Replication and Extention of Colby (2021)*

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Introduction

In a paper by Colby (2021), the author investigates the effect of leadership decapitation (i.e., the capture or killing of the leader of an armed group) on future violence between groups five years before and after Joaquín, "El Chapo" Guzmán Loera, the former leader of the Sinaloa Cartel, was arrested in 2016. Following El Chapo's arrest, Mexico experienced an increase in cartel-related violence and the formation of new cartels and militias (Diaz, 2019; Ahmed, 2019). It is theorized that former alliances between cartels broke down as groups competed to fill the resulting power vacuum after the decline of the Sinaloa Cartel. Colby (2021) hypothesizes that leadership decapitation will (1) weaken alliances between armed actors, (2) lead to greater preferential attachment in networks of cartels and militias, and (3) result in greater transitive closure as cartels seek to expand their power. Using a stochastic actor-oriented model (SAOM), the results show that alliances have virtually no effect on the decision of cartels and militias to fight each other; weaker organizations faced a higher reputational cost after El Chapo's detention; and post-arrest cartel in-fighting did not increase as a result of uncertainty about the relative balance of power among cartels.

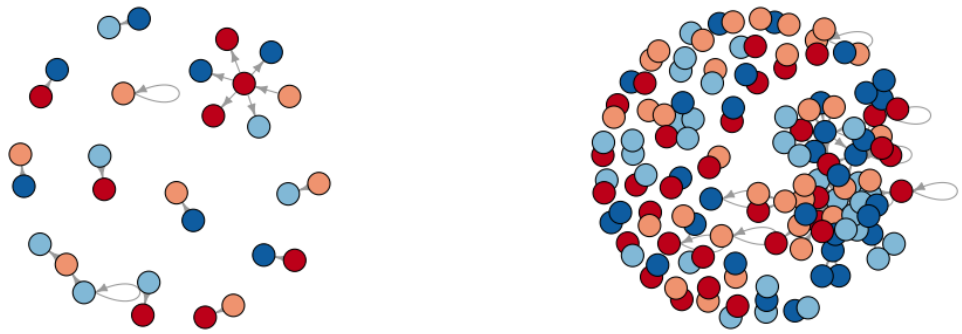
*Please find my replication materials here.

This letter uses additional network analysis approaches to confirm the results of the model from Colby (2021). These approaches include preferential attachment, community detection, and ERGM specification. The letter is structured according to these approaches. Further analyses support the findings from (Colby, 2021), where aggressive cartels are more likely to attack weaker groups, the network is highly reciprocal, there is a tendency towards subfaction and militia homophily, and finally, cartel roles and transitivity/triad closure have minimal effects on the likelihood of infighting. The results of the extension of this analysis provide additional insight into the effect of leadership decapitation on networks of criminal and vigilante organizations.

Network and Data

The data from Colby (2021) are derived from the Social Conflict Analysis Database (SCAD), the Uppsala Conflict Data Program Georeferenced Events Dataset, and the Armed Conflict Location and Events Database (Idean Salehyan and Williams, 2012; Sundberg and Melander, 2013; Raleigh et al., 2010) from 2012-2021. Ties between actors are directed and represent at least one violent interaction from the sender to the receiver.

The main plots of the network can be found in Figure 1 below, with Figure 1a showing the network prior to El Chapo's arrest in 2017, and Figure 1b showing the network following his arrest. The network in the pre-arrest period only contains 29 nodes and 19 edges while the post-arrest network contains 132 nodes and 124 edges, due to the formation of new subfactions and militias after El Chapo's arrest. The majority of nodes in Figure 1a are small cartels and militias that control small swaths of territory.



