Chapter 2
Complex Systems Studies and Terrorism

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Introduction

Although terrorism has been present in social life for decades, only after the World Trade Center attacks of September 11, 2001, did the topic gain new significance as a sociopolitical phenomenon and as a method of warfare. Terrorism has been analyzed from a variety of viewpoints, ranging from security and military research to cultural studies and anthropological analyses. Scholars in the field of Complexity Science (Complex Adaptive Systems [CAS] Research and Nonlinear Dynamical Systems Modeling) have recently been developing a number of models for the identification and prediction of terrorist activities (Bar-Yam, Carley, Clauset and Gleditsch, Fellman, Galam, etc.). It may even be argued that ideas are drawn from CAS research (the term complexity theory, or complexity science, is purposely avoided in this chapter), which could be applied not only in specialized research on how to deal with terrorism as a form of warfare, but also in a broader sense, for studying terrorism as a sociopolitical phenomenon.

The aim of this chapter, which is part of a broader research project both here and in another forthcoming publication from Springer Verlag, is to present a survey of the applications of ideas drawn from CAS research in a theoretical discourse on terrorism. In so doing, I shall examine the use of these concepts both in policymaking and in more applied settings. Other authors in this book will focus on more specific applications of various tools and models, while in this chapter, I shall endeavor to provide a more general theoretical foundation for the entire volume.

This chapter is based upon three assumptions. First, that contemporary terrorism has become a peculiar facet of modern society, which itself can be viewed as a complex system [1]. Second, that concepts drawn from complex systems research

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broadly defined can be applied as new instruments both to facilitate the understanding of terrorism as a pervasive phenomenon affecting the security of modern society and to provide new applications for improving counter-terrorism measures. Third, that expectations regarding the ability of complex systems research to predict terrorist activities (including those models developed by theoreticians as well as programs designed for policymakers engaged in counter-terrorism activities) can only be partially fulfilled.

Due to the fuzziness of the term “complexity” and its multitude of uses and abuses, the meaning of the term “the complexity of social systems” will be explained in detail in the present chapter. The concepts associated with complexity studies will also be defined and analyzed. Subsequently, an overview of the interpretations of terrorism in contemporary security theory will be presented along with an analysis of the relationship between the complexity of terrorism and the complexity of modern society.

This survey of the linkages between complexity studies and terrorism is divided into two parts. The first part of the analysis examines the role of systems thinking in the theoretical consideration of terrorism as well as in practical applications and responses to terrorism. This line of reasoning, which originates from the definitions of the complexity of social systems, is an attempt to identify those characteristics of terrorism that are typical of modern complex society. In the second part of the survey, the methods of dealing with terrorism and terrorist activities related to complex systems studies are the primary focus. The scope of the topics related to terrorism is obviously too broad for a single book chapter. Therefore, not all complex models applied to the study of terrorism are included. Rather the selection of models focuses upon those models which are most representative of the ways in which CAS research approaches terrorism. For the same reason, two issues are purposely left for separate consideration—cyber-terrorism and the applications of complex systems-related ideas in combating terrorism.

The conclusions stemming from this study should allow for a better understanding of terrorism as a factor of security/insecurity in contemporary complex society. This chapter is also designed to function as a point of departure for understanding the potential changes and improvements which can be made to various counter-terrorism activities and programs as the result of a better understanding of CAS research and models.

**Complexity and Social Systems: The Characteristics of Complexity**

Often used as a byword, or even a “buzzword,” the term *complexity* has gained a specific role in the language of modern science and social practice. Simultaneously, “complexity scholars,” i.e., the authors claiming to study the complexity of nature and society, whether purposely or not, directly or indirectly, stimulate the expectations of policymakers by assigning marketable titles to their works: “Hidden Order” [2],
“Harnessing Complexity” [3], “Order out of Chaos” [4], “Understanding Complex Organizations” (repeated in various contexts), etc.

The demand for actionable knowledge from policymakers, military planners, bankers, financiers, managers, and others as well as the attempts to provide useful responses by the scholarly community is nothing unusual in and of itself. A new element in the discourse between practice and “complexity studies” has resulted from the awareness of the limited possibilities, or even the impossibility, of the analysis and prediction of various social phenomena. This impossibility is often expressed in a declaration of fuzzily defined concepts which refer to the “complexity” of the subject of research.

The question thus arises: how can we understand the complexity of social systems and social phenomena? If limited possibilities for explanation, unpredictability, or low reliability of prediction are key features of complexity, then ideas drawn from complexity studies may be able to help social scientists to better understand complex social systems. This question holds a special significance in policy-oriented, normative sciences dealing with society—economics, finance, management theory, international relations, security theory, peace, and conflict studies, which aim not only at description and explanation, but also at providing guidance for action.

The need or the fashion of studying the complexity of society has brought about a tremendous wave of writings in which the authors, whether they be sociologists, political scientists, economists, mathematicians, physicists, or biologists, attempt to describe, explain and, in particular, to predict phenomena occurring in social life. There are numerous writings in the social sciences, in economics, management, and finance where the authors use such concepts as “systems theory,” “complexity,” “equilibrium or stability,” “non-equilibrium dynamics,” “the onset of turbulence,” “strange attractors,” “catastrophe theory,” “emergence,” “self-organization,” “chaos,” “fractals,” etc. The nature and character of the applications of those concepts varies tremendously, beginning with very precisely defined mathematical models and ending with analogies and metaphors, with the vast majority of the literature being dominated by the latter approaches.

At the same time, in works which are rooted in broadly defined systems thinking, for example, research using an applied systems approach, or research based on general systems theory, CAS theory, complexity studies, or even more ambitiously, “complexity science,” many authors have discovered that the concepts which they have developed when embodied in mathematical models, or even when used as analogies and metaphors, can help to encapsulate various aspects of social reality [5]. Since “complexity” is the key concept in all these discussions, it is necessary to ask the following question: “Is it possible to describe the complexity of social systems knowing that unequivocal definitions are unachievable?”

Numerous problems arise in defining terms associated with “studies of complexity,” “complex systems studies,” or the like. The author refrains from using

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1 Social system is understood herein as human system. In general sense social systems may also include other actors—animals or artificial agents.
the terms “complexity theory,” or “complexity science,” although an idea of the “emerging science of complexity” has been already proposed by Waldrop [6], the first attempts to explicitly study complexity and complex systems go back at the very least to the works of Weaver [7] (disorganized complexity and organized complexity), and includes those of Simon [8] (the architecture of complexity), and Ashby [9] (the Law of Requisite Variety). In his search for explaining the meaning of complexity, Lloyd [10] identified 45 definitions of complexity. In other writings, numerous definitions and interpretations of complexity and of its characteristics have been proposed. In particular, the following authors have been recognized as conceptual leaders in this enterprise: Prigogine and Stengers [4], Gleick [11], Gell-Mann [12], Holland [2], Kauffman [13], Bar-Yam [14], Axelrod and Cohen [3], Biggiero [15], Kwapień and Drożdż [16].

The most universal characteristics of complex systems are: large numbers of constituent elements and interactions, non-linearity of the characteristics depicting its behavior, various forms of hierarchical structure, non-decomposability, unpredictability, and self-organization. Complexity can also be characterized by a multitude of other ideas and exemplified by a variety of phenomena such as: artificial life, autopoiesis, universal bifurcation, co-evolution, emergent properties, stability at far-from-equilibrium states, fractal dimensionality and scaling behavior, power-law behavior, self-organized criticality, sensitivity to initial conditions (“butterfly effect”), spontaneous self-organization (such as stereo-specific autocatalysis), and other similar phenomena typically observed at the edge of chaos.

In some instances, complexity studies or complexity science is identified solely with CAS, which are treated as a specific case of multi-agent systems (MAS). As of the time of this writing there is no universally accepted interpretation of the term “complex adaptive systems.” Following the initial concepts of CAS [2], their most representative properties are the following: non-linearity of interactions (internal and external), emergent properties arising from simple rules of behavior for their constituent elements, self-organization, diversity of internal structure, existence at the edge of chaos, and co-evolution with other complex entities or with the environment. The above list is obviously not complete. CAS are regarded at present as an instrument of modeling of collective phenomena in all disciplines of science. Due to the possibility of creating elements of theoretically unlimited varieties of behavior, they are perceived as the most promising tool of modeling for broadly defined social phenomena and social systems.

The methods applied in complexity studies include: agent-based modeling (less commonly known as generative computer simulation), cellular automata or iterative arrays, catastrophe theory, CAS research, data mining, nonlinear dynamical systems modeling (otherwise known as “chaos theory”), fractal geometry, genetic algorithms, neural networking (otherwise known as distributed artificial intelligence), power-law scaling, scale-free network dynamics, self-organized criticality, and synergetics.

In order to identify the meaning of complexity, one must base the meaning on some particular properties of the relationships between human observers (or the observation of systems in general) and various types of observed systems. These
systems may be natural or artificial, and include social systems. Biggiero [15, pp. 3, 6] treats the predictability of the behavior of an entity as the fundamental criterion for distinguishing various kinds of complexity. In their novel solution to the problem of clustered volatility in financial economics, Ilija Zovko of the University of Amsterdam and J. Doyne Farmer of the Santa Fe Institute [17] describe the complex phenomena which they treat as an “observed behavioral regularity” which is characteristic of Farmer’s treatment of scientific laws and law-like behavior in complex systems.

