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Original Abstract:

Endogenous versus Exogenous Events in The Global War on Terror
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Are large-scale terrorist events such as September 11th and its aftermath the result of an exogenous shock or self-organized criticality? Determining the chain of causality for extreme events in complex social systems requires disentangling interwoven exogenous and endogenous contributions with either no clear signature or too many signatures. In this paper, we use techniques from earthquake physics to identify foreshocks and aftershocks leading to and following September 11th by drawing on large N datasets of conflict events.

Introduction

> "Like any social phenomenon, violent conflict does not result from the linear summation of a neatly defined set of causes but from interactions among multiple phenomena in a complex system with several levels or organization. Some factors may predispose certain societies to violence, but only the decisions of actors in dynamically changing situations realize these potentials, or their opposite.
> As complexity and chaos theories show, in such a system behaviors will not respond in a linear way to changes in one variable, however significant that variable may be."
> Barnett R. Rubin (2004), *Sources of Violent Conflict*

Are there discernible foreshocks and aftershocks in social systems? Can endogenous and exogenous causes of extreme events be identified? The rise and fall of great powers (Kennedy 1987) are marked by punctuated equilibria (Gould 1982) such as political revolutions (behavior) that alter the structures (rules) of the system (institutions) (Krasner 1984). Revolutions or wars may be the product of mounting tensions (disequilibria in power relations) between active agents. At times, the stress finds its release through violent armed conflict, after which the influence of each actor (armed group or nation) is brought back into stasis (metastable state or stable equilibrium state) with its true economic and military might (Buchanan 2001, 23; Doyle 1997; Levy 2002; Morgenthau 1967; Claude 1962; Jervis 1997; Wagner 1994; Powell 1996; Mearsheimer 1990; Mansfield 1992; Midlarksy 1989; Geller 1993; Van Evera 1999; Walt 1985; Krasner 1984; Bruadel 1962). To be sure, violent conflict is "often like an earthquake: it's caused by the slow accumulation of deep and largely unseen pressures beneath the surface of our day-to-day affairs. At some point these pressures release their accumulated energy with catastrophic effect, creating shock waves that pulverize our habitual and often rigid ways of doing things..." (Homer-Dixon 2006, 13).

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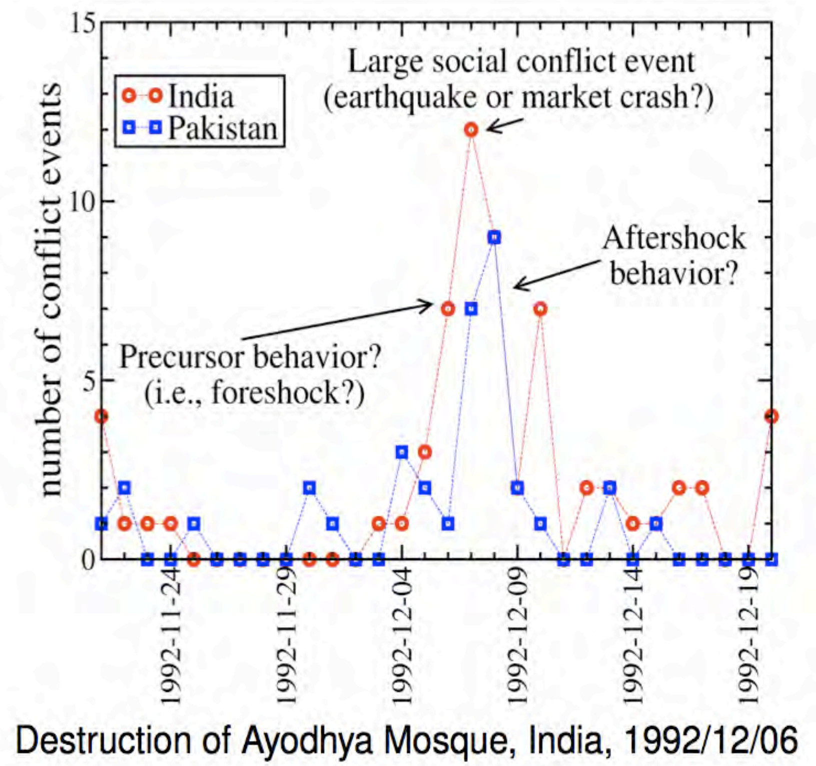


Figure 1: Can earthquake physics inform conflict analysis?