a Pre-Arrest Cartel Network   b Post-Arrest Cartel Network

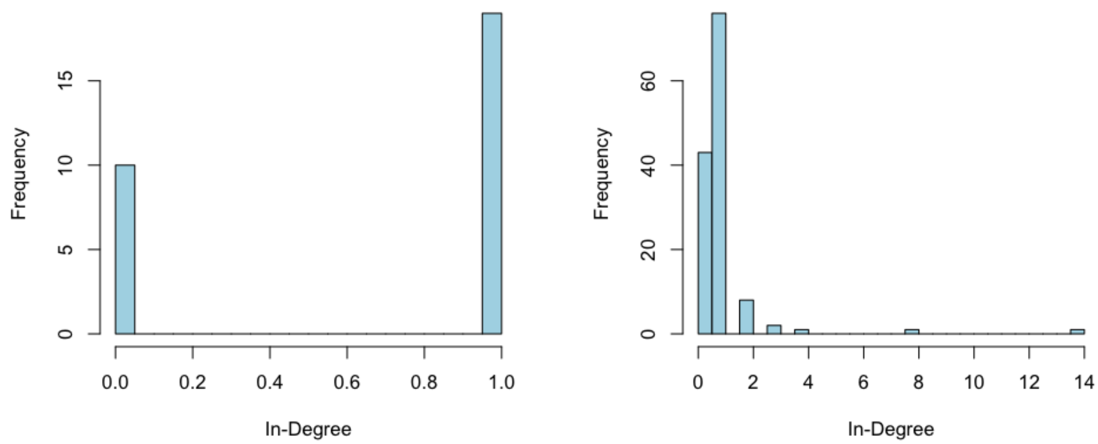
Figure 1: **Pre- and Post-Arrest Networks from Colby (2021)**

The network also includes various vertex attributes, including group aggression, militia status, subfaction status, and role as a small or large cartel group.[1] Overall, a majority of cartels have low aggression scores, which is the log of the number of attacks conducted by each actor during both periods. Most cartels are non-militia, nor sub-factions of larger groups. The most powerful cartels – the Gulf, Jalisco Nueva Generacion (NG), Los Zetas, and Sinaloa cartels are less frequent. Small cartels and militias that control small swaths of territory are the most frequent roles. These cartels tend to specialize in a small number of subtasks of drug trafficking and align themselves with larger cartels. There are a smaller amount of Rising Challengers, which are relatively new cartels that are rapidly growing. Finally, the White Dwarfs represent cartels that are on the decline.

Figure 2 shows the replicated in-degree centrality distributions for the pre-arrest and post-arrest networks (Figure 2, row 1 in the main analysis of Colby (2021)). In-degree is the

[1]See Appendix A for visualizations of each attribute

number of incoming edges, and the distribution of that number increases after the arrest.

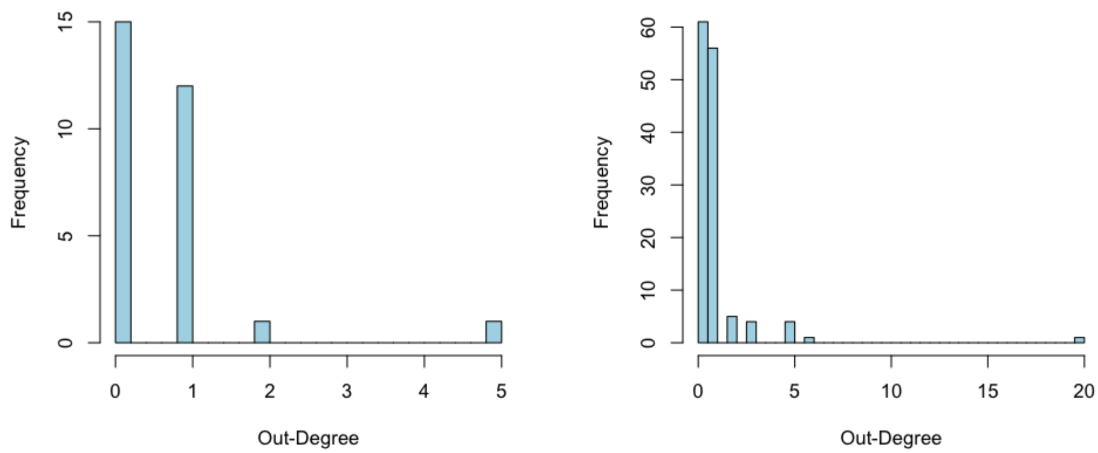


a Pre-Arrest In-Degree

b Post-Arrest In-Degree

Figure 2: **In-Degree Distributions from Colby (2021)**

Figure 3 shows the replicated out-degree centrality distributions for the pre-arrest and post-arrest networks (Figure 2, row 2 in the main analysis of Colby (2021)). Out-degree is the number of outgoing edges, with the number decreasing after the arrest.