To return to Biggiero, the conceptual foundation which he proposes is an interpretation of complexity as a property of objects which are neither deterministically nor stochastically predictable (Gleick describes a similar line of reasoning with respect to Stephen Smale’s work and Smale’s discovery of the properties of systems which are neither periodic nor random in their behavior). In Biggiero’s words, “Complexity refers to objects which are predictable only in a short run and that can be faced only with heuristic and not optimizing strategies” [15, p. 6]. He proposes three characteristics of complexity: (a) objects not deterministically or stochastically predictable at all; (b) objects predictable only with infinite computational capacity; (c) objects predictable only with a transcomputational capacity (beyond the Bremermann’s limit) [15, 18].

Edgar Peters [19, 20] has proposed similar definitions, with the additional typology of chaotic systems which exhibit one of two kinds of behavior, globally deterministic but locally random (such as the weather, which at one level of analysis contains global boundaries recognized as seasons, within which virtually any local variation might be observed but which many readers will also recognize as being distinguished by a global strange attractor—the Lorenz Attractor) or objects which exhibit behavior which is locally deterministic over short periods of time, but which is random or unpredictable over extended periods of time and for which no final state of the system can be predicted. Peters discusses this in terms of financial systems such as foreign exchange futures, which are anti-persistent because they have no underlying “fundamentals” (and no well-defined second moment). He has further developed a sophisticated system of autoregressive fractal integrated moving averages, ARFIMA, to more accurately replace the historical methods of ARCH (autoregressive conditional heteroskedasticity), GARCH (generalized autoregressive conditional heteroskedasticity), and I-GARCH (integrated generalized autoregressive conditional heteroskedasticity).

Peters’ approach is designed to capture a relatively low dimensional strange attractor present in the ill-behaved time series returns of financial markets [21] and resembles the moving average depth of the order book approach used by Smith, Farmer, Gillemot, and Krishnamurthy [22] in the more fully developed, long-form solution to clustered volatility in financial markets, “Statistical Theory of the Continuous Double Auction.” Examples of complex systems defined by strange attractors (closed form global systems) and chaotic attractors (open form global systems) are also discussed in mathematical detail by Ali Bulent Cambel [23]. Finally, the vast majority of the foregoing materials are comprehensively linked together in Bar-Yam’s [14] study “The Dynamics of Complex Systems.”
“Hard” and “Soft” Complexity

Systems thinking, complex systems studies, etc., can be divided into two basic streams relevant to social science research methodology. The first stream was developed through the use of mathematical modeling and can be called “hard” complexity research by way of analogy to “hard” systems thinking. “Soft” complexity research, a term also coined as the result of an analogy with “soft” systems thinking, includes qualitative concepts of complexity elaborated in other areas such as cybernetics and systems thinking, social science research, and research in psychology [24]. It is necessary to stress that soft complexity initially had two domains—(1) purely verbal considerations about complexity, and then (2) the application of ideas from “hard” complexity in qualitatively defined situations. Subjectivity or qualitative methods are the main aspect of complexity in the “soft” approach. This quality is just a consequence of the fact that complexity is not an intrinsic property of an object but rather depends on the observer.

In the social sciences, and particularly in sociology, special attention is given to the concepts of complexity in social systems proposed by a German sociologist, Niklas Luhmann. First of all, Luhmann is one of only a few authors who has attempted to elaborate a comprehensive definition of a social system based solely on communication and on the concept the autopoiesis (self-creation) of biological systems. Autopoiesis means “auto (self)-creation” (from the Greek: auto—αυτό for self- and poiesis—ποίησις for creation or production), and expresses a fundamental dialectic between structure and function. The concept of autopoiesis was introduced by Chilean biologists Umberto Maturana and Francisco Varela in the early 1970s. It was originally presented as a system description that was designed to define and explain the nature of living systems [25].

Autopoiesis also refers to self-reference and to the role of the observer. It is reflected in the assertion: “everything said is said by an observer” [25, p. xix]. Due to such a self-referential approach, the concept of autopoiesis was criticized as a form of solipsistic methodology and radical constructivism.

The concept of autopoiesis was used by Luhmann to elaborate an indigenous theory of social systems, and has become one of most popular universal social theories. He defines a social system of conscious units as an autopoietic system of meaningful communication. In this case, Autopoiesis refers not to the tangible attributes of a system but to communication [26, 27].

The theories of social systems proposed by Luhmann are broadly discussed in social science, especially in Europe. The Luhmann concept of “soft” complexity is likely its most influential interpretation in contemporary social theory. According to Luhmann, a complex system is one in which there are more possibilities than can be actualized. Complexity of operations means that the number of possible relations exceeds the capacity of the constituent elements to establish relations. It means that complexity enforces selection. The other concept of complexity is defined as a problem of observation. Now, if a system has to select its relations itself, it is difficult to foresee what relations it will select, for even if a particular selection is known, it is not possible to deduce which selections would be made [26, p. 81].
The idea of complexity promulgated by Luhmann has also been applied to defining risk in social systems. The existence of a large number of elements in a given system means that not all elements can relate to all other elements. Complexity implies a need for selectivity, and the need for selectivity means contingency, and contingency means risk [28].

The complexity of social systems developed by Luhmann is strongly linked to self-reference since the irreducibility of complexity is also a property of the system’s own self-observation, because no system can possess total self-insight. In “hard” complexity, this approach might be likened to that of Gödel’s second incompleteness theorem, which proves that no axiomatic system can demonstrate its own consistency [29]. This phenomenon is representative of the epistemology of post-modern social science, where observation and self-observation, reflexivity and self-reflexivity, and subsequently, self-reference and recursion have been playing increasing theoretical roles. According to this interpretation, social systems are self-observing, self-reflexive entities attempting to solve emergent problems through the processes of adaptation (learning).

**Social Systems as “Complexities of Complexities”**

Applications of the concept of complexity, with its multitudinous interpretations in the social sciences, are becoming even more difficult to describe and explain due to another obstacle—the vast multitude of meanings attributed to the phrase “social systems.” The basic assumption is that social systems are mental constructs of the observers (participants) as interpretations of the behavior of their components and of the entities which make up the system. In this context, the most important distinction in defining social systems lies in defining the role of the participant–observer. If she/he remains outside the system and is not able to interfere with the system’s behavior, then a physicalist approach can be applied (obviously without the need to refer to quantum mechanics and its own special observer relations). Such an approach belongs to the tradition of “first order cybernetics” in “hard” systems thinking. If the participant/observer is able to exert an impact on the system, then the consequences of reflexivity and self-reflexivity must be taken into account. Under such circumstances, “second order cybernetics” or “soft” systems thinking become the basic methods of research [30].

The complexity of social systems is more difficult to comprehend since it is always the result of an intersubjective discourse. The “hard” approach allows for the more precisely defined tangible attributes of the system to be described as measurable quantities with a “strong” ratio scale that possesses tangible characteristics. The “soft” approach makes the description much more difficult since inter-subjectivity depends on the transfer of imprecise meanings in the discourse. In both cases it is necessary to consider the limitations stemming from the reification of subjective/intersubjective categories. It may thus be concluded that if studies concentrate upon the “tangible” measurable attributes of social systems, then “hard” complexity
methods, mainly mathematical models, including simulations, can be applied. Otherwise, the discussion must also include reflexive ideas taken from “soft” complexity studies. Therefore a mixed approach is necessary—mathematical modeling and/or analogies and metaphors [31].

There is a specific set of factors which allow us to differentiate between traditionally defined systems thinking and complexity research, at least through the mid-1980s. While systems thinking sought holistic ideas and universal patterns in all kinds of systems, complexity research defined its goals in a more specific manner. A common theoretical framework, the vision of underlying unity illuminating nature and humankind, is viewed as an epistemological foundation of complexity studies [6]. This claim for unity results from an assumption that there are simple sets of mathematical rules that, when followed by a computer, give rise to extremely complicated, or rather extremely complex patterns. The world also contains many extremely complex patterns. In consequence, it can be concluded that simple rules underlie many extremely complex phenomena in the world. With the help of powerful computers, scientists can root those rules out. Subsequently, at least some rules of complex systems can be unveiled.

Two important conclusions with respect to studying social systems in particular can be drawn here. Firstly, in all discussions on the complexity of social systems composed of conscious elements, the role of the observer–participant must be taken into account, even when studies concern objectively defined complexity. This postulate does not necessarily mean radical constructivism (in which case the observer invents reality). It should simply be remembered that when the quantitative modeling of social systems is conducted, that no part of the model is absolutely objective. Second, human systems are characterized by the presence of all sources and types of complexity [15]. We might then summarize the discussion by noting that, in a universal sense, all or many collective phenomena may be complex, including, for example, animal or artificial social systems, but human systems made of conscious elements are the “complexities of complexities.”

