Dynamic modeling of organizational coordination over the course of the Katrina disaster

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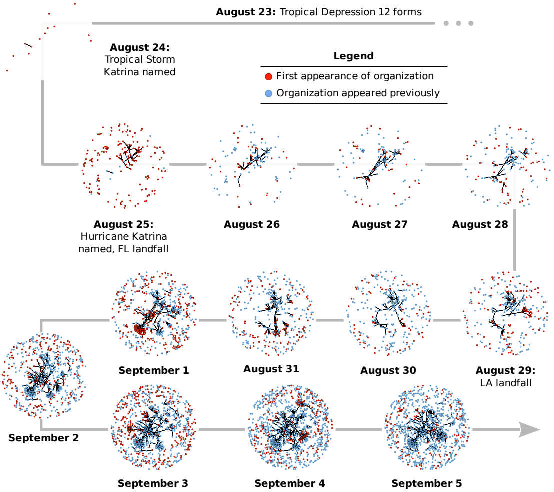
Research questions: dynamic model of Katrina EMON

- What can we say about the collaboration network as it changes over time?
  - What influence has the past had on present collaboration?
  - What structural effects predict collaboration?
  - Does homophily predict the EMON?

Katrina disaster, 2005: ?



Data basics

- 1577 organizations over 13 time points
- Most organizations are isolates (i.e. have no relationships)
  - This means collaboration is a rare event
- 1755 undirected ties over 13 days

Current approaches to modeling dynamic networks

1. Actor oriented dynamic modeling
   - **???**
2. Dynamic exponential random graph modeling (ERGM)
   - **??**
3. Relational event modeling
   - **?**

Issues. . .

- Unfortunately these models are quite computationally intensive
    - Current software and algorithms cannot handle a data set as large as this one.

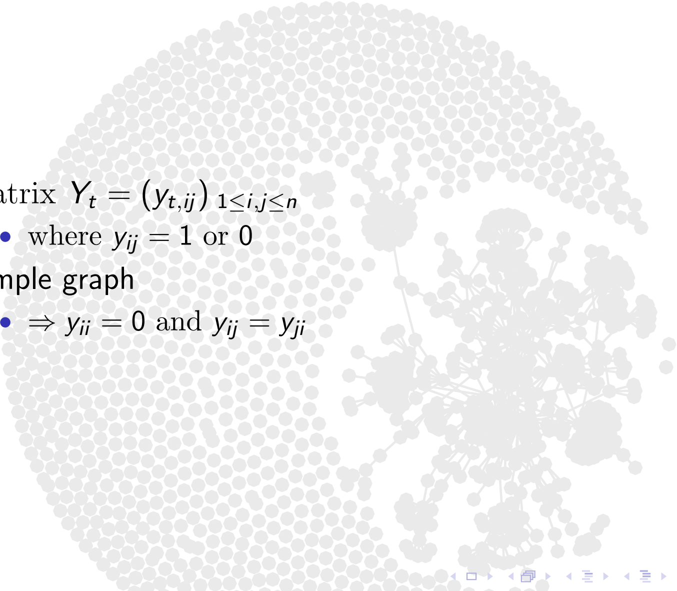
Possible solution . . .

- **One possible solution:**
  - One-lag logistic regression
    - Given certain assumptions can be derived from the ERGM family.
- **Advantages of the one-lagged logistic model**
  - Similar to traditional cross section regression methods
    - Network-regression and network-logistic regression **????**
  - Allows for time-dependence through the lag term

Computational problems

- Can't use software readily available such as R's GLM function.
    - One solution: compute MLE directly
    - Another possibility is subsampling

Notation



- matrix $Y_t = (y_{t,ij})_{1 \le i,j \le n}$
    - where $y_{ij} = 1$ or 0
- Simple graph
    - $\Rightarrow y_{ii} = 0$ and $y_{ij} = y_{ji}$

Model Assumptions

- Assume that the population of organizations stays constant over the 13 days
  - i.e. no entry or exit of organizations
  - This is a standard assumption made in dynamic network models
  - This assumes all organizations observed over the 13 days are at risk for collaborating in the time period

Model Assumptions

- Markov assumption (**?**)
  - $Y_t|Y_{t-1}$ is independent of $Y_1, \ldots, Y_{t-2}$
- Time-homogeneous Markov assumption
  - $P(Y_{t+1}|Y_t) = P(Y_t|Y_{t-1})$
- Conditional edge independence
  - $y_{t,ij}|y_{t-1,ij}$ $(i \neq j)$ is independent of all other $y_{t,kl}|y_{t-1,kl}$, where $k, l \neq i, j$

One-lag logistic model: ERGM Family

$$Pr(Y_{t+1} = y | Y_t = y_t, \theta) \propto \exp\left\{ \sum_{i,j} (y_{ij} * \theta^T * x(y_t, i, j)) \right\}$$

Under the aforementioned assumptions the model reduces to the product of

$$Pr(Y_{t+1,ij} = 1 | Y_t = y_t, \theta) = logit^{-1}\left\{\theta^T * x(y_t, i, j)\right\}$$

Where $x(y_t, i, j)$ the covariate function of y_t.

