Modeling Frequency and Type of Interaction in Event Networks

Does structural balance theory explain negative events?

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Negative ties vs. conditionally negative ties.

Consider networks with positive and negative interaction events.

Typical research questions in such settings:

Which actors fight each other?
Which actors cooperate with each other?

Claim: structural balance theory explains

Which actors fight, **if they interact at all?**
Which actors cooperate, **if they interact at all?**

These differences have huge impact.

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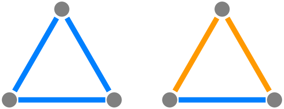
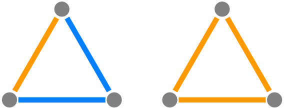
Structural balance theory (Heider 1946).

Structural balance theory (SBT) applies to triplets of actors that are pairwise connected by **positive** or **negative** ties

balanced



not balanced



Cartwright and Harary (1956) extend SBT to larger, not necessarily complete networks.

SBT predicts the sign of a tie **only if there is a tie**.

$P(\text{negative tie})$?

$P(\text{negative} \mid \text{tie}) \downarrow$

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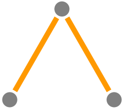

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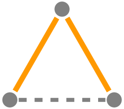

$P(\text{negative} \mid \text{tie}) \downarrow$

Structural balance predicts the conditional type of events.

Separating occurrence of events and conditional type of events

$$P(u, v, t, x) = P(u, v, t) \cdot P(x|u, v, t)$$

$P(u, v, t, x)$	probability of interaction of type x on (u, v)
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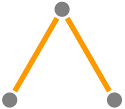

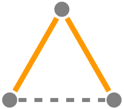

$P(\text{negative tie})? \quad = \quad P(\text{tie}) \uparrow \quad \cdot \quad P(\text{negative} \mid \text{tie}) \downarrow$

Related work.

negative ties vs. conditionally negative ties

Wouter de Nooy (2008) "Signs over time." *Journal of Social Structure*:

(positive or negative reviews among literary authors and critics)

> *In my case, the* **presence or absence of a line** *(literary evaluation) is* **not the important phenomenon** *to be explained because it depends on events and constraints outside the power of the actors in the network. [. . .]*
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> *As we will see, it is possible and interesting to predict the* **sign of an evaluation, conditional on the presence** *of an evaluation, from the pattern of signs of previous evaluations.*

Argumentation in this talk is different:
Even in networks in which the occurrence of ties could be explained, the conditional sign can be more appropriate.

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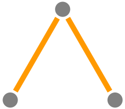
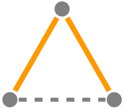
Outline.

Present several models in which structural balance theory is used to explain the **occurrence of negative interaction**.



$P(\text{negative tie})$



$P(\text{negative} \,|\, \text{tie})$

Repeat this by modeling the **conditional sign** of interaction, given that there is interaction.

Structural balance in international relations.

data from the *Correlates of War* project

Analysis from Maoz et al. (2007) "What is the enemy of my enemy?" *The Journal of Politics*.

Time: 1816 – 2001 (granularity = calendar years)

Actors: sovereign countries

Negative event (outcome): militarized interstate dispute (MID) in year $t+1$

Explanatory variables: indirect relations via alliances (positive) and MIDs (negative) in year t

Some results: enemies-of-enemies, enemies-of-friends, and friends-of-enemies are all **more likely** to engage in an MID.

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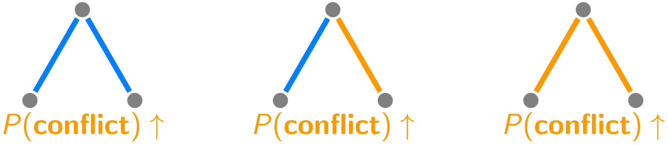
Interpreting results from Maoz et al. (2007)

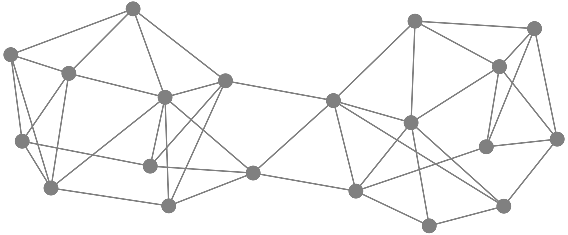
Some results: enemies-of-enemies, enemies-of-friends, and friends-of-enemies are **more likely** to fight each other.



Indirectly connected actors are more likely to interact; apparently the signs of indirect ties do not matter!

Potential explanation I.

Actors can be members of various clusters
$\Rightarrow$ higher probability for indirect and direct ties within clusters.



Control for geographic proximity, trade, membership in IGOs, form of government, . . .

Controlling for relevant covariates.

data from Russet and Oneal (2001) *Triangulating Peace*

Logistic regression model for MID in year $t+1$. Significantly higher MID probability coded by **conflict**; lower by **peace**.

explanatory(t)				
friend-of-friend	**conflict**	·	·	**conflict**
friend-of-enemy	·	**conflict**	·	**conflict**
enemy-of-enemy	·	·	**conflict**	**conflict**
logCapRatio	**peace**	**peace**	**peace**	**peace**
allied	**peace**	**peace**	**peace**	**peace**
minPolity	**peace**	**peace**	**peace**	**peace**
minorPowers	**peace**	**peace**	**peace**	**peace**
logTrade	**conflict**	**conflict**	**conflict**	**conflict**
contiguity	**conflict**	**conflict**	**conflict**	**conflict**
logDistance	**peace**	**peace**	**peace**	**peace**
logJointIGOs	**peace**	**peace**	**peace**	**peace**

$\Rightarrow$ **indirectly connected actors are still more likely to fight.**

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friend-of-enemy	·	**conflict**	·	**conflict**
enemy-of-enemy	·	·	**conflict**	**conflict**
logCapRatio	**peace**	**peace**	**peace**	**peace**
allied	**peace**	**peace**	**peace**	**peace**
minPolity	**peace**	**peace**	**peace**	**peace**
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logTrade	**conflict**	**conflict**	**conflict**	**conflict**
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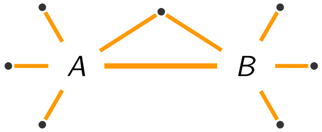
Potential explanation II.