The Linguistic Approach to the Complexity of Social Systems

All of the aforementioned barriers to the interpretations of social systems’ complexity can be analyzed with reference to linguistics. Systems thinking/complex systems studies or whatever name may be used for the subject (viz., our earlier mention of nonlinear dynamical systems modeling, general systems theory, CAS research, etc.) can be used in the social sciences as a great source for analogies and metaphors as well as mathematical models. According to this distinction, the term “(formal) models” refers solely to mathematical structures. Using a deepened approach, attention should be paid to three of Wittgenstein’s [32] “language games,” including the meaning of three utterances: (1) the meaning of social systems, (2) the meaning of complexity, and (3) the meaning of ideas in which the concepts of social systems and the concept of complexity are together applied.
Mathematical models can be applied in three areas of complexity studies: computationally based experimental mathematics; high precision measurements made across various disciplines and confirming the “universality” of various complex systems properties; and mathematical studies embodying new analytical models, theorems, and results (see, for example, [33–35]).

Models, analogies, and metaphors deriving from systems thinking and complexity studies are gaining a special significance in the social sciences. Mathematical models are associated with “objective” research. Analogies and metaphors taken from complex systems studies are related to ideas drawn from “rational” science. They are treated as “scientific” and may provide additional political influence in the discourse resulting from “sound” normative (precisely prescriptive) legitimacy in any policy-oriented debate.

In the application of complexity-based analogies and metaphors to the social sciences, the following nine approaches can be identified:

1. Descriptive
2. Explanatory
3. Predictive
4. Anticipatory
5. Normative
6. Prescriptive
7. Retrospective
8. Retrodictive (backcasting)
9. Control and Regulation

Following the distinction from traditional cybernetics and control, a regulation approach can be also proposed. In normative social sciences this approach is expressed by the way in which the dominant analogy or metaphor influences the control of a system (i.e., they differ for mechanistic, evolutionary, and learning systems).

Complexity associated with nonlinear dynamics adds some new elements to our knowledge of social dynamics. We are aware that social systems are uncontrollable, but even the desirability of such control has already been put in doubt. Self-organization is regarded as a desired pattern for the dynamics of economics and politics. The value of this proposition is reflected in Hayek’s [36] interest in the complexity of social systems as an argument against centrally planned economies.

Another lesson that nonlinear dynamics and complex systems teaches us is that social change, or in a broader sense, evolution, is produced by both deterministic historical factors and chance events that may push social phenomena to new patterns of behavior. Thanks to a better understanding of the confluence of chance and determinism in social systems, we may now have a vastly improved opportunity to learn what kind of actions we have to undertake, or even perhaps, what kind of norms we have to apply in order to reach desired social goals.

It must be also reminded that analogies and metaphors of rather loosely interpreted non-linearity, chaos, complexity, self-organization, etc., in many instances have become the backbone of the post-modernist (post-structuralist) new science.
Reaffirmation of limited predictability has become an epistemological foundation of discourse-based science. Numerous examples could be quoted here, but as an illustration, it is worth recalling the synthesis of the post-modernist ideas of Braudel and Prigogine’s concepts on far-from-equilibrium states made by Wallerstein [37, pp. 160–169] in modeling social systems, although solely at a metaphorical level.

The above epistemological links between complexity research and the social sciences are predominantly associated with “hard” complexity. However, the inputs to this area from “soft” complexity research are equally significant. The reflexive complexity of society has become one of the primary foundations of post-modernist social theory [26].

Unfortunately, various abuses and misuses of the theory may occur, particularly when eminent social theoreticians of post-modernism/post-structuralism treat analogies and metaphors drawn from “hard” complexity research carelessly, and to a lesser extent from their use of “soft” complexity research itself. Several examples of such abuses are mimicked in the so-called “Sokal Hoax” and there are other examples which have been described by the originator of that hoax [38].

In summarizing the considerations discussed above, we may conclude that the application of complex systems analogies and metaphors to the social sciences exposes two basic weaknesses of the approach. First, in most of their applications, the authors have failed to explain that these methods are useful primarily, if not entirely as purely descriptive or narrative instruments. The application of such analogies and metaphors for prediction and norm-setting is always limited by their reification. This limitation has brought about two sets of rather undesirable consequences.

First, in theoretical research, a great deal of time, energy, and money has been expended on what are inherently futile efforts to make use of these analogies and metaphors, and the research positions which they support, more “scientific,” “objective,” or “analytical.” Often this produces a non-causal literature which is filled with “objective” terms such as “stability” or “equilibrium” in the attempt to make the exposition sound more “scientific” when what has actually happened is that the author/authors have simply embedded supernumerary terms with hidden normative loading. Secondly, researchers who are limited by inclination, profession, or capacity to employing a non-quantitative analogical or metaphorical approach to complexity may seek to enhance the influence and credibility of their work by finding someone else to add some kind of quantitative data or mathematical treatment, whether that treatment is appropriate to the subject or not and whether or not it brings any additional value to the research. John Baez [39] characterizes this kind of effort as taking place along the lines of “I’m not good at math, but my theory is conceptually right, so all I need is for someone to express it in terms of equations.” Likely any researcher who has presented or chaired the presentation of a “hard” complexity application to one or more social science problems at a major research conference has been approached at one time or another to undertake this kind of work for someone who is trying to lend a more scientific flavor to their research. Rather than increasing the legitimacy of such research, the metaphorical and analogical approach, particularly when supplemented by spurious mathematical or quantitative terms drawn from the physical sciences, has frequently served to obscure or to decrease the legitimacy of the research [39–41].
In addition it should also be remembered that contrary to the approach used in physics, where axiomatization is possible, mathematical modeling in the social sciences—with the exception of the axiomatic approaches used in economics—always has its origins in operationalization. However, in such cases, the process of building operationalizable definitions begins from a “central metaphor” or “stylized fact.” This core element of the research is a qualitative idea later developed with the use of formal models, e.g. equilibrium, stability, risk, and even complexity! In such cases, the selection of the model is subjective in all possible ways—self-reflexive and self-referential (from the point of view of the modeler).

**Terrorism as Security Threat for Modern Complex Society**

**Terrorism as a Social, Political, and Military Phenomenon**

A plethora of approaches to the study of terrorism have been developed in the literature. They include sociological, psychological, anthropological, political, legal, philosophical, and military approaches to the problem. As a result of this diversity, only a brief overview of the study of terrorism is presented in this chapter. This overview is not a recapitulation of the specialized studies presented in later chapters of the book, but rather is undertaken for the purpose of allowing us to better understand the state of contemporary theories regarding terrorism as a complex social phenomenon.

It is commonly agreed that terrorism is not merely a contemporary phenomenon and that there is no universal definition of terrorism. A study by Schmid and Jongman in 1988 identified 109 definitions of terrorism. The study included a total of 22 different definitional elements. It is not possible to find a consensus in defining terrorism, since in addition to purely conceptual barriers, there are important normative (predominantly ideological), political, and legal obstacles to finding a common definition. Much of this difficulty is derived from the potentially relative character of certain cases of terrorism, which is reflected in the question “terrorists or freedom fighters?”

The needs of society, typically expressed in political, legal, economic, or military terms represent a kind of pluralist demand for dealing with the problems of terrorism [42]. This demand requires researchers at a minimum to attempt to put some order into theoretical discourse in the context of both a domestic and an international framework as a prelude to enlightened or at least more effective policymaking with respect to terrorism than we have seen to date. However, this also exacerbates tensions to the extent that on the one hand, international institutions, especially the UN and its agencies are attempting to elaborate more or less universal interpretations of terrorism, while at the nation-state level efforts are tailored to each individual nation’s political climate and institutional demands. Finally, the entire picture is further complicated by the fact that much of what is commonly characterized as terrorism is undertaken by non-state actors (NSAs) who are not easily incorporated into either type of framework (national or international).
A rank ordering of publications and websites is also useful in characterizing existing studies of various aspects of terrorism: Laqueur [43, 44], Schmid [45–47], Schmid and Jongman [48], Defining Terrorism [49], Gadek [50], White [51]. From the vast literature on terrorism, published before, and predominantly, (which is understandable) after 2001, a collection of works and the concepts contained within those works was surveyed in order to provide a background for this chapter’s analysis of the linkages between complex systems studies and the study of terrorism.

Schmid as far back as the 1980s proposed an approach basing on the terms applied in definitions of terrorism, which led to the elaboration of an “academic consensus definition,” accepted by the UN [46, pp. 39–81; 51, p. 12]: “Terrorism is an anxiety inspiring method of repeated violent action, employed by (semi) clandestine individual, group or state actors, for idiosyncratic, criminal or political reasons, whereby—in contrast to assassination—the direct targets of violence are not the main targets. The immediate human victims of violence are generally chosen randomly (targets of opportunity) or selectively (representative or symbolic targets) from a target population, and serve as message generators. Threat-and-violence-based communication processes between terrorist (organization), (imperiled) victims, and main targets are used to manipulate the main target (audience(s)), turning it into a target of terror, a target of demands, or a target of attention, depending on whether intimidation, coercion, or propaganda is primarily sought.”

Schmid has extended this definition [46, pp. 86–87; 47, pp. 158–159], by identifying 12 dimensions of terrorism. This approach may prove helpful in developing a better understanding of terrorism, but at the same time it only reaffirms our inability to elaborate a set of commonly accepted definitions of terrorism. One illustration of the difficulties involved in describing and explaining terrorism is the discrepancies between various definitions created by state institutions in the USA, such as the FBI, the Department of Defense (DoD), the Department of Homeland Security (DHS), the Central Intelligence Agency (CIA), and the US Department of State [50].