"If this sounds at all like the processes at work in the Earth's crust, where stresses build up slowly to be released in sudden earthquakes … it may be no coincidence" (Buchanan 2001, 23). Like earthquakes, both inter-state and internal wars actually occur with the same statistical pattern (power-law distribution). Earthquakes and conflicts are complex systems and share such emergent features (Rubin 2004, Cederman 2003, Buchanan 2001, Lukas and Milov 1997, Richardson 1941). Both earthquakes and conflicts exhibit features associated with critical states—geophysical fault lines and the locus of structural violence respectively (Gribbin 2005, Shaw 2004; Mansfield and Snyder 2002, Buchanan 2001, de Mesquita et al. 1999, Auerswald 1999, Gaubatz 1998, Uvin 1998, James 1995, Maoz and Russett 1993, Thompson 1992, Krasner 1984, Galtung 1980, Braudel 1963). "The science of earthquakes then, can help us understand sharp and sudden changes in types of complex systems that aren't geological--including societies..." (Homer-Dixon 2006, 105).

Data Source

Building on these findings, we suggest that methods produced to model earthquakes may shed light on how comparable models might be adapted to model conflict systems. More than a conceptual exercise, this research project seeks to modify and empirically test a model developed for earthquake prediction using a 15-year conflict data time series.

Earthquake physicists work from global spatial time series data of seismic events to develop models for earthquake prediction. We use a global time series dataset of conflict events to adapt methods from earthquake prediction to conflict forecasting. The dataset is generated using a natural language processing algorithm that codes newswires (Bond et al. 2004, King and Lowe 2002). This parsing technology yields time series data for conflict and cooperation events. The dataset is populated using an automated full-syntax natural-language frame parser that "reads" Reuters newswires and codes them using the parameters: *who (source) did what (event) to whom (target), where (place), when (time)*? The events are machine-coded in near real time into 249 categories to include information on events, actors, and targets in a four-level event hierarchy (Bond et al., 2003). In this paper, we assume that "news reports can be considered a semantic rendition of reality and the events of cooperation and conflict that occur around the world" (Bhavnani and Bracanti, 23, 2006).

24 conflict event types

Abduction	Armed actions
Armed battle	Arrest and detention
Artillery attack	Assassination
Beatings	Bodily punishment
Coups and mutinies	Criminal arrests
Crowd control	Force use
Hijacking	Hostage and kidnapping
Mine explosion	Missile attack
Physical assault	Political arrests
Riot	Sexual assault
Small arms attack	Suicide bombing
Torture	Vehicle bombing

27 cooperation event types.

Acknow. respons.	Agree to mediation
Agree to negotiate	Agree to peacekeeping
Agree to settlement	Apologize
Collaborate	Demobilize armed forces
Ease sanctions	Empathize
Engage in negotiation	Evacuate victims
Forgive	Grant asylum
Host a meeting	Improve relations
Mediate talks	Observe truce
Offer peace proposal	Offer to Negotiate
Offer to mediate	Promise to mediate
Provide shelter	Relax curfew
Request mediation	Request withdrawal or ceasefire
Travel to meet	

Bond et al 2003; King and Lowe 2003

Figure 2: This study focuses aggregates all conflict event types into one index.

The decision to use the IDEA dataset was based on three key factors. First, the IDEA dataset is thought to offer the most detailed account of interactions between actors (King and Lowe, 2003). Second, compared to other available sources of events-data that produce aggregated observations, "IDEA data examines events as they occur, providing much more accurate and granular data" (Bhavnani and Bracanti, 23, 2006). Third, the natural-language parser used by IDEA performs as well as human coders (King and Lowe, 2002).