Some actors are more involved in conflicts than others.

- higher probability for being enemies of enemies
- higher probability for having a direct conflict



Must controll for (positive and negative) degrees and for past direct conflicts.

Controlling for covariates, past MIDs, and degree.

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explanatory(t)		
friend-of-friend	**conflict**	
friend-of-enemy	**conflict**	
enemy-of-enemy	peace	(not significant)
MID	**conflict**	
avgNegDegree	**conflict**	
avgPosDegree	**conflict**	
covariates	*as before*	

Repeating this with daily event data.

data from the Kansas Event Data System (http://eventdata.psu.edu/)

Daily events extracted from news reports.

Event type ranges from -10 (most hostile) to $+10$ (most cooperative).

Use $304,000$ events from the GULF conflict (1979–1999).

Model the frequency of events with $w = -10$ (most hostile).

Model framework from Butts (2008) "A relational event framework for social action." *Sociological Methodology*.

Explanatory variables as in Brandes, Lerner, and Snijders (2009) "Networks evolving step by step." *Proc. ASONAM*.

Friends-of-friends, friends-of-enemies, and enemies-of-enemies have a **higher conflict frequency**.

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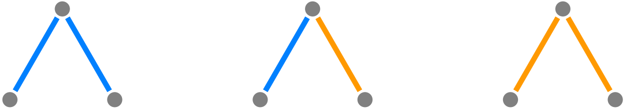
Intermediate summary.

When modeling the probability of conflict



$P(\textbf{conflict}) \uparrow$ $P(\textbf{conflict}) \uparrow$ $P(\textbf{conflict}) \uparrow$

indirectly connected actors are more likely to fight; apparently the signs of indirect ties do not matter!

Outline.

Repeat the same analyses by modeling the **conditional sign** of ties, given that there is a tie (right-hand side in the picture below).

Absolute probability of conflict vs. conditional probability.

yearly data from Russet and Oneal (2001) *Triangulating Peace*

Contrasting unconditional MID probability with **conditional** MID probability, given that there is (positive or negative) interaction.

$$P(u, v, t, x) = P(u, v, t) \cdot P(x|u, v, t)$$

explanatory(t)	*uncond.*	**cond.**	**cond.**	**cond.**
friend-of-friend	conflict	peace	peace	peace
friend-of-enemy	conflict	conflict	conflict	conflict
enemy-of-enemy	peace	peace[1]	peace	peace
MID	conflict	conflict	conflict	·
avgPosDegree	conflict	conflict	peace	·
avgNegDegree	conflict	conflict	conflict	·
covariates	*included*	*included*	·	·

[1]significant at 10% level

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MID	conflict	conflict	conflict	·
avgPosDegree	conflict	conflict	peace	·
avgNegDegree	conflict	conflict	conflict	·
covariates	*included*	*included*	·	·

[1] significant at 10% level

Repeating this with daily event data.

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Event type ranges from -10 (most hostile) to $+10$ (most cooperative).

Model the conditional type of events, given that there is an event

as in Brandes, Lerner, and Snijders (2009) "Networks evolving step by step." *Proc. ASONAM*.

Results: Friends-of-friends and enemies-of-enemies have a tendency to interact friendly, if they interact;

Friends-of-enemies and enemies-of-friends have a tendency to fight each other, if they interact.

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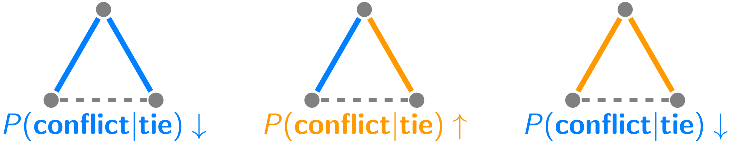
Intermediate summary.

When modeling the **conditional** probability of conflict, given that there is interaction



conditional tendency for conflict is well predicted by SBT. Here the signs of indirect ties do matter!

Lessons learned.

Structural balance theory does not predict the probability of negative interaction.

Structural balance theory predicts the conditional sign of interaction, given that there is interaction.

Some thoughts on generalizability.

Modeling $P(u, v, t, x)$ is very different from modeling $P(x|u, v, t)$.

$$P(u, v, t, x) = P(u, v, t) \cdot P(x|u, v, t)$$

$P(u, v, t, x)$	probability of interaction of type x on (u, v)
$P(x|u, v, t)$	conditional probability of type x, given that there is interaction on (u, v)

This also seems to apply to networks of relational states.

Models such as SAOMs (Siena) or ERGMs could be extended to separate the occurence of ties from the conditional type of ties.

Conclusion.

Don't analyze this $P(u, v, t, x)$,

when you want to analyze that $P(x|u, v, t)$.