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DISCUSSION OF "ESTIMATING THE HISTORICAL AND FUTURE PROBABILITIES OF LARGE TERRORIST EVENTS" BY AARON CLAUSET AND RYAN WOODARD

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1. Introduction. The terrorist attacks in the United States on September 11, 2001 appeared to be a harbinger of increased terrorism and violence in the 21st century, bringing terrorism and political violence to the forefront of public discussion. Questions about these events abound, and "Estimating the Historical and Future Probabilities of Large Scale Terrorist Event" [Clauset and Woodard (2013)] asks specifically, "how rare are large scale terrorist events?" and, in general, encourages discussion on the role of quantitative methods in terrorism research and policy and decision-making.

Answering the primary question raises two challenges. The first is identifying terrorist events. The second is finding a simple yet robust model for rare events that has good explanatory and predictive capabilities. The challenges of identifying terrorist events is acknowledged and addressed by reviewing and using data from two well-known and reputable sources: the Memorial Institute for the Prevention of Terrorism-RAND database (MIPT-RAND) [Memorial Institute for the Prevention of Terrorism] and the Global Terrorism Database (GTD) [LaFree and Dugan (2007), National Consortium for the Study of Terrorism and Responses to Terrorism (START) (2012)]. Clauset and Woodard (2013) provide a detailed discussion of the limitations of the data and the models used, in the context of the larger issues surrounding terrorism and policy.

The models proposed fit tail probabilities for power-law and alternative models based on data from both the MIPT-RAND database and the GTD. These models are thoroughly explained and well executed, as are the results. The predictive capabilities and forecasts, along with consideration of the influence of exogenous factors such as attack type, target and economic development are considered, presented and discussed clearly, affirming the robustness of the methods. The authors estimate that, in the 40-year period since 1968, there is an 11–35% chance of a terror event at least the size of September 11, 2001.

2. Comments. Terrorism and political violence are complex phenomenon of human behavior [Horgan and Boyle (2008), Taylor and Horgan (2006)], and rely on the fear and uncertainty surrounding rare events to create a disproportionate effect that is difficult to directly measure [Crenshaw (1981, 1986), Thornton (1964),

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Waugh (1983)]. In this context, making predictions about human behavior is a tricky business, and interpreting an 11–35% probability for an extreme event illustrates part of this problem. An 11–35% probability sounds ominous, but, over a 40-year period, that translates to a seemingly innocuous daily probability around 1 in 100,000. The temptation is to interpret an 11–35% chance as near certainty, and a 1 in 1,000,000 chance as near impossibility. Neither of these time scales for interpretation are useful, and belie a further problem with considering large scale historical trends when making predictions about rare events using only previous history.

For example, in 224 years there have been 44 US Presidents; 4 (9%) were assassinated. The first was in 1865; in the period between 1865 and 1901, 3 of the 10 US Presidents were killed in office (30%). Since 1901, only 1 (5%) US President was assassinated. Making a forecast in 1864, and relying solely on historical data, the expected number of US Presidents killed in office in the ensuing 40 years would be 0. In 1902, looking back at the previous 40 years, there would be an expected 5 US Presidents killed in office during the 20th century. This example is hardly definitive, but it illustrates the point that rare events involving humans are difficult to predict.

While Clauset and Woodard (2013) (rightfully) do not address this, their paper does address the caveats of its results in great detail, which provides the basis for raising the question, "what is the role of quantitative methods in terrorism research and in assisting policy and decision makers?"