While the pubic KEDS/TABARI (The Kansas Events Data System and Text Analysis by Augmented Replacement Instructions) is the most commonly used dataset in the field of international affairs, IDEA uses nearly 200 additional event types to code newswires. In addition, TABARI—which has superseded KEDS—is a "sparse parser" whereas VRA is a full-syntax parser (Schrodt, 2001). This essentially means that TABARI is unable to handle complex grammatical structures—that is, not simple subject-verb-object sentences. Indeed, TABARI uses a "complexity filter" that discards (or codes to the null category) sentences with highly dense structures (this can be in the source, event, and/or target positions).

Furthermore, TABARI appears to discard any parsed output that has a blank value in the source and/or target positions, which is problematic because sentences with complex structures are removed and this therefore reduces the number of reports that are parsed. In short, IDEA codes more newswires than TABARI. As a result, TABARI is far faster. In terms of reliability, King and Lowe (2003) rate the IDEA machine coding at 70% to 85% accurate in identifying events. In another study by Craig Jenkins et al. (2002), events in the World Handbook derived from the IDEA dataset were found to have a 50% to 80% recall rate, no false positives, and a 3% false negative rate (see Bhavnani and Bracanti, 25, 2006).

IDEA is certainly not without its fair share of problems. Lastly, world news is disproportionately focused on Western or large developing countries. Tied to this are issues of media bias in news coverage particularly when drawing on a single source [Reeves, Shellman and Steward 2006].

Methodology

Can signatures in this conflict dataset be identified? Do all countries have similar signatures? If not, what explains the difference? Would the knowledge of these signatures even be helpful vis-à-vis policy and operational response?

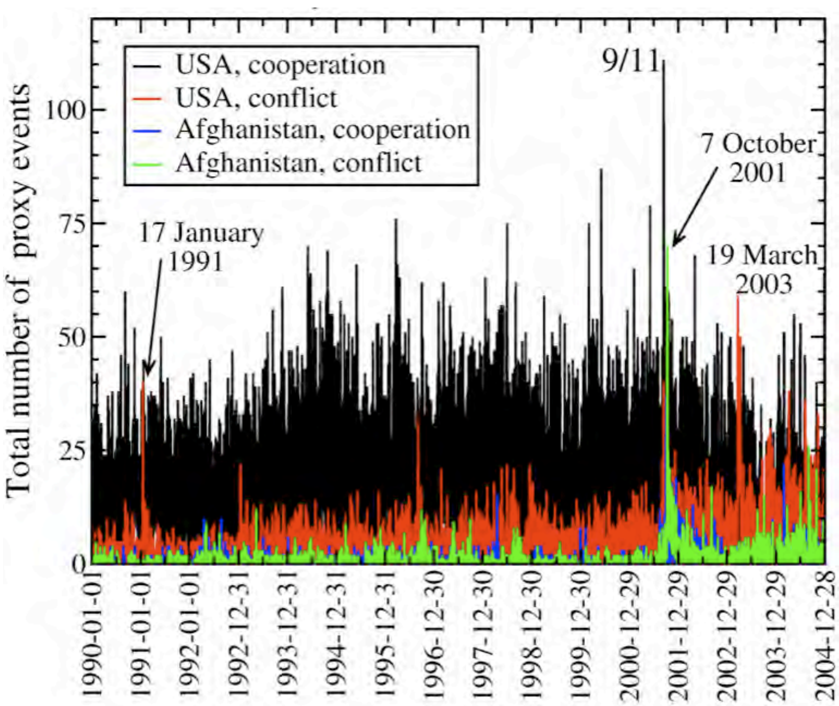


Figure 3: Plot of US data from IDEA dataset.

Earthquake physicists use a variety of mathematical techniques to analyze seismic data. When using a "superposed epoch analysis", our hypothesis is that the precursory and aftershock behaviors surrounding peaks exhibit robust signatures of the characteristic organization of the underlying social system, exemplified by the response function to shocks."

