fear with respect to a_y,
5. positively correlated with a_y's History of Behavior

Data & Analysis

- Researched potential cases (Committee directed use of three cases related to emergency management)
  - Sought cases involving GEEs with repeated internal interactions centering on "costless" information sharing
  - Case 1: Successful federal and multi-state response to 2006 foodborne *E. coli* outbreak (47 interactions)
  - Case 2: Design and construction of the Lake Ponchartrain and Vicinity Hurricane Protection Project (67 interactions)
  - Case 3: Evacuation of New Orleans associated with Hurricane Katrina (71 interactions)
- Understanding key decision points and visualizing information exchanges



- Coding simulation inputs

	Sharer						Receiver						
Exchange #	Agent ID	Strategy	S	T	F	G	Agent ID	Strategy	S	T	F	G	Depends on Exchange #
1	a10	1	3	3	0	0	a1	2	2	2	0	0	
2	a10	1	3	3	0	0	a4	7	3	3	0	0	
3	a10	1	3	3	0	0	a6	8	2	2	1	0	
4	a10	1	3	3	0	0	a8	5	2	2	1	0	
5	a10	1	3	3	0	0	a11	7	2	2	1	0	
6 Critical	a6	8	2	2	1	0	a3	3	3	2	1	2	3
7	a6	8	2	3	1	0	a5	2	3	3	1	1	3
8	a6	8	2	2	1	0	a12	4	3	2	1	2	3
9	a6	8	2	2	0	0	a14	6	3	2	2	2	3
10	a4	7	2	2	1	1	a5	2	3	3	1	2	2
11	a12	3	3	1	2	1	a3	8	3	1	2	1	8

Findings

Data not normally distributed (Q-Q plots and A-D test)

Clear correlations for all forces except Greed

Strong support for hypotheses 1 – 3, moderate support for hypothesis 4, hypotheses 5 not needed to explain behavior

HYPOTHESES		CORRELATIONS BY CASE				
#	a_x's level of ProbC with a_y will be:	Spinach	Levees	Evac	Conclusion	Comments
1	positively correlated with a_x's level of Sympathy with respect to a_y	Moderate Positive (rs = 0.59)	Strong Positive (rs = 0.64)	Strong Positive (rs = 0.62)	Strong positive correlation	Spinach: No actors with Sympathy = 1 Levees; No actors with Sympathy = 0 Evacuation: No actors with Sympathy = 0
2	positively correlated with a_x's level of Trust with respect to a_y	Weak Positive (rs = 0.29)	Strong Positive (rs = 0.66)	Strong Positive (rs = 0.69)	Strong positive correlation	Spinach: No actors with Trust = 0
3	negatively correlated with a_x's level of Fear with respect to a_y	Moderate Negative (rs = -0.47)	Strong Negative (rs = -0.67)	Strong Negative (rs = -0.60)	Strong negative correlation	Spinach: No actors with Fear = 3
4	negatively correlated with a_x's level of Greed with respect to a_y	Moderate Negative (rs = -0.43)	Moderate Negative (rs = -0.54)	Moderate Negative (rs = -0.46)	Moderate negative correlation	Spinach: No actors with Greed = 3 Levees: No actors with Greed = 3 Evacuation: ProbC rose 0.03 as Greed went from 2 to 3. Possible discontinuous relationship
5	positively correlated with a_x's History of Behavior toward a_y	Not tested	Not tested	Not tested	Unable to determine	All cases failed to provide sufficient repeat interactions to establish clear histories of behavior

- Important interactions exist between all variables
- Force-on-force interactions are sensitive to Strategy

Spinach Case*

Variable Pair	Rank	Relationship
Sympathy and Fear	1	Offsetting
Fear and Greed	2	Reinforcing
Strategy and Fear	3	Situational
Sympathy and Trust	4	Reinforcing
Sympathy and Greed	5	Offsetting
Strategy and Sympathy	6	Situational
Strategy and Greed	7	Situational
Strategy and Trust	8	Situational

Evacuation Case

Variable Pair	Rank	Relationship
Strategy and Sympathy	1	Situational
Fear and Greed	2	Reinforcing
Strategy and Fear	3	Offsetting
Strategy and Trust	4	Reinforcing
Strategy and Greed	5	Situational
Strategy and Fear	6	Situational
Sympathy and Greed	7	Offsetting
Sympathy and Trust	8	Reinforcing

Levees Case

Variable Pair	Rank	Relationship
Sympathy and Greed	1	Offsetting
Fear and Greed	2	Reinforcing
Sympathy and Fear	3	Offsetting
Sympathy and Trust	4	Reinforcing
Strategy and Trust	5	Situational
Strategy and Fear	6	Situational
Strategy and Greed	7	Situational
Strategy and Sympathy	8	Situational

* Limited diversity of strategies and force configurations

Methodology

Integrative literature review defined <u>Cooperation</u>:
Activity one actor deliberately and voluntarily carries out that benefits other actors individually or collectively, potentially at a cost to the original actor and with no guarantee of a direct benefit to itself

- **Grounded Theory:** Literature review and thought experiment showed where existing definitions and theories fall short, and provided key ideas for the new theory: *interaction of four forces (sympathy, trust, fear and greed) affect decision making in cooperation dilemmas*
- **Case Studies:** Three emergency management cases, each with key decisions fed by many actor-to-actor interactions
- **Open Data Coding:** Used content analysis processes to translate case information into inputs for simulation
- **Discrete Event Simulation:**
  - Custom-built computational simulation using game theoretic approach simulates each case study.
  - Monte Carlo processes over 10,000 runs of each interaction add randomness to account for boundedly rational actors.
  - Sensitivity analysis established the relative importance of each set of parameters and the model's robustness to variance in the input data
- **Data Analysis:** Exploratory data analysis techniques, nonparametric statistics processes and Multiple Correspondence Analysis to understand the data, test the hypotheses and investigate key details

Future Research

- **Re-do interactions** analysis using Joint Correspondence Analysis (JCA)
- **Develop agent-based simulation** using theory to derive simple rules (may resemble simulations by Baldwin):
  - Agent movement, proximity or strength / persistence of relationships
  - Run the same cases used in this effort
- **Research, simulate and analyze additional case studies**
  - Pursue additional domains including cooperation among:
    - Research Institutions
    - Military organizations
    - Governments
    - NGOs

Contacts/References

- **Full text available online at:** http://www.anser.org/docs/Self-Organizing_Cooperative_Dynamics_in_Government_Extended_Enterprises_Larry_John_29June2016.pdf

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