Typologies of terrorism and the analysis of terrorist behavior constitute the second unequivocal component of discourse on terrorism. It is relatively easier to identify analytical approaches to terrorism, which can be studied from five different conceptual perspectives [45]: (1) terrorism as/and crime; (2) terrorism as/and politics; (3) terrorism as/and warfare; (4) terrorism as/and communication; and (5) terrorism as/and religious/ideological/political/ fundamentalism. In addition, the sources of terrorism constitute a hierarchy—from global issues to religious fanaticism. Terrorism treated as a method of warfare is an example of asymmetric warfare, or of the net-wars/cyberwar. Although each perspective has its specificity, this survey of the applications of complexity methods for the prediction of terrorism behaviors does not separate the perspectives.

As a consequence of the absence of definitions, the elaboration of typologies of terrorism is, naturally, highly challenging. Delving into the details of each typology and explaining detailed criteria is not necessary at this point in the analysis. Instead, it can be done when discussing specific links between complexity studies and terrorism. As a point of departure from discussing the typologies of terrorism, ten bases of classification can be used to differentiate various terrorist activities [48,
These bases can be applied in producing a multitude of typologies which can be augmented by other types of groupings. Applying geographical criteria, it is necessary to distinguish between terrorism on a local, national, or transnational level. Institutional criteria define state and non-state terrorism. Economic criteria help to treat terrorism as an economic phenomenon and to consider, for example, funding of terrorism, and its economic consequences [52]. With respect to military considerations, terrorism can be an element of asymmetric or irregular warfare (the “weapon of the weak”) and in many instances can be linked to guerilla warfare [53].

There is a very specific type of terrorism, which in addition to the lack of definitional clarity, brings about political and ideological disputes. The role of the state, not only as a defender, but also in part as a supporter of terrorism and/or a performer of terrorist activities is also an issue for both theory and policymaking. Two different roles can be distinguished here: state-sponsored terrorism and state terrorism. While the former concerns the activities by proxies, the latter concerns direct involvement of state institutions. The main difference in the interpretations of these links between terrorism and the state lies between those who claim that the state may commit terrorist acts and those who deny such views referring to those definitions of terrorism acts that are committed only by no-state actors [49].

In the era of the development of Information Technologies, cyber-terrorism, a new form of terrorism has become an important threat to modern society. Taking its popular name by adding “cyber” to any social phenomena, e.g. cyber-punk, cyber-society, cyber-space, cyber-warfare, etc., shows the pervasiveness of the connections between the applications of advanced computer networks, and nearly every aspect of modern society. Cyber-terrorism is viewed as the most recent but at the same time one of most dangerous forms of terrorism. Similarly, as in the case of universal definitions of terrorism, no agreement about defining cyber-terrorism has been achieved. The most quoted definition of cyber-terrorism was proposed by Denning in 2000 [54]: “Cyber-terrorism is the convergence of terrorism and cyber-space. It is generally understood to mean unlawful attacks and threats of attack against computers, networks, and the information stored therein when done to intimidate or coerce a government or its people in furtherance of political or social objectives. Further, to qualify as cyber-terrorism, an attack should result in violence against persons or property, or at least cause enough harm to generate fear. Attacks that lead to death or bodily injury, explosions, plane crashes, water contamination, or severe economic loss would be examples. Serious attacks against critical infrastructures could be acts of cyber-terrorism, depending on their impact.”

There is another form of terrorism that is very difficult to identify and to prevent—“lone wolf terrorism.” Terrorist acts by individuals not aligned directly to any social group are particularly difficult to identifying and combat, and are even difficult to study. The key factor of the counter-terrorist response concerning locating lone wolf attacks is in knowing not who will carry out an attack (almost an impossibility) but rather in knowing how such attacks are formulated [55, p. 47].
When studying the links between complex systems studies and terrorism, it is also necessary to recall examples from the philosophical discourse on terrorism in which the ontological, epistemological, and axiological aspects of terrorism are considered in reference to individuals and society. As one of the most representative examples, the ideas of a French influential philosopher Jean Baudrillard provide an excellent foundation for study of this aspect of terrorism.

Terrorism as a subject of analysis after September 11, 2001 was present in several works of Baudrillard [56, 57] who is sometimes viewed as disputable and accused of biases and anti-Americanism. The level of analysis of terrorism proposed by Baudrillard reaches the axiological roots of the functioning of modern society referring at the same time to its systemic properties at the global and local levels. His primary ideas about the systemic consequences of terrorism refer to the internal fragility of the modern world. The more the system is globally concentrated toward ultimately constituting a single unified network, the more it becomes vulnerable to single point failure—examples of hacking and September 11, 2001 only confirm that observation [56].

**Security Theory and Terrorism**

Although terrorism has always been an important aspect of security studies (both domestic and international) it was not present in mainstream discourse until after the 9/11 attacks. In fact, the terrorist attacks of September 11, 2001 have made it one of the main focal points for the theoretical consideration of security. Both prior to and during the Cold War, when classical security theory, which focused primarily on deterrence, was developed terrorism was not analyzed as a principal component of either domestic or international security, but rather as a “specialty” subject, treated apart from the mainstream of the discourse on security theory, e.g. Schmid and Jongman [58], Laqueur [44, 59].

Contemporary discussions of the theoretical aspects of terrorism are generally conducted in the context of one of three major competing International Relations (IR) theories: realism, liberalism, or constructivism. The realist approach depicts international relations as a struggle for power among strategic, self-interested states. International order is based upon power or force projection capabilities. However, realism is not a single theory. There are two cross-cutting, dichotomous versions of realism. The first is classical realism, which came out of World War II and the failure of the 1930s legalist school of international relations, and which is uncompromising in its placing of the national interests of each sovereign nation against those of every other nation. The second, and more popular version of the theory is neorealism, which comes out of mid-1970s regime theory, which is based on the observation of the growing importance of self-organized international agreements (primarily economic, financial, educational, and technological agreements) which transcend the traditional boundaries of national self-interest [60, 61]. One might characterize these two theories as an offensively oriented version of the theory of
international politics (realism) and a defensively oriented version (neo-realism) of the same over-arching theoretical framework [62, p. 150]. Rational choice theory [63], or neo-institutionalism [64], which explains many of the phenomena discussed in neo-realism in terms of the institutional environment and institutional behavior can also be regarded as an offshoot of this group of theories. Neo-institutionalism has many elements in common with the complex systems approach to economics and economic history [64–66].

Leaving apart the differences between these two somewhat differing versions, both realist theories explain the United States’ forceful military response to the September 11 terrorist attacks, as terrorism is countered by the use of force. Commenting on those attacks, Jack Snyder [67, p. 56] argues: “Despite changing configurations of power, realists remain steadfast in stressing that policy must be based on positions of real strength, not on either empty bravado or hopeful illusions about a world without conflict.” In other words, this means that terrorist threats are clearly defined and should be always dealt with relevant resolute forces, while no other approaches should be taken into account.

Liberalism in international relations theory/security theory is derived from an assumption that international politics is not a “jungle.” Liberals see world politics as a cultivatable “garden,” which combines a state of war with the possibility of a “state of peace” [68, p. 19]. Reflecting the aims of the individual, liberal states view security not only in military terms, but also in terms of the protection and promotion of individual rights. In this approach, combating terrorism focuses far more on the application of legal instrumentalities than on the use of military force (see, for example [69]).

The third theoretical concept of security is based upon constructivist and post-modernist foundations of social science. In this case, security is understood in a broadened sense, going beyond political and military issues and is viewed as an intersubjective result of discourse. The concept of the broadened interpretation of security theory developed by the Copenhagen School takes its name from the Copenhagen Peace Research Institute, where new ideas of security were developed in the 1990s [70]. The constructivist approach not only concerns itself with a broadened interpretation of security but also seeks a deepened interpretation, which means that the individual essentially becomes a reference object. This approach gives rise to the concept of human security and embodies various aspects of life, e.g., food security, water security, and obviously, the threat of terrorism to individuals. Curiously, this broader and deeper school of thought arising out of peace studies shares a great deal of common philosophy with the Petraeus Doctrine of counter-insurgency [71, 72].

The essence of the concepts contained in the Copenhagen school’s theory of security can be summarized as follows. Security is not treated as a traditional “objective” concept referring primarily to military and political threats. Under the influence of constructivism, post-modernism, and post-structuralism, it is perceived to arise as a result of social discourse, an “act of speech”—performative utterance, and an outcome of “securitization.” In this case, security is understood in a broadened sense, going beyond political and military issues, and is viewed as an intersubjective
result of discourse. Security refers to the following sectors: military, economic, political, environmental, and societal. Following Buzan et al. [70] the concepts of existential threat and securitization are employed by this approach. Any public issue can be securitized, meaning the issue is presented as an existential threat, requiring emergency measures and justifying actions outside the normal limits of political procedure. Security is thus a self-referential practice, because it is in this practice that the issue becomes a security issue—not necessarily because a real existential threat exists, but because the issue is depicted as such a threat.

Discourse that takes the form of presenting something as an existential threat to a referent object does not by itself create securitization. It is solely a securitizing move and the issue is securitized only if and when the audience accepts it as such. Securitizations in different sectors frequently cannot be separated. Securitization studies aim to gain an increasingly precise understanding of who securitizes, on what issues (threats), for whom (referent objects), why, with what results, and under what conditions [70]. It is then evident that securitization may be influenced by various factors, including political power. Thus, security as a result of the securitization discourse about threats may be biased and prone to distortions deriving from the interests of the dominant securitizing actor.