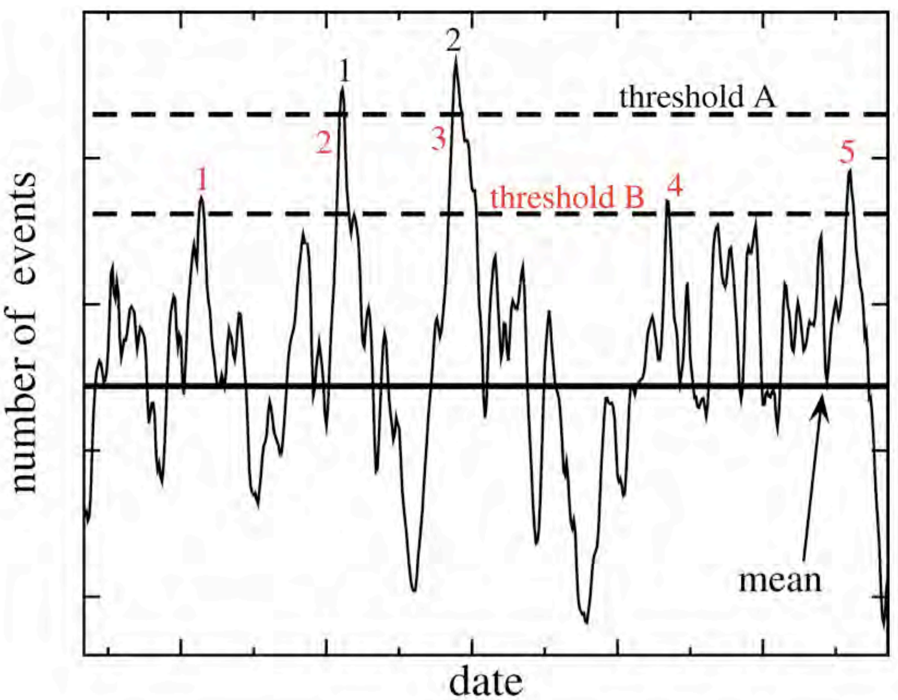
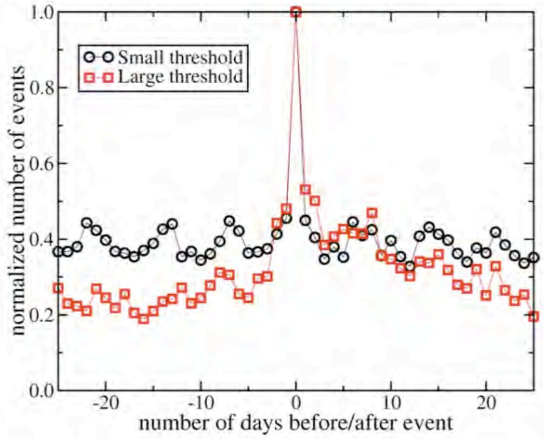


Figure 4: Statistical seismic superposition using arbitrary thresholds.

The curve above represents a time series of conflict events (frequency) over a particular period of time. We select arbitrary threshold, such as “threshold A” denoted by the dotted line. Every peak that crosses this threshold is then “copied” and “pasted” into a new graph. That is, the peak, together with the data points 25 days prior to and following the peak is selected. The peaks in the new graph are superimposed and aligned such that the peaks overlap precisely. With “threshold A”, two events cross the threshold, five for “threshold B”. We then vary the thresholds to look for consistent behavior and examine the statistical behavior of the 25 days before and after the “extreme” conflict event.

In this study, we performed the computational technique described above on the conflict data for the US, UK, Afghanistan, Columbia and Iraq. The resulting graphs are available on the following page.

