Dynamic Patterns of Terrorist Networks: A Comparison of Common Structures in Terrorist Group Ties

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***Abstract*— The current research tests two hypotheses regarding the structure and evolution of dynamic terrorist networks. First, some argue that terrorist networks exhibit string-like structures of sparse connections as an effort to maximize operational security. Others maintain that terrorist networks tend to contain a few highly-connected individuals who play crucial roles in connecting the larger network. Using Separable Temporal Exponential Random Graph Models (STERGMs), we test both of these hypotheses on several multi-wave terrorism networks from the John Jay & ARTIS Transnational Terrorism Database (JJATT). Our dataset includes networks from prominent attacks and bombings that occurred during the last three decades(e.g., the 2002 Bali Bombings), where nodes represent individual terrorists and ties represent social relationships. In contrast to theories of maximizing operational security, results suggest that there is a tendency for terrorist networks to become increasingly well-connected as they prepare for an attack. We also find evidence that highly central nodes develop even more ties in the years preceding an attack, signifying that terrorist networks tend to be structured around a few key actors. Our findings have the potential to inform strategies of counterterrorism efforts by suggesting which actors in the network make the most influential targets for law enforcement.**

Keywords—dynamic networks, terrorist networks, operational security, preferential attachment, STERGMs

I. Introduction

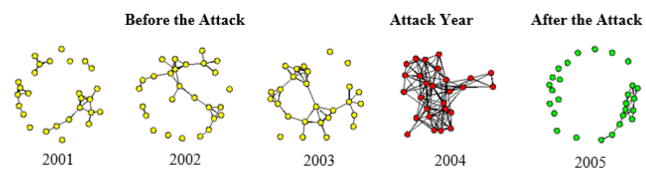
Researchers have become increasingly interested in the structure of terrorist networks. However, most of the extant literature has only analyzed these structures at a single time point. The current project uses longitudinal data to test two alternative hypotheses surrounding the structure of terrorist networks. First, some argue that terrorist networks exhibit string-like structures of sparse connections as an effort to maximize operational security (OPSEC) [1]. When terrorist networks develop in a sting-like pattern they are relatively resilient and difficult to disrupt, but there are also higher risks of communication failure [2] [3]. Others maintain that terrorist networks tend to contain a few highly-connected individuals who play crucial roles in connecting the greater network. Terrorist networks that follow this pattern can efficiently grow and communicate, but they are likely to collapse if the central hubs are effectively targeted by anti-terrorism efforts [3] [4].

II. Data and Methods of Analysis

We test these two hypotheses by using data from the John Jay & ARTIS Transnational Terrorism Database (JJATT). This database includes social network data for individual terrorists who directly participated in an assortment of terrorist attacks from 1993-2005. Our sample of terrorist attacks includes 11 attack networks: 1993 World Trade Center bombing, 1996 Paris subway bombing, 2000 USS Cole bombing, 2000 Christmas Eve bombing, 2000 Philippines Ambassador residence bombing, 2001 Hamburg 9/11 Cell, 2002 murder of Daniel Pearl, 2002 Bali bombing, 2004 Madrid train bombings, 2004 Australian Embassy bombing, 2004 Madrid train bombings, and 2005 Bali bombings.

Each terrorist attack is represented by its own network where nodes represent individual terrorists. Undirected edges signify whether a pair were acquaintances, friends, operational collaborators, or family members during the year of interest. For each network, we analyze five waves of longitudinal data including the three years preceding the attack, the year of the attack, and the year following the attack.

Figure 1. The Evolution of the Australian Embassy bombing terrorist network, 2001-2005



Notes: Circles represent individual terrorists, lines represent social relationships.

The evolving network of terrorists involved in the Australian Embassy bombing in 2004, is plotted in Figure 1 as an example. For the three years before the attack, the network is quite sparse and terrorists tend to be linked together by chain-like structures. As the network evolves, more social ties develop and the network becomes increasingly dense. In 2004, the year of the bombing, there is the greatest number of ties and the chain-like structure of the previous networks is no longer as apparent. In the year after the attack has taken place, the network is again characterized by a sparsity of ties.