There exists a specific link between complex systems studies and securitization, which concerns many issues beyond terrorism. Securitization is a self-reflexive idea since it includes the reflection of the observer/participant about the process of defining a threat to security. In terms of complex systems studies, it means that all securitized aspects of social life, including terrorism, can be analyzed as characteristics of modern complex society. In such case the idea of “soft” complexity emerging when conscious actors/observers face challenges of reflection, self-reflection and self-reference in studying terrorism—similar to other threats—is part of social reflection. In this sense, securitization connects to soft complexity through its epistemology.

Buzan [73], one of the founders of Copenhagen School, treats the approach to terrorism in the USA after September 11, 2001, frequently labeled as the “global war on terrorism” (GWoT), as an example of macro-securitization comparable with the Cold War. Macro-securitization in this case means that terrorism is treated as a global threat to all countries, not only to the developed Western world. The sense of macro-securitization is expressed in the statement: “The war on terror is like a new Cold War where everything is subordinated to a single purpose” 73, p. 1106.

Terrorism on a global scale is securitized according to the above pattern and is linked to a large number of other phenomena, which have previously been securitized. As examples, Buzan recalls major political declarations by NATO, the European Union, and the US Government, arguing about potential security threats resulting from the links between terrorism and organized crime, especially in drug trafficking, human trafficking including illegal labor, prostitution, and slavery as well as weapons sales, the proliferation of weapons of mass destruction (WMD), regional conflict, and state failure. In relation to the securitization of WMD, the macro-securitization includes a strong concern that not only “rogue states,” but also terrorist organizations might acquire nuclear weapons or other WMD [73, p. 1105].
The application of the idea of macro-securitization to the “Global War on Terrorism” is not only an intellectual exercise, but is also a valuable instrument for the analysis of the consequences of terrorism for modern society. In comparison to other viewpoints, such as neo-realism, it allows for a deeper explanation of the full range of the dimensions of counter-terrorism policy and its associated activities. What is especially important in the constructivist approach to security is the consideration of the possibility of an unjustified securitization, which may be used as an instrument for the implementation of extraordinary actions with negative consequences to society. The self-reflexiveness of the constructivist approach might best be characterized by the classical question “Quis custodiet ipsos custodes?” (Who guards the guardians?) One can also see another commonality with soft complexity science at this point and that is the recursive feedback loop between act of securitization and its self-conscious evaluation.

The main conclusion of the constructivist view (i.e., that the macro-securitization approach to terrorism is comparable to the ideological foundations of the Cold War) may be summarized as follows: “It thus becomes clear that terrorism poses a double threat to liberal democratic societies: open direct assaults of the type that have become all too familiar, and insidious erosion as a consequence of the countermeasures taken. It is easy to see how this dilemma drives some towards seeking a solution in total victory that will eliminate both the terrorists and the contradiction. But if it is impossible to eliminate terrorists, as is probably the case, then this drive risks the kind of permanent mobilization that inevitably corrodes liberal practices and values” [73, p. 1117].

Broadly speaking, then, the intersubjective interpretation of security proposed by the Copenhagen School gains significant ground for post-modernist, critical approaches to security theory. The main assumption of the critical studies derived from the Frankfurt School is that post-modernism and constructivism are examinations and critiques of society and culture, constructed by applying knowledge from the social sciences and the humanities. Critical security studies, by exposing the intersubjective character of security, put in doubt classical ideas such as rationality, prediction, etc. Although already visible in initial works concerning broadened security theory [70], constructivism has exerted a strong impact on the development of recent security theory, especially in Europe.

Critical terrorism studies can be then viewed as a part of critical security studies. Some ideas about terrorism presented by the critical approach were perceived as controversial, e.g., the difficulties in defining terrorism, the role of state-sponsored terrorism and state terrorism, and cultural biases in terrorism studies. From the point of view of the application of complex systems studies to research on terrorism, the main contribution of the critical approach lies in extending reflection on terrorism to the problems of culture, cognition, and perception [74, 75]. These considerations are in a natural way connected with “soft” complexity [14].

As a synthesis of approaches to terrorism as a threat to the security of contemporary society and reflecting the complexity of terrorism, we should like to introduce new tools and bring about an updated paradigm which will allow the various targeted state and NSAs to deal with terrorism more effectively. The first thing to do is
to recognize that there is a problem, and then recognize that it is a new problem and it calls compellingly for a new kind of solution. To that end we must be prepared to rename and re-man some of our traditional institutions. However, this kind of activity has to be driven by market pull (that is it must already have the support of the general populace, and not just from Congressmen and Congresswomen, Senators, and present and past high level officials). We suggest that this modern, multi-faceted organization should focus exclusively on terrorists and terrorist activity, in order that institutional memory is preserved intact, and to provide for an orderly succession of DCI’s and DNI’s.

With respect to the change in linguistic paradigm, we shall refer to the complex problems of terrorism in a complex global society as the “New Security Dilemma.” That name, hopefully indicates to the reader some of the self-reflexivity which characterizes the new discipline. Similarly the new nomenclature should be a semiotic indicator that the problems and the levels of analysis reflect the shifting of the focus in the discipline from state security to security of other reference objects, including individuals, thus creating a security theory, with the important caveat that classical realism can still provide a new approach to terrorism. Following Cerny [76, p. 30]: “In this environment, civil wars, ethnic wars, cross-border wars, warlordism, terrorism, and the like must be addressed not as military questions but rather as social, economic, and political ones. What is needed is not so much a war on terror as a political, economic, and social war on the causes of terror—uneven development, inequality, injustice, and, perhaps most importantly, the incredible frustrations engendered by the revolution of rising expectations in a globalizing world.”

Systemic Interpretation of Terrorism in Modern Complex Society

Terrorism can be viewed as an example of collective behavior and the communication of a group of people operating in a broader social environment. Therefore terrorism may be viewed as a subsystem of variously defined social systems. It is also evident that terrorism is a complex phenomenon and the term complexity applied together with terrorism may have all meanings, beginning from a broadly interpreted metaphor to more rigorous understandings. When searching for the links between complexity studies and terrorism it is necessary to ask the following questions:

1. How can terrorism treated as a collective behavior be defined in systemic terms?
2. What are the specific features of modern society which make it more vulnerable to terrorism than the traditional societies of the past?
3. What are the new forms of terrorism, which are particularly able to affect contemporary complex society?
4. What might be the negative consequences of countermeasures addressing this type of terrorism?
Partial answers to these questions may be found in various other discussions about the “old” and the “new” terrorism and in other attempts at periodizing terrorism. Rapoport [77] presented first periodization, distinguishing four waves of terrorism (anarchist, nationalist, 1960s leftist, and the current religious wave). Each wave had a precipitating event, lasted about 40 years before receding, and, with some overlap, faded as another wave rose to take center stage.

This typology was supplemented by the fifth wave identified by Kaplan [78]. The fifth wave of terrorism is characterized by the existence of groups that began on an international wave but which for some reason (clearly these are organizations which have turned inward), cut ties to their international benefactors or ideological/religious bedfellows, and sought to realize a utopian vision of a radically perfected society on the local level. The goal of such groups is the creation of a new man and a new woman comprising an ethnicity or tribal society that is the reconstitution of a lost “Golden Age” model or an entirely new world in a single generation. There have been such movements emerging from the various waves of Rapoport’s theory, and they share a sufficient zeitgeist to constitute a kind of wave of their own. From 11 features of the 5th wave, the ideology of creating new men and women, self-isolation from other terrorist organizations, and excessive violence against women seem most specific [78, p. 13].

The impact of terrorism on modern complex society can be better captured with the idea of “new” terrorism partly relating to the above periodizations. The divide between the “old” and the “new” terrorism, proposed initially in the 1990s, is broadly discussed and contested in theoretical arguments drawing largely upon history. The separation between both types of terrorism should be distinguishable by clear criteria of their division, rather like Hegelian Thesis (Greek θέσις) and Antithesis (Greek ντίθεσις) and, obviously, this is not what has been observed. Several marks of distinction or discontinuity have been proposed by a number of scholars but nothing has yet really come out of this effort. According to Laqueur [79, p. 4], the new terrorism is characterized by a greater accessibility to WMD and unchanged human nature. This kind of terrorism can also be depicted using alternative features proposed by a number of other authors [49, pp. 80–87].

The compilation of the key features of the new terrorism, which is obviously not complete, includes the following features. First, the new terrorism is conducted with, or with the threat of, WMD—chemical, biological, radiological, or nuclear (CBRN). Second, the lethality and indiscriminate nature of the current attacks is rising. The violence used by terrorists in the past is seen as a rational with a discriminating selection of targets in order to send a message to their opponents as well as to their constituents. Third, in contrast to the old secular terrorism, the new terrorism is often religiously inspired. The prospect of seeing WMD employed by religious fanatics only adds an extra level of threat to modern terrorism. Fourth, the network structure of the organization defines much of its behavior [80–82], and is the most specific feature attributable to the new terrorism. In contrast to previous generations of terrorists and guerillas, the new organizations generally do not have a clear, hierarchal organizational structure with an ideological, strategic, and tactical leadership. Such loose network structures make the terrorist groups difficult to...
detect and infiltrate. Similarly, as in other areas of the economy and social life, such a “networkization” is a result of development of the Internet, which provides access to terrorist methods, weapon fabrication, and like-minded individuals with whom ideology and operational information can be exchanged in an anonymous setting, which has become a specific battlefield between all those who try to hide and those who track them.