One-lag logistic model for Katrina

- Dependent variable:
  - y_t
- Independent variables:
  - y_{t-1} (lag term)
  - y_{t-1}^2 (square lag term, two path, shared partner)
  - Triangle (completed triad)
  - Degree (preferential attachment)
  - Homophily and propinquity (exogenously defined)
    - Same HQ state
    - Same HQ city
    - Same FEMA region
    - Same type (of organization)
    - Same scale (of organization)

	Model 1
BIC	30740.45
Intercept	-10.958***
	(0.069)
y_{t-1}	
y_{t-1}^2	
Degree	
Triangle dummy	
Same HQ state	2.668***
	(0.106)
Same HQ city	0.844***
	(0.063)
Same FEMA region	-0.418***
	(0.106)
Same Type	1.293***
	(0.065)
Same Scale	0.605***
	(0.054)

	Model 1	Model 2
BIC	30740.45	21833.942
Intercept	-10.958***	-9.689***
	(0.069)	(0.033)
y_{t-1}		9.917***
		(0.062)
y_{t-1}^2		
Degree		
Triangle dummy		
Same HQ state	2.668***	
	(0.106)	
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	(0.106)	
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	(0.065)	
Same Scale	0.605***	
	(0.054)	

	Model 1	Model 2	Model 3
BIC	30740.45	21833.942	20464.075
Intercept	-10.958***	-9.689***	-10.5***
	(0.069)	(0.033)	(0.06)
y_{t-1}		9.917***	8.194***
		(0.062)	(0.071)
y_{t-1}^2			
Degree			
Triangle dummy			
Same HQ state	2.668***		1.607***
	(0.106)		(0.087)
Same HQ city	0.844***		0.586***
	(0.063)		(0.076)
Same FEMA region	-0.418***		0.35***
	(0.106)		(0.085)
Same Type	1.293***		0.384***
	(0.065)		(0.06)
Same Scale	0.605***		0.535***
	(0.054)		(0.06)

	Model 1	Model 2	Model 3	Model 4
BIC	30740.45	21833.942	20464.075	20180.297
Intercept	-10.958***	-9.689***	-10.5***	-11.17***
	(0.069)	(0.033)	(0.06)	(0.079)
y_{t-1}		9.917***	8.194***	8.612***
		(0.062)	(0.071)	(0.081)
y_{t-1}^2				
Degree				0.123***
				(0.007)
Triangle dummy				
Same HQ state	2.668***		1.607***	1.325***
	(0.106)		(0.087)	(0.103)
Same HQ city	0.844***		0.586***	1.113***
	(0.063)		(0.076)	(0.091)
Same FEMA region	-0.418***		0.35***	0.33***
	(0.106)		(0.085)	(0.095)
Same Type	1.293***		0.384***	1.239***
	(0.065)		(0.06)	(0.077)
Same Scale	0.605***		0.535***	-0.18*
	(0.054)		(0.06)	(0.072)

	Model 1	Model 2	Model 3	Model 4	Model 5
BIC	30740.45	21833.942	20464.075	20180.297	19785.336
Intercept	-10.958***	-9.689***	-10.5***	-11.17***	-10.835***
	(0.069)	(0.033)	(0.06)	(0.079)	(0.07)
y_{t-1}		9.917***	8.194***	8.612***	7.975***
		(0.062)	(0.071)	(0.081)	(0.082)
y_{t-1}^2					2.105***
					(0.097)
Degree				0.123***	0.133***
				(0.007)	(0.006)
Triangle dummy					-2.202***
					(0.103)
Same HQ state	2.668***		1.607***	1.325***	1.362***
	(0.106)		(0.087)	(0.103)	(0.114)
Same HQ city	0.844***		0.586***	1.113***	1.158***
	(0.063)		(0.076)	(0.091)	(0.09)
Same FEMA region	-0.418***		0.35***	0.33***	-0.277**
	(0.106)		(0.085)	(0.095)	(0.101)
Same Type	1.293***		0.384***	1.239***	0.894***
	(0.065)		(0.06)	(0.077)	(0.071)
Same Scale	0.605***		0.535***	-0.18*	0.631***
	(0.054)		(0.06)	(0.072)	(0.065)

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BIC	30740.45	21833.942	20464.075	20180.297	19785.336
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	(0.054)		(0.06)	(0.072)	(0.065)

Some adequacy checks . . .

Model 1

	0	1
0	14910358.00	1754.00
1	0.00	0.00

Model 2

	0	1
0	14909697.00	924.00
1	661.00	830.00

Some adequacy checks . . .