Findings



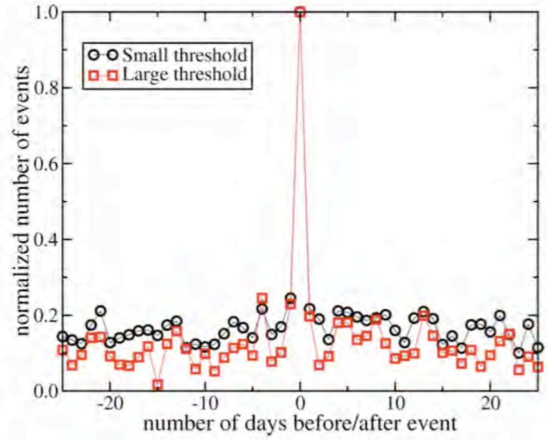
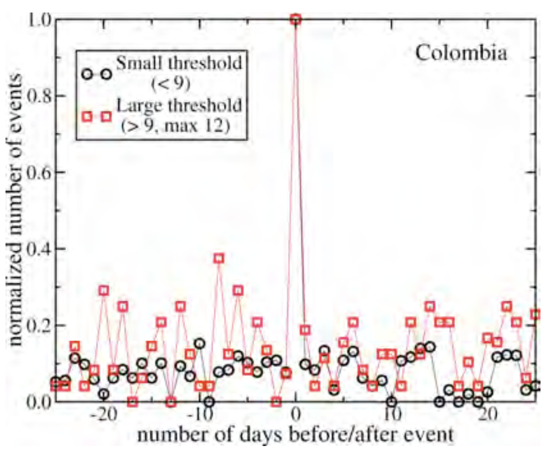


Figure 5: US shows aftershock behavior of large events. There are therefore possible pre-cursor activity to large events. Small events may just be background noise.
N = 24,104

Figure 6: UK shows no fore/after shocks. This is perhaps due to the lack of "memory" or the possibility that the network is more resilient.
N = 10,285

Clearly, the US and UK show different foreshock and aftershock behavior.



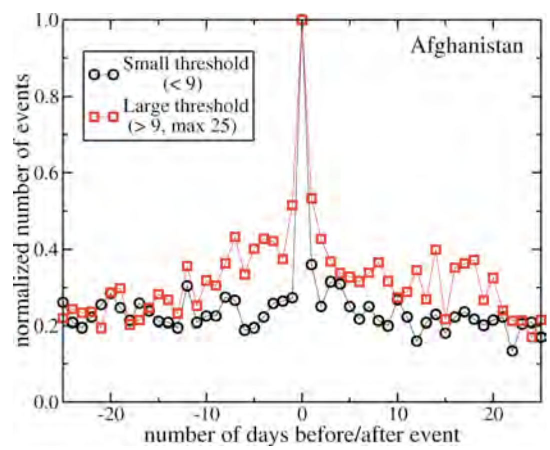


Figure 7: Columbia and Afghanistan show different fore/after shock behavior.
N (Afgh) = 4,815; N (Col) = 4,232.

