



Empirical scaling law connecting persistence and severity of global terrorism



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HIGHLIGHTS

- The continuity and persistence of worldwide terrorism are governed by scaling laws.
- The scaling parameter for a country is related to its yearly global terrorism index.
- The new terrorism is more accurately considered evolutionary than revolutionary.
- A seesaw model is developed to quantify the severity of the global terrorism.

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ABSTRACT

Terrorism and counterterrorism have both been evolving rapidly. From time to time, there have been debates on whether the new terrorism is evolutionary or revolutionary. Such debate often becomes more heated after major terrorist activities, such as the terrorist attacks on September 11, 2001 and the November 13, 2015 coordinated Paris terror attack. Using country-wide terrorism data since 1970, we show that there exist scaling laws governing the continuity and persistence of world-wide terrorism, with the long-term scaling parameter for each country closely related to its yearly global terrorism index. This suggests that the new terrorism is more accurately considered evolutionary. It is further shown that the imbalance in the seesaw of terrorism and counterterrorism is not only responsible for the scaling behavior found here, but also provides new means of quantifying the severity of the global terrorism.

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1. Introduction

The worst terrorist attacks on United States of America, the September 11 2001 attacks, have singularly changed the world's perception on terrorism. Since then, the Global Terrorism Database (<http://www.start.umd.edu/gtd/>) has been created and made publicly available. The Database covers terrorism events since 1970. Facilitated by the increased availability of terrorism data, a lot of effort has been made to study the macroeconomic consequences of terrorism [1,2], the sectoral effects of terrorism [3], the root causes of terrorism [4], the role of failed states on terrorism [5], the influence of the economy and social grievances on terrorism [6,7], the effect of types of minority discrimination on terrorism [8], the variation in terrorism within and across political regimes [9], the relation between terrorism and trust [10], modeling of the frequency of severe

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terrorist attacks [11,12], statistical physics of crimes and terrorism [13,14], and the dynamics of terrorist attacks [15]. There also has been psychoanalytic exploration of religious terrorism [16], as well as game theory based analyses of terrorism and counterterrorism [17–20]. The major understanding so far obtained is that terrorism, especially the religiously motivated international terrorism, is better viewed as largely originating from long-standing feelings of humiliation and frustration that has little to do with economics or education; rather, it is often driven by an impulse to revenge [4,16]. Such terrorism cannot be aptly understood by game theory or other rational choice models popular in social science [16].

A different line of research on terrorism focuses on how new the new terrorism is [21–25]. Advocates of the “new terrorism” emphasize some characteristics of terrorism such as religious motivation [26,27], networked organizational structures [28,29], tendency to launch mass casualty attacks [27,28], possible use of weapons of mass destruction (WMDs, i.e., nuclear, radiological, biological and chemical weapons) [30], and that counterterrorism has also become increasingly sophisticated and intelligent. Critics of the new terrorism argue that religiously motivated terrorism has always existed [31,22,32]; that traditional terrorist targets were also indiscriminate [22]; that increased frequency of mass casualty attacks may be due to factors other than conceptualized [33,31,34]; that terrorist attempts to use WMDs is nothing new [35], and that horizontal terrorist networks are also nothing new [36,33]. So far, the debate on whether the new terrorism is revolutionary or evolutionary has not been fully settled. In fact, purely qualitative studies will not settle the debate.

While the battle between terrorism and the counterterrorism is clearly a dynamic process, critics of new terrorism argue that there is continuity in all those features. The debate on new terrorism has become more acute after the November 13, 2015 coordinated Paris terror attack. Can a definitive answer to the issue whether the new terrorism is evolutionary or revolutionary be obtained not largely based on qualitative arguments but based on advanced quantitative analysis? Can new measures be developed to help quantify the severity of global terrorism? To help answer these questions, we resort to random fractal theory [37] to carry out scaling analysis of individual countries’ terrorism data, and examine whether there exist relations between the scaling parameters and the yearly global terrorism index (GTI), which measures the severity of terrorism, of each country.

An important class of random fractals is the $1/f^\alpha$ noise [38–40], which is characterized by a power-law decaying power spectral density (PSD) as well as power-law decaying rank-ordered eigenvalue spectrum [41]. $1/f^\alpha$ noise has been fruitfully used to quantify DNA sequences [42,43], human cognition [44] and coordination [45], posture [46], cardiac dynamics [47–50], as well as the distribution of prime numbers [51], among others. In the present study, we work with a subclass of $1/f^\alpha$ noise, denoted as $1/f^{2H+1}$ process, where $0 < H < 1$. Such processes are said to have antipersistent correlations if $0 < H < 1/2$, have only short-range correlations if $H = 1/2$, and have persistent long-range correlations (long memory) if $1/2 < H < 1$ [52]. The rationale for our study is based on the observation that scaling laws are based on the data from 1970 to the present, and therefore characterize long-term persistent behavior. If they are connected with short-term yearly measure of the severity of terrorism in each country, then there is a continuity and persistency in the terrorism, and the new terrorism is indeed more accurately viewed as evolutionary than revolutionary. In this case, one has to further consider the possible mechanisms for the scaling laws. The scaling parameters and the mechanisms for the scaling may be used to construct new measures of quantifying the severity of terrorism.

2. Data and methods

2.1. Data

The yearly country-wise terrorism data analyzed here were downloaded from the Global Terrorism Database (GTD), which is maintained by the National Consortium for the Study of Terrorism and Responses to Terrorism (START) headquartered at the University of Maryland. The GTD is an open-source database which is the most comprehensive database on terrorist events around the world from 1970 through 2015 with the data of 1993 missing, because the data were lost prior to START’s compilation of the GTD from multiple data collection efforts. The GTD events are drawn from a wide variety of news, which were collected over 4,000,000 news articles and 25,000 news sources around the world from 1998 to 2015. Gathering a wide variety of etiological and situational variables pertaining to each terrorist incident, the database records more than 120 separate attributes of each incident, including approximately 75 coded variables, such as date, country, city, weapons, terrorist organizations, motives, casualties and property damage that can be used for statistical analysis. For more details, we refer to the GTD Codebook and the GTD website. Here we focus on the time series of each country’s yearly number of fatalities, injuries, and incidents, as well as the time intervals between successive terrorist attacks, which we call inter-event-interval (IEI). In order to correlate with the severity of each country’s terrorism, we also use the GTI data, which are based on data from the GTD and released yearly by the Institute for Economics and Peace (IEP) from 2003 to 2016. GTI provides a comprehensive summary of the key global trends and patterns in terrorism over the last 16 years, from 2000 to 2015, as well as the ranking of 163 countries (99.7% of the world’s population) in terms of the severity of terrorism.

2.2. Fractal analysis

2.2.1. Fractal process

Many processes in natural and social sciences and engineering exhibit fractal or self-similar patterns or dynamics [53]. Dynamic fractal patterns possess scale-invariance or scaling behavior, i.e., a faster time-scale fluctuation pattern simulates

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