According to the previously referenced study [49], related to the fourth feature is a lack of state sponsorship that the new terrorism seems to have. The new terrorists provide themselves with funds through a variety of criminal means, such as smuggling weapons or drug trading and trafficking. In addition, the new terrorists are for the most part amateurs who operate on a peculiar part-time basis [34, 35]. They are often living normal lives in the societies against which they are fighting.

This collection can be supplemented with other characteristics proposed by Banks et al. [83, pp. 17–18]. Incidentally, the set of characteristics for modern terrorism exhibits virtually no overlap, so it perfectly reflects the existing discrepancies which characterize the discussions of terrorism which we previously reviewed. Maintaining the continuity of enumeration, the fifth characteristic of terrorism is international, or even transnational, that is, which has been enabled by the development of the media.

Attacks against political, historic, and cultural symbols can be treated as the sixth attribute of the new terrorism. Finally, contemporary terrorism is increasing due to the development of various modern media, beginning from the classical and ending with the Internet [84]. As observed by Nacos [85, p. 10], the “act of terrorism is in reality an act of communication.” On the one hand, commercial media terrorist attacks are the “breaking news” to increase their audience, but at the same time, terrorists know that the modern media constitute a kind of “proxy” weapon.

The above typologies constitute a point of departure for the search of “complexity-era” terrorism. However, they also avoid directly addressing the increasing vulnerability of contemporary society. Only by examining both aspects of the problem (i.e., by addressing changing patterns of terrorist ideology, instruments (weaponry), methods and communications and then examining their impact on specific new characteristics of modern society, including electrical power grids, transportation infrastructure, internet commerce, and medical treatment centers, all of which can be exploited as vulnerabilities by both the “old” and the “new” terrorism, can a more comprehensive picture of terrorism in the “complex society” be accurately elaborated. It must be remarked, however, that those new characteristics are not only vulnerabilities, but have a dual character and may constitute advantages in counter-terrorist activities, for example the development of Internet has completely changed the nature of open source intelligence.

The threat of terrorism in a modern complex society can be treated as one of the attributes of a “risk society” as depicted by Anthony Giddens [86] and Ulrich Beck [87–89]. A risk society develops or emerges as a consequence of changes in contemporary society on a global scale, which, for the most part, can be summarized with a single word—“modernization.” One of the causes of the risk is the interdependency between major elements of the global system. The modern complex world
provides better living conditions for the average citizen, who in two generations typically has products and services which were inconceivably costly or else simply “inconceivable” in his/her grandparents’ day. However, this kind of rapid growth simultaneously creates risks and vulnerabilities resulting from complexity and the unreliability of the technology as well as emergent factors which may negatively impact basic social structures (manufactured risk). As Beck [89, p. 8] puts it: “A core contradiction in contemporary society is the fact that advanced modernity, with the aid of its scientific instruments and its mass mediated communication, is forced to accord the priority to the mega-threats it itself has generated, although it is clear that it lacks the necessary concepts to observe or impute, let alone ‘manage,’ them adequately—at any rate, not as long as the institutional status quo is absolutized and held constant in an ahistorical manner.”

In addition to the above core paradox of the “risk society,” one dominant feature of modernity reflexivity means that as a society examines itself, it in turn changes itself in the process [26, 28, 90, 91]. In Beck’s [89, p. 11] interpretation, the risk is also a reflexive phenomenon. It directly leads to reference to social autopoiesis and makes “soft” complexity studies the fundamental method of studying the risk of social systems. The interpretation of risk shown below only strengthens the argument that ideas developed within complex systems research are the only instruments capable of helping to understand the deepest meaning of terrorism.

Focusing on the place of terrorism in the “risk society,” Beck [89, p. 15] describes the paradoxes of terrorist activities. Contrary to economic and environmental crises, which can be understood as side effects of radicalized modernization, terrorist activities must be understood as intentional catastrophes. More precisely, they conform to the principle of the intentional triggering of unintentional side effects. The principle of deliberately exploiting the manifest vulnerability of modern civil society replaces the principle of chance and accident. What is striking is how the global anticipation of terrorist attacks is ultimately “manufactured” in an involuntary interaction with the power of the Western mass media, Western politics, and the Western military. To put it pointedly, the belief in “global terrorism” springs from an unintended self-endangerment of modern Western society.

Terrorism in modern risk society brings about another paradox often exposed in theory and policymaking discussions as an argument against too far-reaching counter-terrorism activities. Beck [92, p. 330] puts it as follows: “… in order to protect their populations from the danger of terrorism, states increasingly limit civil rights and liberties, with the result that in the end the open, free society may be abolished, but the terrorist threat is by no means averted. The dark irony here is that, while very general, risk-induced doubts on the part of average citizens regarding the alleged benevolence of the promises of governments to protect them leads to criticisms of the inefficiency of scholarly and state authorities, critics are blind to the possibilities of erecting (or expanding) the authoritarian state on this very inefficiency.”

There may be different descriptions of the characteristics of contemporary society which make it simultaneously more vulnerable and more resilient to terrorism. An example of a typology of such characteristics is given in Table 2.1. Due to the
Reflexivity and self-reflexivity, the core ideas of “soft” complexity, bring about a consideration of the meta-role of reflections about terrorism. It is evident that the secrecy of terrorist organizations and the secrecy of counter-terrorist activities are

**Table 2.1 Systemic characteristics of complex contemporary society facilitating/hampering terrorist activities**

<table>
<thead>
<tr>
<th>Attribute of modern society</th>
<th>Perceived as a vulnerability</th>
<th>Perceived as advantage in protecting against terrorism</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reliance on modern sophisticated technology—high speed trains, air transportation, energy supply, biotechnology</td>
<td>Modern technologies in all areas of life (non-IT-based control systems) are becoming more sophisticated and vulnerable, e.g. high speed trains, air transportation, energy supply, threats of use of biological weapons</td>
<td>Modern technologies of that category can be used for protection against terrorism, e.g. more advanced methods of tracking terrorists traffic</td>
</tr>
<tr>
<td>Reliance on IT technology in private and professional life, predominantly the systems of control (non-communication technology)</td>
<td>Systems of control dependent upon sophisticated and subsequently more complex devices, which can become more exposed to targeted attacks (cyber-terrorism)</td>
<td>Sophisticated systems of control can become more reliable due to multiple-level (loop) protection mechanisms</td>
</tr>
<tr>
<td>Development of monitoring technologies, including data gathering, storing, and tracking</td>
<td>Possibility of hacking and destroying the systems (cyber-terrorism)</td>
<td>Facilitation in identification of terrorist activities</td>
</tr>
<tr>
<td>Development of communication technology—traditional and the Internet</td>
<td>Possibility of clandestine communication and networking (cyber-terrorism)</td>
<td>Possibility to transfer information and track communication</td>
</tr>
<tr>
<td>Expansion of the media, including the Internet</td>
<td>Media as the means of communication is one of most important facets of terrorism</td>
<td>Publicizing acts of terrorism may contribute to negative perception of terrorist acts</td>
</tr>
<tr>
<td>Increased standards of living and changing patterns of behavior leading to more openness and trust in interpersonal relations</td>
<td>This feature of modern developed societies has been significantly damaged by terrorist attacks in the 1990s and especially after September 11, 2001. An example—changing patterns of social behavior in the USA</td>
<td>In an open society of people trusting each other, suspicious behavior can be more easily identified</td>
</tr>
<tr>
<td>Radical religious inspiration</td>
<td>Increased determination of terrorists and possibility of manipulation</td>
<td>Facilitates disclosure if publicly demonstrated</td>
</tr>
<tr>
<td>Increasing individualization and changes (weakening) of traditional social ties—family, friends, acquaintances</td>
<td>Facilitates activities of clandestine organizations as well as rise of the “lone wolf” terrorists—ideologically/religiously motivated and/or mentally imbalanced individuals</td>
<td>Weakening social coherence makes less plausible and more difficult terrorist activities of groups united by ideology and political goals</td>
</tr>
</tbody>
</table>

**Source:** Author’s personal research

specificity of cyber-terrorism’s characteristics (which can only be associated with that form of terrorism) cyber-terrorism is herein treated very cursorily.
their most fundamental attributes. Therefore, a question should be asked: what is the role of scientific publications in which terrorism is described and analyzed? What if such publications are aimed at improving the knowledge of terrorism, including the amelioration of the methods for identifying and combating terrorist? Last, but not least, if one of the aims of this chapter, and of the entire volume, is to deepen the understanding of terrorism with the assistance of complex systems concepts, in such cases, will those publications serve present and future generations of terrorists as a source of information about the actions of their enemies? If such publications are an element of deception, a question that arises is who is to be deceived—society as a whole, policymakers, or terrorists? It can be easily seen that the arguments above lead to multiple levels of hierarchical considerations about knowledge, and common knowledge (in the sense used in game theory, in the theory of communications, and in modern linguistic philosophy).2

This example is just a preliminarily look at how the clandestine character of terrorism and counter-terrorism action reminds one of the roles of reflexivity, self-reflexivity, and self-reference in public discourse on terrorism-related issues. Reflexivity and self-reflexivity have been always inherent attributes of social systems but at present, due to the development of science and technology allowing for higher self-awareness, they are regarded as representative features of modern complex society [26, 90].