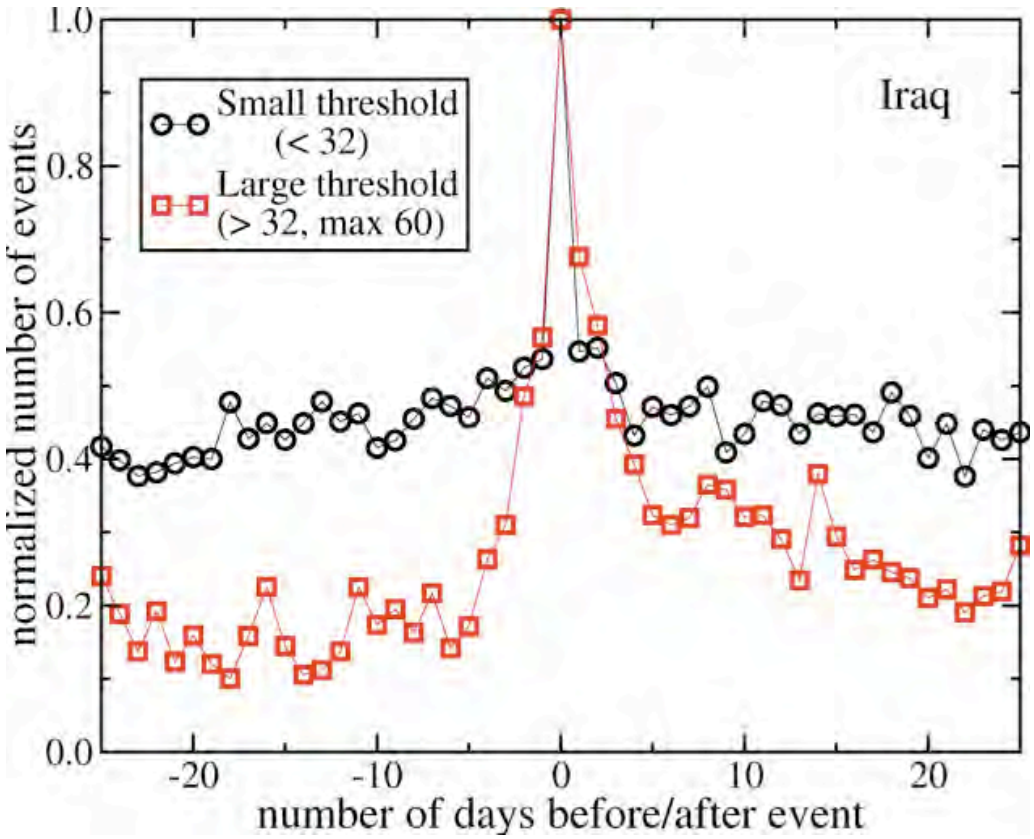


Figure 8: Statistical behavior of foreshocks and aftershocks in Iraq.
N = 10,855.

The foreshock and aftershock behaviors in Iraq and Afghanistan appear to be similar. Is this because the conflicts in both countries were the result of external intervention, i.e., invasion by US forces (exogenous shock)? In the case of Colombia, an internal low intensity and protracted conflict, the statistical behavior of foreshocks and aftershocks are visibly different from those of Iraq and Afghanistan. Do the different statistical behaviors point to specific signature associated with exogenous and endogenous causes of extreme events? Does one set of behavior contrast with another one in the same way that old wars and new wars differ?

Future Research

Are certain extreme events endogenous or exogenous in nature? Can endogenous or exogenous signatures be identified? In other words, are extreme events just part of the fat tail of a power law due to self-organized criticality (endogeneity)? Or is catastrophism in action, extreme events require extreme causes outside the system (exogeneity)? Another possibility still is that extreme events are the product of both endogenous and exogenous effects. How would this dynamic unfold? To answer these questions, we need to go beyond political science.

Figure 9: Can we learn from the complexity of other systems?

An example that may shed light on the above questions is book sales on Amazon.com. Take the pattern of sales in the graph below (Figure 10). Clearly, the signatures of the sales dynamics show fundamental differences. Sales of the Roberts book show smooth 'precursor' behavior in the sense that there is a gradual build-up of activity leading to the peak followed by a gradual build-up of activity leading to the peak followed by a gradual decline. This behavior suggests that thes sales are the result of word-of-mouth recommendations, i.e., an endogeneous process within the sales network (Sornette *et al.* 2004). In contrast, sales of the Nelson book show a sudden unexpected spike in activity, suggesting an external perturbation on the sales network, that is, an exogenous shock. What sort of external event could cause such behavior? The answer is most certainly yes, as depicted in Figure 11 below.