To statistically analyze our data we use Separable Temporal Exponential Random Graph Models (STERGMs), an ideal method for understanding what factors cause ties to both form and dissolve in social networks. To the best of our knowledge, this research represents one of the first applications of STERGMs to the analysis of terrorist network data. After taking both structural and attribute-based controls into account in a multivariate framework, STERGMs compare the evolution of the observed network to what we would expect to occur by random chance [5]. One of the unique strengths of the STERGM approach is that it can include two types of parameters: those that consider the formation of ties and those that consider the dissolution of ties. Coefficients for these parameters can be exponentiated and interpreted as the odds that a tie will form or dissolve, under the given circumstances. We combine our findings from each STERGM by using a two-level meta-analysis.

We include two main variables of interest in our study that are both concerned with the formation of new ties: geometrically-weighted edgewise shared partner (GWESP) and degree popularity squared. The GWESP parameter tests whether there is a tendency towards triadic closure in the network. In other words, it test whether there is a greater chance for node *a* to be tied to node *b* if both *a* and *b* are already tied to node *c*. This parameter is included to test whether terrorist networks develop following an operational security (OPSEC), or string-like, structure. If networks become more string-like over time, this parameter will be negative since triadic closure is antithetical to an OPSEC structure. The degree popularity squared parameter tests whether there is a tendency towards preferential attachment, that is, a tendency for the most highly connected actors to become even more connected over time. This term adds one network statistic to the model equaling the sum over the actors of each actor's degree taken to the 3/2 power. Positive values indicate that more central nodes receive even more ties as time progresses.

We also include three variables as controls. The geometrically-weighted dyadwise shared (GWDSP) formation parameter is included to reduce bias in the GWESP parameter. We also include both an edge formation and edge dissolution parameter which control for the general tendency for new ties to form and for existing ties to dissolve.

III. STERGM Results

We find evidence that as terrorist networks develop, there is an increased tendency towards preferential attachment and decreased tendency towards OPSEC (see Table 1). The GWESP parameter is positive and significant, suggesting that ties are 225% more likely to form that result in triadic closure than would be expected by chance. The degree popularity term is also positive and significant, suggesting that highly central nodes tend to become even more centralized as time passes.

Table 1 also presents standard deviations for the variance of each parameter in the meta-analysis. All of these are statistically significant according to chi-squared tests, which suggests that there are significant differences in the ERGM parameters across the 11 networks that are included in the meta-analysis. In analyses not shown here, we test whether this variation can be explained by differences in network size (the number of terrorists involved), the target of the attack (US, European, or Asian), and the effectiveness of the attack (number of casualties). We find that the tendency towards triadic closure is highest when the network involves greater numbers of actor. In addition, there is an increased tendency towards preferential attachment when the target of the attack is the United States.

Table 1. Meta-analysis of STERGM results for 11 terrorist networks

	Coefficient	Standard Error		Standard Deviation		95% CI	
Formation							
Edges	-4.897	0.422	***	1.135	**	-7.121	-2.672
GWESP (weight = 0.1)	1.178	0.243	***	0.763	***	-0.318	2.674
GWDSP(weight = 0.1)	-0.053	0.049		0.144	***	-0.335	0.230
Degree Popularity Sq	0.144	0.056	*	0.154	***	-0.159	0.446
Dissolution							
Edges	1.051	0.370	*	1.250	***	-1.398	3.500

Note: *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

IV. Discussion

We believe that our results have important implications for anti-terrorism efforts when considering the types of insurgent groups examined here. At their inception, terrorist networks in our sample are more string-like, and there are few to no actors who operate as highly central hubs. At this point, randomly targeting actors in the network should be just as effective at breaking up the network as selective targeting. However, as the network matures, central hubs start to play a more important role and thus, actors in these central locations likely make particularly tactical targets.

V. Acknowledgement

This research was sponsored in part by the U.S. Army Research Laboratory and the U.K. Ministry of Defence under Agreement Number W911NF-16-3-0001. The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the official policies, either expressed or implied, of the U.S. Army Research Laboratory, the U.S. Government, the U.K. Ministry of Defence or the U.K. Government. The U.S. and U.K. Governments are authorized to reproduce and distribute reprints for Government purposes notwithstanding any copyright notation hereon.

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