a Pre-Arrest Out-Degree

b Post-Arrest Out-Degree

Figure 3: **Out-Degree Distributions from Colby (2021)**

SAOM Replication

The main analysis of Colby (2021) includes estimating four stochastic actor-oriented models (SAOM). Each of these estimates the alliances, reputations, strength, and clustering of the cartels based on four independent variables.[2] *Out-degree Jaccard similarity* is the Jaccard similarity of out-degree ties between a node and every other node in the network, where a larger value would indicate alliances between groups. *In-degree popularity* measures preferential attachment, indicating that attacks against a cartel or militia are likely to lead to attacks on the same group. *Out-in-degree assortativity* indicates stronger cartels and militias preying on weaker groups. Finally, *transitive closure* measures clustering, suggesting increased competition among cartels due to uncertainty about the balance of power after El Chapo's arrest. The author also controls for *reciprocity*, which corresponds to the pairs of

[2]Explanations of each variable are paraphrased from pgs. 4-5 of Colby (2021)

nodes attacking one another, and homophily for node-level attributes (aggression, subfaction, militia, and role). *Aggression* is the log of the number of attacks conducted by each actor during both periods. *Subfaction* is whether organization is a subfaction of a larger group or independent. *Militia* is a dummy variable that takes the value 1 if an organization is a militia and 0 if an organization is a cartel. The *role* variable assigns each organization to one of seven roles.

Table 1 below depicts the results (p. 9 of original paper), which show that (1) alliances had virtually no effect on cartels' and militias' decisions to fight one another; (2) after El Chapo's arrest, cartels and militias faced greater reputational costs for appearing weak, and; (3) El Chapo's arrest did not affect the territorial control and relative power of other cartels. The goodness of fit for the SAOM model can be found in Appendix B.

Table 1: SAOM Estimation

	Alliances	Reputation	Strong-vs-weak	Clustering
Jaccard Similarity	0.13			
	(3.29)			
In-degree Popularity		0.18		
		(0.10)		
Out-in-degree Assortativity			-0.90^{***}	
			(0.23)	
Transitive Closure				0.34
				(0.63)
Aggression Homophily	-0.20	-0.19	-0.30	-0.20
	(0.47)	(0.44)	(0.43)	(0.47)
Subfaction Homophily	2.06^{***}	2.04^{***}	1.87^{***}	2.05^{***}
	(0.58)	(0.56)	(0.54)	(0.55)
Militia Homophily	1.23^{***}	1.20^{***}	1.32^{***}	1.24^{***}
	(0.34)	(0.35)	(0.32)	(0.33)
Role Homophily	-1.91^{***}	-1.55^{***}	-2.65^{***}	-1.89^{***}
	(0.39)	(0.45)	(0.48)	(0.37)
Reciprocity	4.72^{***}	4.73^{***}	4.83^{***}	4.72^{***}
	(0.76)	(0.96)	(0.69)	(0.84)
Iterations	19176	19176	19176	19176

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

While Colby (2021) controls for network attributes in the SAOM estimation, examining each individually will better probe the underlying formation of networks. I analyze the reciprocity (which has positive, significant effects in Table 1) and transitivity (which has positive, but insignificant effects on clustering) of the network, as well as preferential attachment (which has positive but insignificant effects on reputation). I also analyze the networks via community detection to further analyze clustering. Finally, I use ERGM models on the network to examine the likelihood of cartel in-fighting based on the same independent variables in the SAOM model.

Reciprocity and Transitivity

The large and statistically significant effect of reciprocity in 1 implies that cartels and militias on the receiving end of attacks are quick to reciprocate violence to prove that they are not easy targets. Additionally, the insignificant effect of transitive closure indicates that El Chapo's arrest did not lead to uncertainty around contested territories, and the Sinaloa Cartel's rivals did not greatly change the perceived balance of power. To supplement these findings, I analyze basic reciprocity and transitivity scores before and after the arrest in 2016, as shown in Figure 4 and Table 2.

Before the arrest, there were no stable relationships in which the nodes attacked one another, nor were there transitive closures. Afterward, reciprocity is a bit stronger, meaning that more cartels are attacking and reciprocating violence with one another. After the arrest, transitivity is still very small, meaning very few triads are forming in the cartel network and supporting the SAOM results. This also supports the hypotheses from Colby (2021), where leadership decapitation will decrease clustering but increase ties between groups.