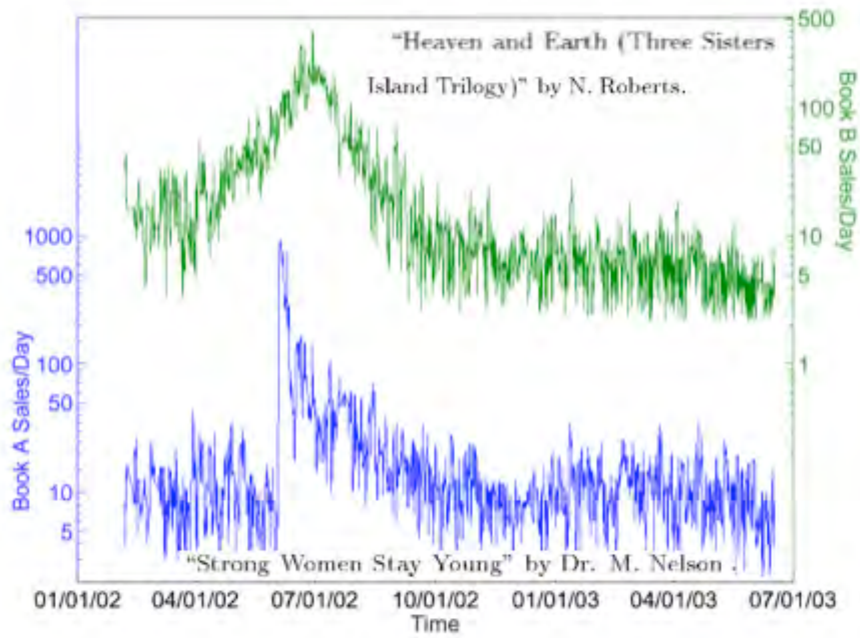


Figure 9: Endogenous vs. exogenous causes of book sales. Source: Sornette et al. 2004.

The graph below shows the signature of repeated external perturbations on the sales of Nelson's book:

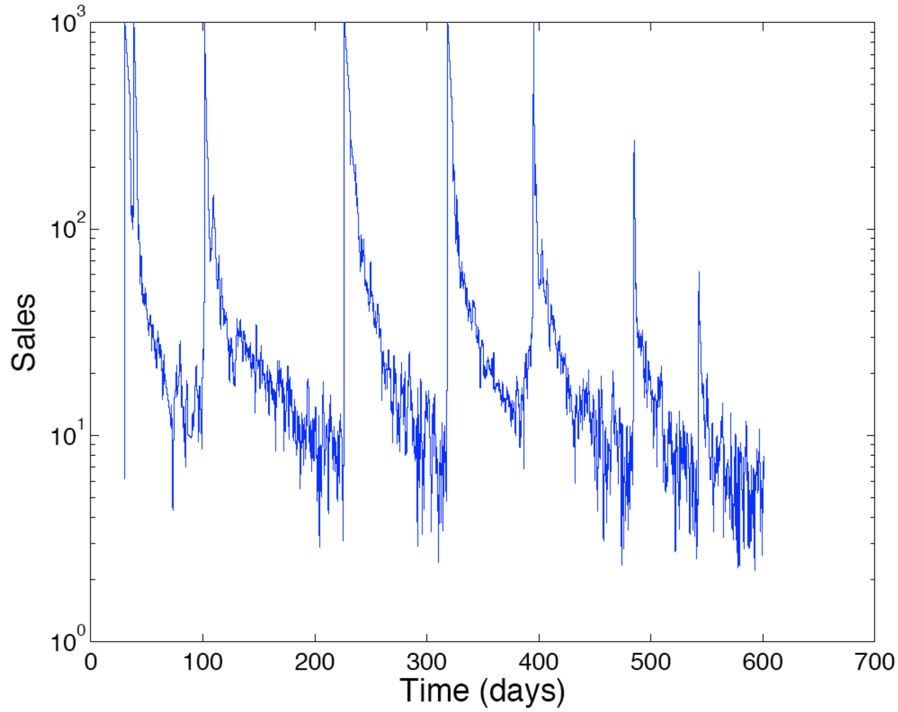


Figure 10: Repeated exogenous shocks to sales of Nelson's book. Source: Sornette et al. 2007.

So what are the exogenous shocks behind the Nelson book sales signatures? Each time the book was presented on the Oprah Winfrey Show, the sales would jump overnight and then relax according to a specific exogenous response function (Sornette *et al.* 2007). The book sales also generate power law behaviors as depicted in the graph below.

