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

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Data Dynamic models

Model

Notation Model Assumptions One-lag logistic regression

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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?

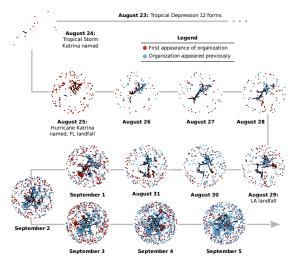
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Katrina disaster, 2005: ?



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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

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Current approaches to modeling dynamic networks

- 1. Actor oriented dynamic modeling
 - ???

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- Dynamic exponential random graph modeling (ERGM)
 ??
- 3. Relational event modeling

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Issues. . .

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

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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

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Computational problems

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



• 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 $y_{ij} = y_{ji}$

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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

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Model Assumptions

• Markov assumption (?)

Model ○ ○●

- $Y_t | Y_{t-1}$ 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 $k, l \neq i, j$

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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

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

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

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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)

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	Model 1
BIC	30740.45
Intercept	-10.958***
y_{t-1}	
2	
y_{t-1}^2	
200,00	
Degree	
Triangle dummy	
Same HQ state	2.668***
Same HO site	(0.106) 0.844***
Same HQ city	
	(0.063) -0.418***
Same FEMA region	
Sama Tuna	(0.106) 1.293***
Same Type	
Same Scale	(0.065) 0.605***
Same Scale	
	(0.054)
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Outline	Introduction	Model	Results	Analysis	Further research and Problems	Summary
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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 y_{t-1}^2 (0.062) Same HQ state 2.668^{***} (0.106) (0.063) Same FEMA region -0.418^{***} (0.106) (0.065) Same Type 1.293^{***} (0.065) (0.054)		Model 1	Model 2
$ \begin{array}{c} (0.069) & (0.033) \\ 9.917^{***} \\ (0.062) \\ y_{t-1}^2 \\ \hline \\ Degree \\ \hline \\ Triangle dummy \\ Same HQ state & 2.668^{***} \\ (0.106) \\ Same HQ city & 0.844^{***} \\ (0.063) \\ \hline \\ Same FEMA region & -0.418^{***} \\ (0.106) \\ Same Type & 1.293^{***} \\ (0.065) \\ Same Scale & 0.605^{***} \\ \end{array} $	BIC	30740.45	21833.942
$\begin{array}{c} y_{t-1} & 9.917^{***} \\ (0.062) \\ y_{t-1}^2 \\ \hline \\ Degree \\ \hline \\ Triangle dummy \\ Same HQ state & 2.668^{***} \\ (0.106) \\ Same HQ city & 0.844^{***} \\ (0.063) \\ Same FEMA region & -0.418^{***} \\ (0.106) \\ Same Type & 1.293^{***} \\ (0.065) \\ Same Scale & 0.605^{***} \\ \end{array}$	Intercept		
(0.062) 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***		(0.069)	
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***	y_{t-1}		
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***	2		(0.062)
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***	y_{t-1}		
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***	Degree		
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Same Scale 0.605***	Same Type		
	Same Scale		
		(0.054)	

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	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)
<i>y</i> _{t-1}		9.917***	8.194***
2		(0.062)	(0.071)
y_{t-1}^2			
Degree			
Triangle dummy			
Same HQ state	2.668***		1.607***
Same HQ city	(0.106) 0.844***		(0.087) 0.586***
Same rig city	(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)

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

Outline	Introduction	Model	Results	Analysis	Further research and Problems	Summary
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	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***
	C(0.069) Oct	(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***
200,000					(0.097)
Degree				0.123***	0.133***
				(0.007)	(0.006)
Triangle dummy					-2.202***
Same HQ state	2.668***		1.607***	1.325***	(0.103) 1.362***
Jame rig state	(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)	200000	(0.06)	(0.072)	(0.065)

Outline	Introduction	Model	Results	Analysis	Further research and Problems	Summary
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	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)
<i>y</i> _{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***
025250				(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)	000000	(0.06)	(0.072)	(0.065)

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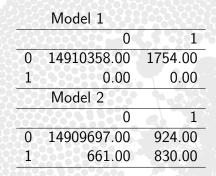
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Some adequacy checks . .

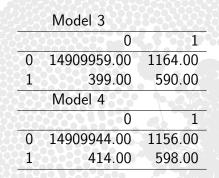


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Some adequacy checks . .



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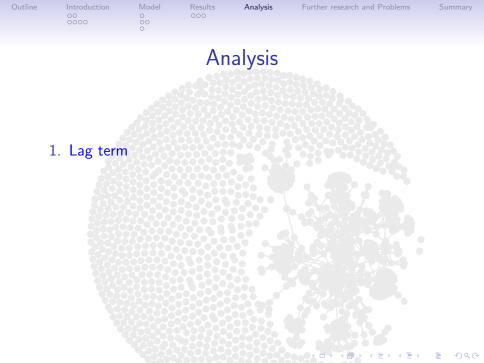
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Some adequacy checks . . .

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- 1. Lag term
 - Greatly increases the chance of collaboration, but decreases as we add more terms

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- 1. Lag term
 - Greatly increases the chance of collaboration, but decreases as we add more terms
- 2. Shared partner term (two path)

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- 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

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3. Preferential Attachment

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

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

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- 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 (??)

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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

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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.

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