In Lum, Kennedy and Sherley (2006), a systematic review of the literature reveals a significant increase in research on terrorism and counterterrorism efforts since 2001, though only a small minority apply quantitative methods. Despite this, there are some notable examples, both included in Lum, Kennedy and Sherley (2006) and after. Enders and Sandler (1993) use vector autoregression (VAR) and an interrupted time series approach to model the effects of counterterrorism policies on transnational terrorism from 1968 through 1988. Dugan, LaFree and Piquero (2005) and Dugan (2011) use Cox proportional hazard models, and their variants, to analyze the effects of interventions on hijackings and IRA terrorist activity in Northern Ireland [LaFree, Dugan and Korte (2009)]. Arce M. and Sandler (2005) propose a game theoretic framework for modeling the interactions between terrorists and counterterrorism efforts, and Saperstein (2008) and Minami and Kucik (2009) suggest modeling the interaction between terrorists and counterterrorism efforts using a dynamic linear modeling approach. Recent research shows that patterns of terrorist activity are well modeled using a cluster process interpretation of self-exciting process models [Hawkes (1971a, 1971b), Hawkes and Oakes (1974)]. Self-exciting models have been applied to airline hijackings [Holden (1986, 1987)], insurgent activity in Iraq [Lewis et al. (2011), Mohler (2010), Mohler et al. (2011), Lewis and Mohler (2013)] and terrorism data from Southeast Asia and Colombia [Porter and White (2012), White and Porter (2013), White, Porter and Mazerolle (2013)].

One important aspect of modeling terrorism that is not explicitly stated, but is implicit in Clauset and Woodard (2013), is the notion of different processes for different levels and types of terrorist activity. This idea, illustrated by the fitting of tail probabilities for rare events, can help explain the relative scarcity and sporadic nature of terrorism [Porter and White (2012), Raghavan, Galstyan and Tartakovsky (2013)]. This extends to a complex, unobserved latent process as a model for the occurrence, and resulting characteristics, of terrorist events. The capability to model and describe complex unobserved processes is well established and is an ongoing area of significant research in the mathematical and statistical sciences. The advent of newly available data sources, like the GTD and the MIPT data sets, and increased awareness outside of the field of terrorism studies creates an opportunity for mathematicians and statisticians to work more closely and in conjunction with experts from academia, in policy and decision-making roles to create new models and methods to expand our understanding of terrorism and terrorist activity.

For the quantitative researcher, the utility of these models is obvious. As exploratory tools they can reveal heretofore unobserved patterns in activity. As confirmatory tools they can be used to test specific ideas and theories about these patterns. The challenge for the quantitative researcher is to understand their place in the field of terrorism studies as a whole, assisting in the building of sound knowledge, and aiding policy and decision makers.

3. Conclusion. Terrorism studies itself faces an important epistemological quandary, and there is an ongoing debate over whether terrorism—however it is understood—should be analyzed within its individual context or whether it can be assessed on a more universal level, across space and time [Duyvesteyn (2004), Neumann (2009), Silke (2001), Weinberg, Pedahzur and Hirsch-Hoefler (2004)]. As a result, the role of quantitative (particularly statistical) methods in terrorism studies is often lost in this debate. The argument of terrorism scholars is that individual terrorists and acts of terrorism are too unique to benefit from statistical analysis. The statistical perspective is that the purpose of the statistical analysis of data is to make inferences about the underlying process or *context* that produce the data, not specific observations. Or, in the words of Sherlock Holmes:

> "...while the individual man is an insoluble puzzle, in the aggregate he becomes a mathematical certainty. You can, for example, never foretell what any one man will do, but you can say with precision what an average number will be up to. Individuals vary, but percentages remain constant." The Sign of Four—Sir Arthur Conan Doyle [Doyle (2003)]

While Holmes is a fictional character, his statement neatly sums up the miscommunication that often occurs between statisticians–nonstatisticians. Terrorism studies scholars and policy and decision makers want (and rightly so) predictions at a very fine level, down to the individual's behaviors. Statisticians should agree that this is often beyond the reasonable expectation of their methods. But statistical and quantitative methods can contribute understanding on combating terrorism

by identifying and measuring specific differences *between* contexts (i.e., countries, regions or groups). These can be analyzed to identify contextual differences and explore *why* they exist, providing a deeper understanding of terrorism and political violence.

Statistical methods do not intend to provide definitive answers; their results, couched in uncertainty, should inform, not make decisions. In order to advance the understanding of terrorism, the benefits and limitations of quantitative methods need to be clearly understood, and it is the role and duty of the expert to clearly and effectively communicate the benefits and limitations of quantitative methods to qualitative researchers and policy and decision makers.

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