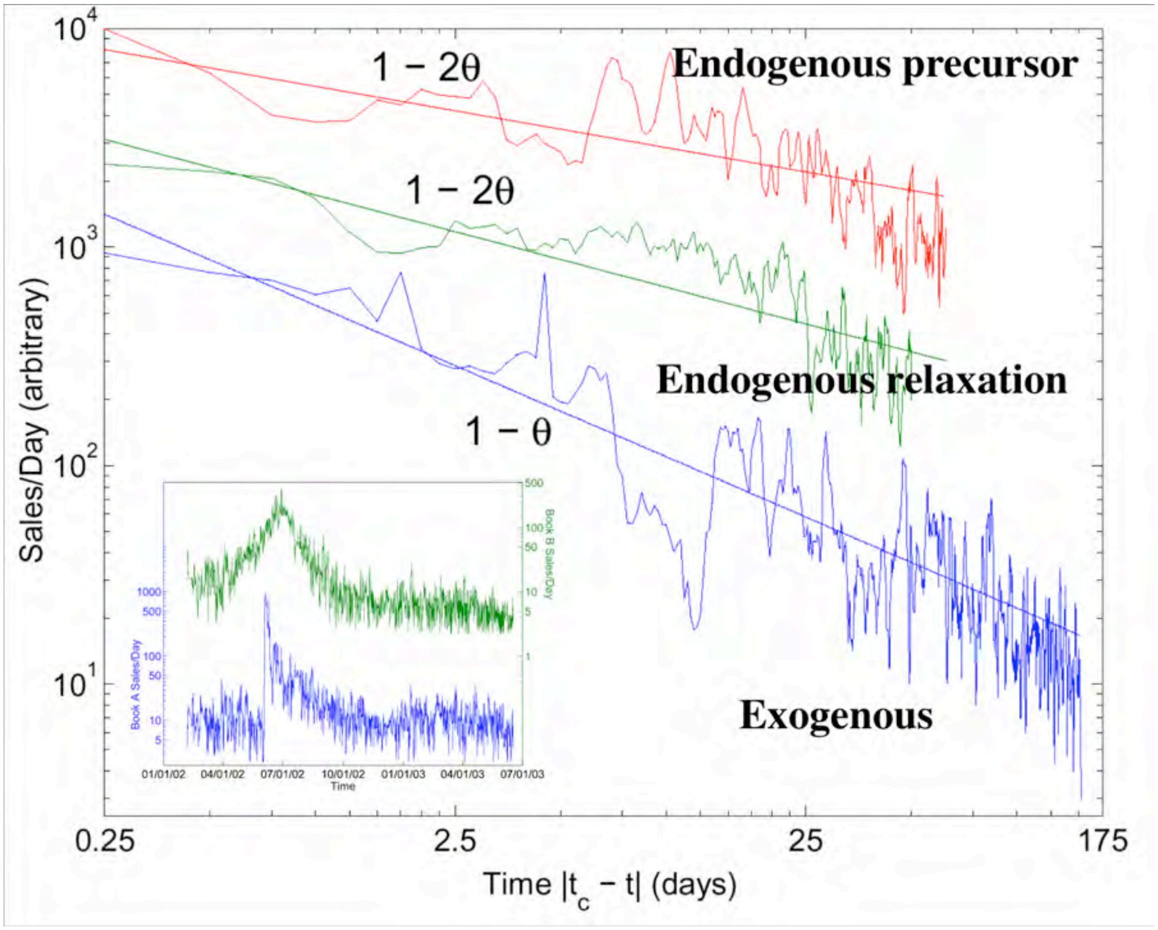


Figure 11: Exogenous and endogenous causes of extreme events produce distinct power law signatures (slopes). Source: Sornette et al. 2007

This distinction between responses to endogenous and exogenous processes is a fundamental property of physics and is quantified as the fluctuation-dissipation theorem in statistical mechanics (Plischke 1989; Callen 1985). This theory has been successfully applied to social systems (such as books sales) as a way to help understand different classes of causes and effects. Our goal is to use the same techniques to investigate the questions: Do conflict among actors in social systems display measurable endogenous and exogenous behavior? If so, can a quantitative signature of precursory (endogenous) behavior be used to help recognize and then reduce growing conflict?

The next phase of this research will be to apply the above techniques to the conflict dataset already used to examine the statistical behavior of foreshocks and aftershocks.