Figure 4: **Reciprocity and Transitivity Scores**

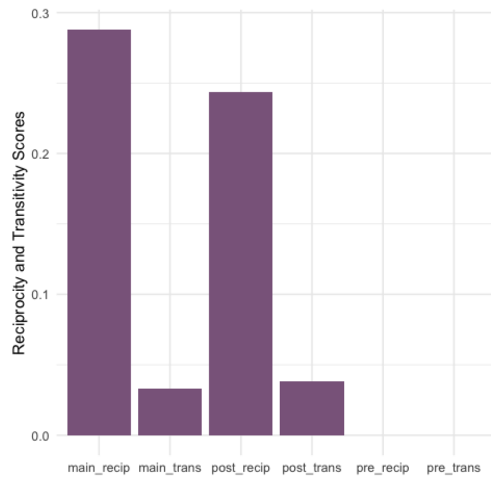


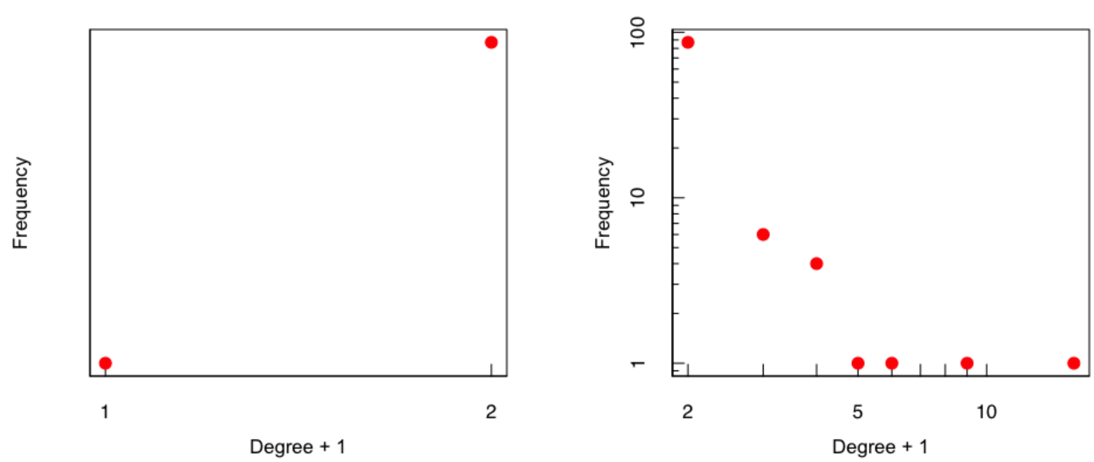
Table 2: Reciprocity and Transitivity Scores

Reciprocity	
Pre-Arrest Recip	0.000
Post-Arrest Recip	0.243
Full Graph Recip	0.288
Transitivity	
Pre-Arrest Trans	0.000
Post-Arrest Trans	0.039
Full Graph Trans	0.033

Preferential Attachment

The main theory for preferential attachment is related to violence between cartel groups. If alliances break down, smaller cartels that were part of alliances should be less protected from violent confrontation with rivals, eliciting a preferential attachment for future violence. The findings from the main analysis show that preferential attachment measured by in-degree popularity is positive, but insignificant for reputation costs to cartels. However, out-in-degree assortativity is negative and significant for examining strong-vs-weak infighting. This means more aggressive cartels preferentially attack cartels and militias that have already been attacked. To supplement these findings, I examine the degree centrality of the network before and after the arrest and conduct one-shot preferential attachment using the `PAFit` package in R.

Figures 5 show the degree centrality before and after the arrest. Before the arrest, there were only a few cartel groups engaging with one another, all with lower centralities. However, after the arrest, only a handful of cartels have larger degrees meaning they are more central to the network and attack the disbanded cartels after El Chapo's death.