The Role of Complex Systems in Understanding, Preventing, and Combating Terrorism

Due to the intricate character of terrorism as a sociopolitical phenomenon, it has become natural that in addition to modern technology, the social sciences and psychology have been applied to studying and combating terrorism. As described by Weinberger in [95], in a Wired article with the very thought provoking title, “Can Social Scientists Win the War On Terrorism?,” the possibilities that can be achieved in that area, thanks to computational social science (as complexity-based models are called in that article), would significantly enhance the capability of predicting who might join a terrorist or insurgent group.

It seems only natural that, as in other domains of social life, terrorism itself and the activities connected with it are attracting the attention of researchers in complex systems. Since terrorism is part of society seen as the “complexity of complexities,” it is natural that approaches relating to the utterance of “complexity” have become common in the theoretical considerations of terrorism and in the context of counter-terrorist policymaking. Terrorism as a complex phenomenon can be also be seen as

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2 The concept of common knowledge was proposed by Lewis [93]. In an interaction of two agents A and B common knowledge exists when A knows that B knows and B knows that A knows that B knows … ad infinitum. It can be extended to n agents. A similar idea was used by Schelling [94] in the Department Store Problem.
a “wicked problem” characterized, among other things, by the absence of a single definition, by a multitude of different and sometimes contradictory approaches, dependent upon unique conditions, as well as having solutions which may be characterized by very grave consequences [96, pp. 4–6; 97].

By applying our earlier consideration of complex systems as a point of departure which avoids the superficial discourse in which terrorism, systems, and complexity are applied as bywords, if not buzzwords, it is possible to enumerate what are and what could be the applications of ideas drawn from modern complex systems studies to better understand and combat terrorism. The characterization of all of the features of terrorism which demand the application of systems thinking exceeds the scope of this study. Herein a kind of analogy with the application of systems thinking in management and international relations results (security studies) can be obtained by showing only the characteristics of terrorism that can be analyzed with the use of ideas drawn from complex systems studies as broadly defined.

As we mentioned earlier, in the application of complex systems mathematical models, analogies and metaphors in the social sciences, and subsequently to all of the various kind of studies of terrorism and in the study of all counter-terrorism activities, the following approaches can be identified: descriptive, explanatory, predictive, anticipatory, normative, prescriptive, retrospective, retrodictive (backcasting), control, and regulation.

In particular, the following aspects of terrorism are and should be a subject of interest to complex systems studies:

– The identification of the sociopolitical context of terrorism,
– The understanding of terrorism as a sociopolitical phenomenon,
– The identification of threats of terrorism,
– The explanation of the causes of terrorism,
– The possible responses to terrorism,
– The prevention of terrorism,
– The range of possible incident responses,
– Terrorism and social communication,
– The media and terrorism,
– The government and terrorism,
– The relationship between law enforcement and terrorism,
– Military responses to terrorism.

First and foremost, systems thinking, including complex systems studies, can be applied to gain a better understanding of terrorism as a sociopolitical phenomenon with all its psychological, historical, cultural, economic, and even philosophical factors. For these and other, similar relationships (e.g., the media and terrorism, politics and terrorism, law enforcement, etc.) the “soft” complexity studies seem to be more applicable, although mathematical models can be applied as well. For example, the study of terrorism by Grant [98] using the concepts of “soft” complexity developed by Luhmann [26, 27, 91] can be analyzed as a case of this type. Grant’s study stems from assumptions about the self-referential qualities of the system and strives for a reduction of complexity in the system as it seeks to reduce dependence on uncertain communications.
In Grant’s study, the complex communications between two complex social systems—terrorist organizations and counter-terrorist institutions—are scrutinized. Here two different types of systems, on the one hand, a fluid network which characterizes the terrorist organization, and on the other hand, the more hierarchically structured counter-terrorist institutions are communicating both directly and indirectly. In consequence, as the level of uncertainty is increased, so too does the level of complexity increase.

In a simplified way, this study can be used as an example which shows that the “soft” complexity approach to terrorism may not be directly useful for building models but rather, for making the language of the description and analysis of terrorism more sophisticated. It may help us to better understand terrorism, but it also gives us the grounds on which to build more advanced mathematical models (“hard” complexity) and allows for deepened heuristic interpretations of the results of mathematical modeling.

While general explanations are necessary for a better understanding of terrorism, and subsequently for the more efficient prevention of terrorism as well as for the more effective combating of terrorism, it is the mathematical models of CAS research, or “hard complexity,” that are expected to be of practical use in counter-terrorism activities. In such cases, the models described in the remainder of this chapter are primarily designed for enhancing predictive capabilities in identifying, preventing, and combating terrorist activities.

Applications of Complex Systems Models to Counter-Terrorism Activities: Complexity and Prediction—The Key Issues in Dealing with Terrorism

Our expectations of complex systems studies with respect to the theories of terrorism and related policymaking are similar to those in other areas of security policy. First, the elaboration of the theoretical foundations of terrorism should allow for a better understanding of terrorism as a sociopolitical phenomenon. Second, the applications of complexity science to the identification and prediction/anticipation of terrorist threats should assist in combating terrorism. Strategic surprise and prediction/anticipation are key issues in all security-oriented studies, but in the case of terrorism, they acquire a special weight since unexpected targets, methods, and time constitute the basic ingredients of terrorist attacks. As Sandler and Enders [99, p. 288] put it: “By making their acts appear random and dispersed, terrorists seek to cause anxiety to the widest possible audience.” It may be concluded then, that the key elements of preventing and combating terrorism are vulnerability, surprise, and subsequently, prediction, prevention, and anticipation (pre-emption).

The question concerning the function of terrorist organizations and the occurrence of terrorist attacks is whether they are purely random or whether there are any regular patterns underlying them. The answer is relatively simple. Terrorism, like other social phenomena, demonstrates both random and non-random characteristics,
and the only real techniques available for analyzing the latter are the models taken from complex systems studies—assuming that a sufficient amount of good quality data is available for building the models.

Similar to other social phenomena, especially in the normative sciences, expectations of an enhanced level of predictability in dealing with terrorism can be achieved, thanks to the application of complex systems models. However, there is then a new question which arises. If unpredictability, or a low reliability of prediction is the key feature of complex social phenomena, which ideas drawn from complexity studies can help the social sciences better understand the nature of prediction and of its limitations in such a context [100]? This question is of special significance for policy-oriented sciences dealing with social phenomena—economics, management, finance, and security studies—which aim not only at description and explanation, but also at providing guidance for action. In those areas, prediction is the one of main objectives of research.

The question of the limits of prediction has an additional significance in the application of complexity models in the social sciences in “generative social science” [101]. Undoubtedly, models drawn from “hard” complexity studies are helpful in prediction and policymaking but they are also prone to suffer from the general limits of the prediction of social phenomena. It thus becomes a matter of some debate as to the extent to which they can actually diminish the inherent structural impact of those limitations.

All social sciences are bounded by three limitations of prediction. The first stems from the very “objective” character of external reality, number of elements, their interactions, decomposition, fundamental limits of probability theory, and of mathematics in general, (computability, intractability), etc. The second results from limitations of human cognition—we frequently do not know what we do not know. The third derives from the political, cultural, and even the ethical constraints which shape social discourse on future events. In some cases, one may even consider “politically correct” [102] limitations on discourse as the worst-case scenario.

As a matter of fact, all of these barriers overlap and they are all composed of more elementary factors. The latter two barriers are the result of a mixture of psychological and sociocultural constraints. In any social and economic/financial prediction, a special challenge is also associated with “unthinkable” events—“the unknown unknowns.” Without delving into an ontological discussion regarding the extent of possible futures and future states of prediction, the barriers to prediction for the behavior of social systems can be reduced to two interrelated groups—epistemological limits at the level of the individuals (observers and actors) and social limits resulting from interactions of those individuals.

**Epistemological Limits**

- Limits resulting from constructivism and post-modernism (inter-subjectivity),
- Limits deriving from non-linearity as a distinctive facet of complex systems,
– The fundamental limits of mathematical models, which in some cases, e.g. non-linearity and indeterminism, computational complexity, and computational (i.e., algorithmic) intractability, can be treated as an ontological limit. In essence, we are not only dealing with the limits of cognition, but we are now also limited by the very structure of nature,
– The subjectivity of our definitions of risk/threat/hazard, etc.,
– The limits to our abilities in identification (taxonomy and typology)
– The logical deficiencies of our methods (i.e., the fallacy of observing the consequent)
– Limitations with respect to our understanding of and ability to communicate about risk, (motivated bias)
– The inherent cognitive limits of the observer—limited physiological capability to identify and process variables (information) depicting the phenomenon (phenomena) under scrutiny; these limits are also the causes of “bounded rationality” [103], framing, and prospect theory [104], all cognitive distortions which affect our reasoning.