Model 3		
	0	1
0	14909959.00	1164.00
1	399.00	590.00

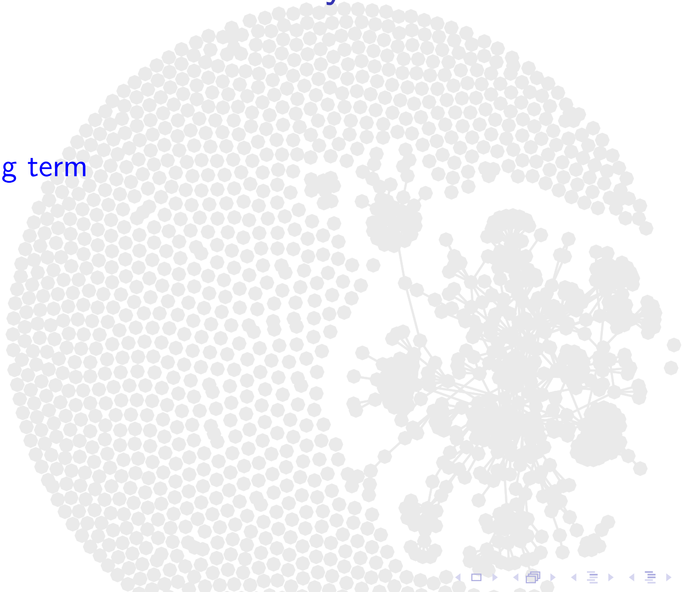
Model 4		
	0	1
0	14909944.00	1156.00
1	414.00	598.00

Some adequacy checks . . .

Model 5

	0	1
0	14910018.00	1250.00
1	340.00	504.00

Analysis



1. Lag term

Analysis

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   - Greatly increases the chance of collaboration, but decreases as we add more terms

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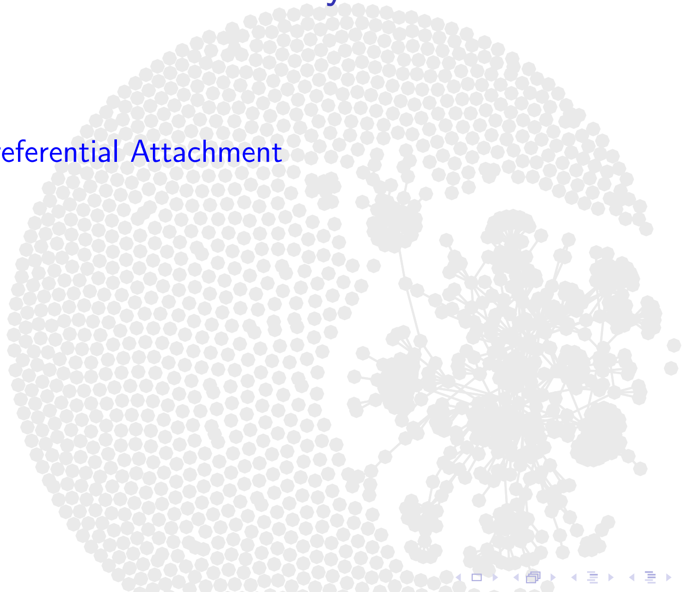
Analysis

1. Lag term
   - Greatly increases the chance of collaboration, but decreases as we add more terms
2. Shared partner term (two path)
   - Positive for two paths, but negative for completed triads– brokerage rather then completed triads

Analysis

3. Preferential Attachment



Analysis

3. Preferential Attachment
    - Positive and significant, but never big enough to overcome the intercept.

Analysis

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4. Homophily and propinquity

Analysis

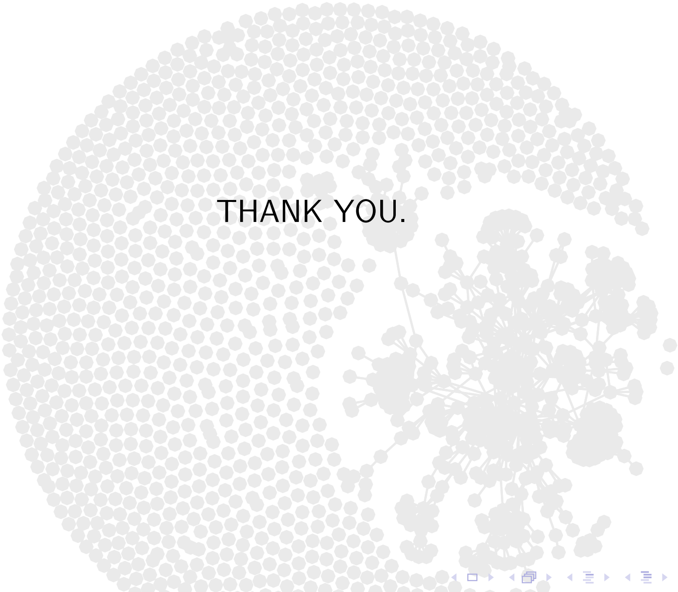
3. Preferential Attachment
   - Positive and significant, but never big enough to overcome the intercept.
4. Homophily and propinquity
   - Same HQ state, city, and type –positive and significant
   - FEMA and scale– sometimes positive, sometimes negative, always significant (??)

Further research

- Extend the one-lag logistic regression model into a inhomogeneous time model
- Attempt to use this model to simulate the evolution of the Katrina collaboration network
- Attempt to apply more sophisticated models to a portion of the data
- Compare different model results

Summary

- One-lag logistic regression performs reasonably well on the data
- We find that yesterday's collaboration effects todays collaboration
- That preferential attachment, and homophily increase the chance of collaboration
- A slight tendency towards two paths and not completed triads.



THANK YOU.

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