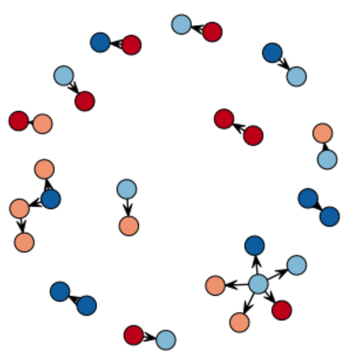


a Pre-Arrest Degree Centrality

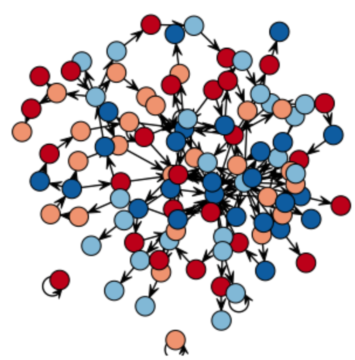
b Post-Arrest Degree Centrality

Figure 5: **Degree Centrality Pre- and Post-Arrest**

Figures 6 confirm this possibility, showing that there were few cartels fighting with one another before 2017, but many afterward. This also points to the presence of hub nodes in the network. The estimated attachment exponent (α) is 3.826 without temporal aspects (shown in Table 3), meaning the attachment process is *super-linear*. Basically, high-degree nodes are even more likely to attract new connections. The higher the degree of a node, the disproportionately higher the probability that new nodes will attach to it. In the case of the cartel network, the process is highly skewed toward high-degree cartel groups, which act as "hubs" and attack a lot of the new or disbanded groups. With a power vacuum left after El Chapo's arrest, more aggressive cartels probably view cartels that are frequently attacked as easy competition to eliminate.



a Pre-Arrest Preferential Attachment



b Post-Arrest Preferential Attachment

Figure 6: **Preferential Attachment in Cartel Networks**

Table 3: Preferential Attachment

Estimated attachment exponent	3.826

Community Detection

The effect of transitive closure in Table 1 is not statistically significant and only marginally contributes to the decisions of cartels and militia, meaning El Chapo's arrest did not lead to uncertainty around contested territories. To further examine the clustering of cartels, I use community detection algorithms to uncover groups of nodes that may signal a change in the power balance after the arrest.

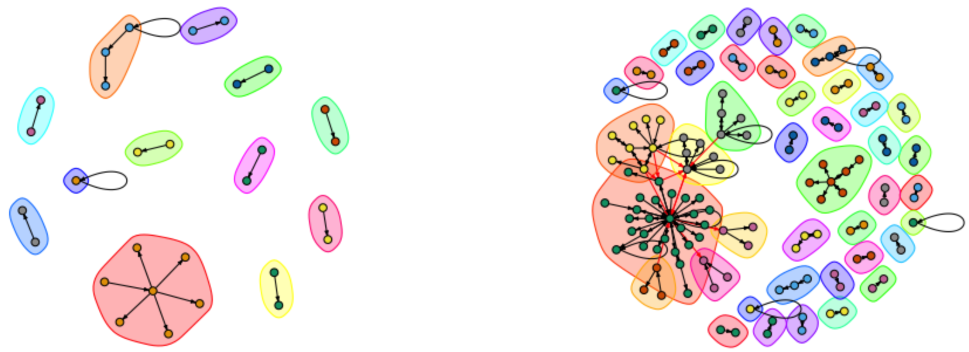
Table 4 shows the modularity scores for four community detection algorithms used on the entire network: Infomap, Leading Eigenvector, Spinglass, and Walktrap.[3] Of these, Infomap performs the best.

Table 4: Modularity Scores

Infomap	0.791
Leading Eigenvector	0.742
Spinglass	0.641
Walktrap	0.730

Figures 7 shows the plotted community clusters for pre- and post-arrest, depicting many more communities after the arrest, with a presence of some larger communities (left-side of Figure 7b). These are likely the more established and stronger cartels, engaging in attacks toward smaller, weak, or new cartels. Otherwise, the remaining communities after the arrest are small, two-node clusters, which supports the main analysis that clustering marginally contributes to cartel decisions.

[3]When analyzing modularity scores for the network before and after the arrest, the results are the same, therefore I used the entire network.



a Pre-Arrest Communities

b Post-Arrest Communities

Figure 7: **Cartel Network Communities (Infomap)**

ERGM Specification

To further supplement Colby (2021), I use two ERGM models to examine the effect of leadership decapitation on in-fighting between cartel groups. The first is a baseline, dyad-independent ERGM, controlling for node-fixed effects for each of the attributes from the main analysis. The second model is a dyad-dependent ERGM model, which also includes terms for reciprocity and transitivity.

Table 5 shows the results of these models. For the dyad-independent model (Column 1), when examining the sender and receiver aggression, an increase in the receiver's aggression score increases the odds of being attacked by about 49.6%, whereas an increase in the sender's aggression score increases the odds of being attacked by about 92.4%. This supports findings from Colby (2021), where more aggressive cartels are more likely to attack to consolidate power. Additionally, while the difference in aggression scores between the two cartels is insignificant, this also supports the SAOM results in which the effect of aggression homophily is insignificant across all models.

Sender and receiver subfactions and militia status effects both have minimal effects on the likelihood of violence between groups. However, the absolute differences between subfaction status and militia status, respectively, are positive and significant. Interestingly, the odds of two nodes fighting one another are approximately 5.1 times higher if they belong to the same subfaction or same militia status, which supports the main results. Finally, contrary to the main findings, role homophily is insignificant meaning there is no indication of if cartels do or do not attack those in similar roles.

Looking at the dyad-dependent ERGM model in Table **??** (Column 2), the direction of the effect of node attributes is similar. However, the magnitude of such effects decreases. For example, an increase in the receiver's aggression score increases the odds of being attacked by about 18%, whereas an increase in the sender's aggression score increases the odds of being attacked by about 76.8%. This supports Hypothesis 2.1 from Colby (2021), where the probability that one cartel attacks another will be greater if the attacker is more aggressive. Homophily for the additional vertex attributes is also significant and aligns with the SAOM model: subfaction and militia homophily have positive effects, whereas role homophily has insignificant, negative effects.

Reciprocity is strong and positively associated with the likelihood of being attacked, as in the SAOM model. Finally, similar to the SAOM model, transitivity has positive but insignificant effects. Taking the results of the ERGM and SAOM models together, aggressive cartels are more likely to attack, the network is highly reciprocal, there is a tendency towards subfaction and militia homophily, and cartel roles and transitivity have minimal effects.

Table 5: ERGM Models

	Dyad-Independent	Dyad-Dependent
Edges	-8.36^{***}	-8.17^{***}
	(0.55)	(0.51)
Receiver Aggression	0.40^{***}	0.17^{*}
	(0.07)	(0.08)
Sender Aggression	0.65^{***}	0.57^{***}
	(0.07)	(0.08)
Aggression Homophily	-0.01	0.04
	(0.07)	(0.07)
Receiver Subfaction	0.79^{*}	0.78^{*}
	(0.37)	(0.37)
Sender Subfaction	0.20	0.07
	(0.38)	(0.38)
Subfaction Homophily	1.63^{***}	1.33^{***}
	(0.37)	(0.33)
Receiver Militia	0.58	0.53
	(0.31)	(0.32)
Sender Militia	0.11	0.09
	(0.32)	(0.33)
Militia Homophily	1.66^{***}	1.45^{***}
	(0.30)	(0.30)
Role Homophily	-0.24	-0.14
	(0.29)	(0.27)
Reciprocity		3.67^{***}
		(0.39)
Transitivity (gwesp)		0.19
		(0.17)
AIC	1375.46	1303.31
BIC	1463.76	1407.67
Log Likelihood	-676.73	-638.65

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Discussion

Colby (2021) examines the effect of leadership decapitation on in-fighting between cartel groups in Mexico. My extended analyses support the findings in the main paper, where aggressive cartels are more likely to attack weaker groups. The network is also highly reciprocal, and there is a tendency towards subfaction and militia homophily. Additionally, transitivity/triad closure has minimal effects on the likelihood of in-fighting. Both the SAOM model and dyad-dependent ERGM finds that triad closure is insignificant, meaning there is minimal clustering in the network.

The results of the extension of this analysis provide additional insight into and confirmation of the effect of leadership decapitation on networks of criminal and vigilante organizations. Removing an important figurehead from the picture (i.e., a hub node) has important effects and implications for the network as a whole. Nodes change and reform ties naturally over time, but the lack of the hub node makes such changes more likely.

References

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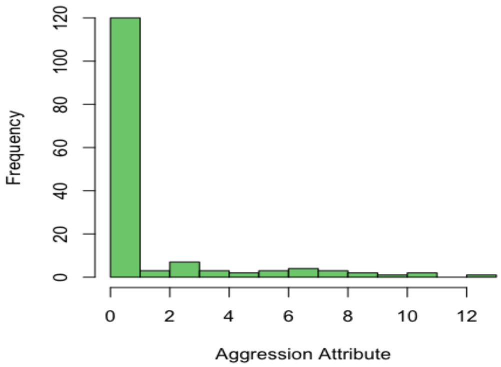
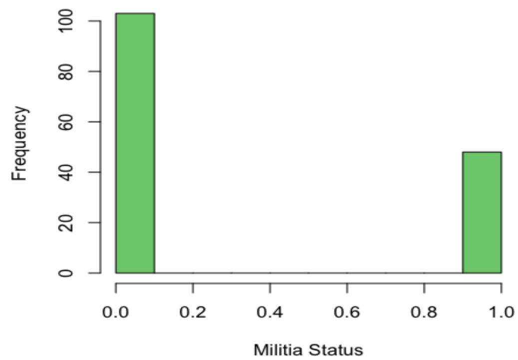
URL: *https://doi.org/10.1177/0022343313484347*

Appendices

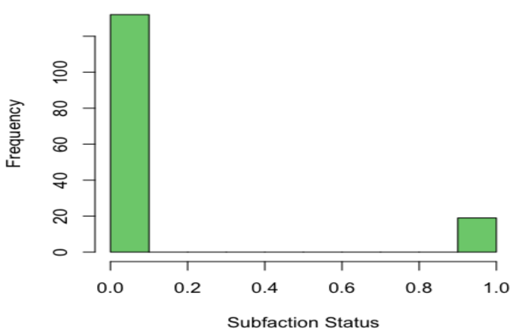
A Vertex Attributes



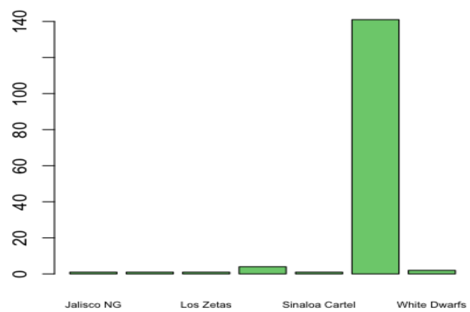
a Aggression Attribute



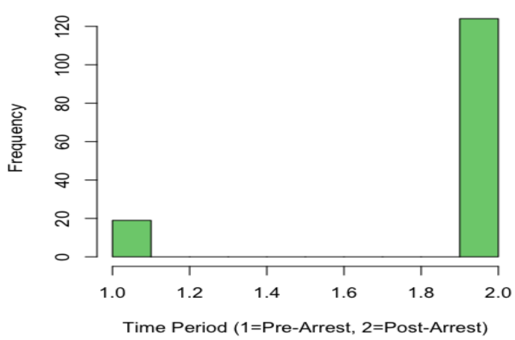
b Militia Status



c Subfaction Status



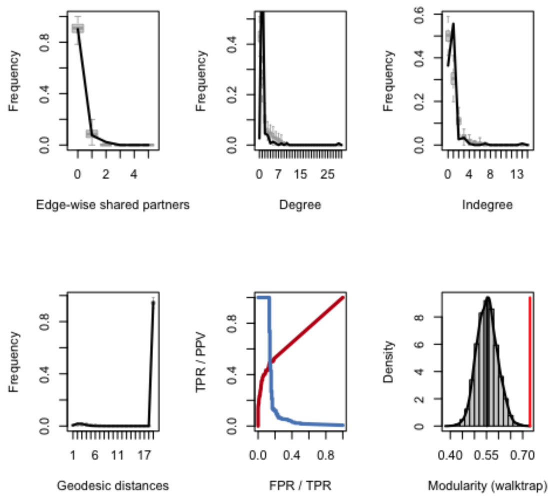
d Cartel Roles



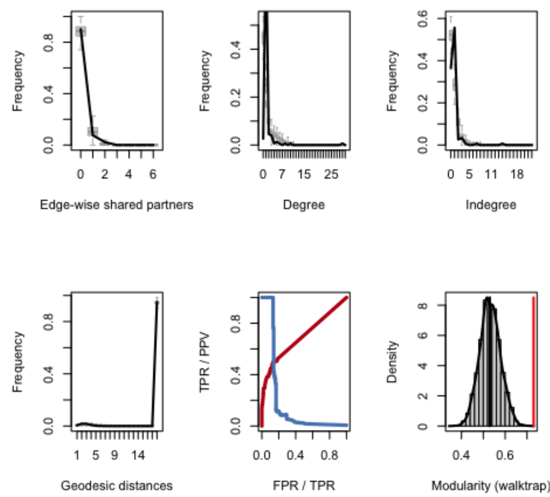
e Time Attribute

Figure 8: **Vertex Attributes**

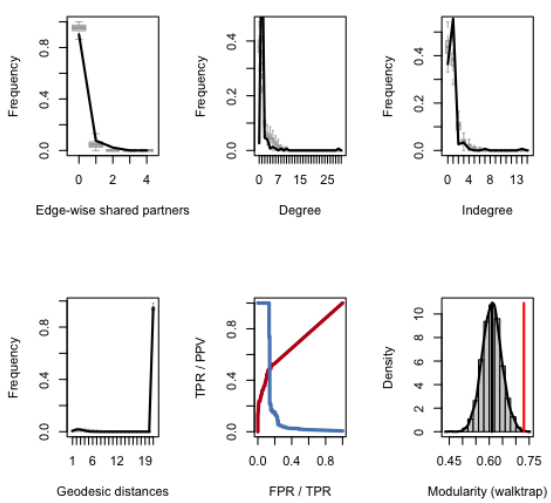
B Goodness of Fit - SAOM Model



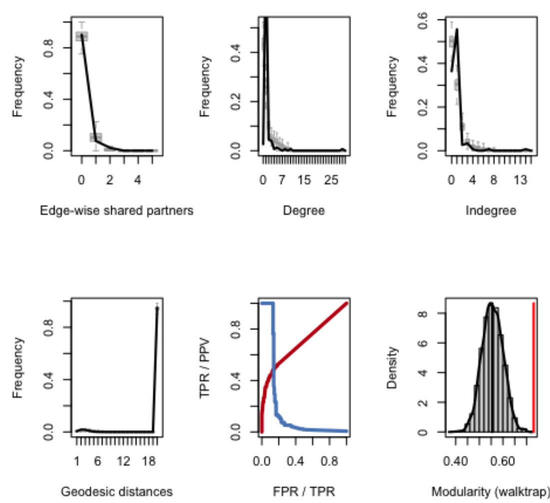
a Model 1



b Model 2

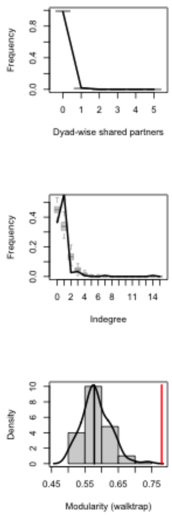


c Model 3

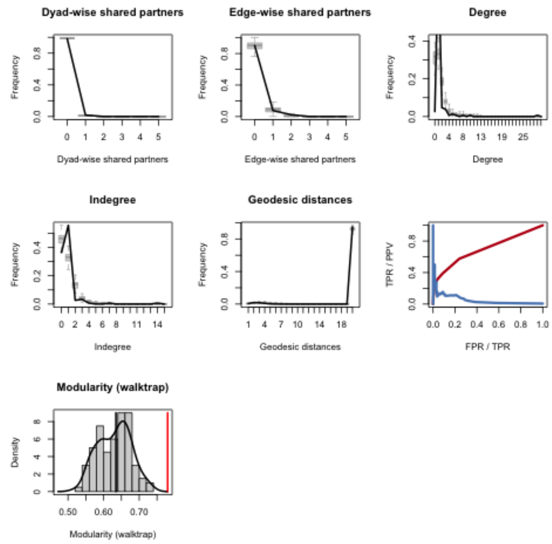


d Model 4

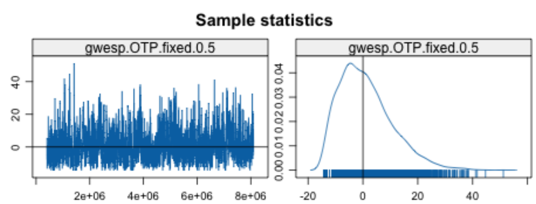
C Goodness of Fit - ERGM Models



e GOF - Baseline ERGM



f GOF - Dyad-dependent ERGM



g MCMC Diagnostics