Sociopolitical Limits

– The sociopolitical consequences of complexity of social systems,
– Sociopolitical pressures (external pressure, conformism, political correctness),
– Sociocultural factors—cultural bias in prediction and anticipation,
– The inherent limits of subjectivity and inter-subjectivity exposed in post-modernist and constructivist approaches, e.g. definitions of meaning, deficiencies in transfer (negotiation) of meaning,
– Uneven access to information, including secrecy (such a situation corresponds with asymmetry of information in economics). 

Since terrorism-oriented theory and policy are predominantly based upon mathematical modeling—“hard complexity”—it is worthwhile to remind the reader of some of the basic limitations on the applications of those models in predicting social phenomena.

The epistemological and social obstacles of prediction in social sciences have already been mentioned. The inherent limits of mathematical modeling go to the very foundations of probability theory and of mathematics, in general, described with reference to the works by Kolmogorov [105] and Chaitin [106]—descriptive complexity, Solomonoff–Kolmogorov complexity, Kolmogorov–Chaitin complexity, stochastic complexity, algorithmic entropy, or program-size complexity—and Wolfram [107] (Computational Irreducibility). Those barriers result from attempts to provide an explanation to the observation made by Kolmogorov: “…the epistemological value of probability theory is based on the fact that chance phenomena, considered collectively and on a grand scale, create a non-random regularity.” Quoting and commenting on this statement, Mandelbrot and Hudson [108, p. 30] add that: “sometimes this regularity can be direct and awesome, at other times strange and wild.”
Bearing in mind the above and other limitations of the prediction of social phenomena, it must be emphasized that the models based upon complexity studies and related to terrorism, which are presented in the remainder of this chapter are treated twofold. First, they allow for prediction, directly and indirectly, by showing observed behavioral regularities in the phenomena under study. Those regularities may not necessarily occur in reality, so prediction is a rather heuristic exercise. Second, awareness of the limitations of predictability of phenomena reflected in those models also, paradoxically, allow for better predictions—it is now known what will not happen.

The application of complex systems ideas to studying terrorism and counter-terrorism can be employed at several different levels, beginning with broad speculation and ending with specific technical considerations. In this enterprise there are three areas of prediction that need to be taken into account:

– Prediction in preventing terrorism, allowing for the elimination of its fundamental political, social, and economic causes;
– Prediction in combating terrorism (the prevention of terrorist attacks, and prediction and pre-emption in counter-terrorist operations);
– The identification of the vulnerabilities of modern complex socioeconomic-political-systems.

At the highest level of generality, complexity-related considerations do not provide any special insights into the possibilities of prediction in the study of terrorism. Rather, they aim to explain terrorism as a sociopolitical phenomenon as was presented in the earlier part of this chapter. At this level of analysis, the limitations of prediction do not play much of an important role. For example, take the case of Russell Ackoff, one of the founders of modern systems thinking. For Ackoff, the systems approach is a vital necessity for combating terrorism at all levels of the societal hierarchy, although he links the emergence of terrorism to the unequal distribution of wealth all over the world. If such injustices could be eliminated through the applications of a systems approach, then the causes of terrorist attacks would be, to a large extent, eliminated [109].

As we saw in the previous chapter, in considering generalized models of terrorism and complex systems, Fellman and Wright [110, p. 3] emphasize two approaches. In the first case, they argue that when trying to predict the trajectory of something, you have to understand all of the details and keep track of every little thing. This is like solving terrorism by the application of surveillance and physical security measures. It is fundamentally impossible to do it well, particularly when it involves a large number of independent actors, each of which is difficult to predict. The second approach is founded upon a more universal assumption. While interpreting terrorism as a complex phenomenon state in terms of formal properties of the system, terrorist behavior falls somewhere between the purely chaotic and the fully deterministic realms, which can be represented as a non-linear dynamical system, characterized by a low-order chaotic attractor. Therefore, the greatest room for improving the performance of organizations tasked with preventing or combating terrorism is at the mid-range level. Not at the level of state leadership, and not at the
level of mapping and predicting the behavior of each individual terrorist, but rather
at an intermediate or organizational level—“action at the mid-range.”

**Complex Systems and Terrorism: Typology of Models**

The following presentation of mathematical models is elaborated for the prediction
of various aspects of terrorism. A detailed explanation of complex systems and their
dynamics would require a book-sized study. However, we can review the kinds of
models and concepts which would go into that typology:

– Forecasting based on statistical methods,
– Exploratory data mining,
– Game theory (simple models and evolutionary game theory)
– Strategic thinking,
– Application of CAS,
– Network models,
– Power-law models and distributional patterns in terrorist attacks,
– Models of collective phenomena directly and indirectly related to complex sys-
tems, e.g. statistical thermodynamics, etc.

The above typology requires some clarification. First, although game theory and
statistical models are not directly assigned to the category “complex systems mod-
els,” they are included in the survey since many of them constitute either the point
of departure for more advanced modeling or are applied in complexity-based
models. Game theory as a method of modeling interactive decisions is an adequate
method of studying interdependent decisions in CAS models and/or in networks.
Second, applications of CAS include networks, but not all network models can be
treated as directly related to CAS. Therefore two of the typological categories par-
tially overlap one another.

Table 2.2 includes representative models for the aforementioned categories. The
typology can be treated as an introduction to the detailed presentations of the mod-
els and should help provide a better understanding of the meaning of complexity of
terrorism and its theoretical and practical consequences.

**Conclusion**

The above survey draws several conclusions arising from the application of com-
plex systems models to theory and policy concerning terrorism. Deeper insights that
stem from the application of complex systems concepts in studying terrorism result
from a better understanding of the dynamics of social phenomena. This improved
understanding is achieved when those concepts are applied as mathematical mod-
els, analogies, and metaphors. Two particular achievements resulting from the
application of complex systems research to the study of terrorism are especially noteworthy. First, complexity-related ideas, both “soft” and “hard,” allow for a profound understanding of terrorism as a sociopolitical phenomenon. Secondly, thanks to complex systems models of advanced description and the use of tools like social network theory, agent-based modeling, general systems theory, nonlinear dynamical systems modeling, and NK-Boolean dynamic fitness landscapes; new causal links have been discovered, allowing for the exploration of otherwise concealed phenomena, which has directly improved the ability to describe and predict of terrorist activities ranging from bio-terrorism and maritime piracy to irregular warfare and ethnic violence.

Complexity models show that stable regularities in observed social, economic, and political phenomena do not really exist. So the usefulness of those models for prediction is twofold. Firstly, they help in capturing the subtleties of the phenomena under study—thus, in some way, enhancing predictive capabilities. Secondly, complexity models are helpful in disclosing new limitations of prediction. In consequence, this leads us to better predictions—we now know with far greater clarity what is, and what is not predictable. This change in the way in which we approach the problem of prediction can further assist us in the efficient use of resources by showing us what kinds of problems are amenable to the efforts we wish to make and

Table 2.2 Typology of complex systems models applied in terrorism studies

<table>
<thead>
<tr>
<th>Type of models</th>
<th>Selected example works</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forecasting based on statistical methods—identification of patterns in time series</td>
<td>Sandler and Enders [99]</td>
</tr>
<tr>
<td>Predictive data mining</td>
<td>Jonas and Harper [111]</td>
</tr>
<tr>
<td>“Big data”</td>
<td>Page [112]</td>
</tr>
<tr>
<td>Game theory (simple models and evolutionary game theory)</td>
<td>Arce and Sandler [113], Bueno de Mesquita [114], Enders and Sandler [115]</td>
</tr>
<tr>
<td>Strategic management thinking</td>
<td>Fellman and Strathern [116]</td>
</tr>
<tr>
<td>Terrorism as complex adaptive system</td>
<td>Elliott and Kiel [117], Ahmed et al. [118], Bousquet [119]</td>
</tr>
<tr>
<td>Terrorism, complex adaptive systems, multi-agent based models, networks</td>
<td>ISAAC (Irreducible Semi-Autonomous Adaptive Combat) [120]; Enhanced ISAAC Neural Simulation Tool (EINSTein); SOTCAC (Self-Organized Terrorist and Counter-terrorist Adaptive Co-evolutions)—in Ilachinski [121–123]</td>
</tr>
<tr>
<td>Networks models (social networks analysis [SNA]) and complex networks</td>
<td>Krebs [124, 125], Fellman and Wright [110, 126], Fellman and Strathern [116], Fellman et al. [81], Sageman [127], Bohannon [128]</td>
</tr>
<tr>
<td>Power-law and patterns of occurrence of terrorist attacks</td>
<td>Cederman [129], Clauset and Young [130], Johnson et al. [131, 132], Piepers [133], Clauset and Wiegel [134], Clauset et al. [135], Zhu et al. [136], Clauset and Gleditsch [137]</td>
</tr>
<tr>
<td>Models of collective phenomena—statistical physics (percolation, Ising model)</td>
<td>Galam [138–140], Zhu et al. [136], August et al. [141]</td>
</tr>
</tbody>
</table>

Source: Author’s personal research
which problems might be better left for the future. In this fashion we may better
direct the utilization of manpower, capital, and information so as not to unnecessar-
ily drain our capabilities in a futile attempt to solve impossible problems or in a time
and resource consuming effort which is bound to yield only very modest results. All
of these topics will be discussed in detail, along with their models and their empiri-
cal context in the chapters which follow.

A final aspect of the new insights which CAS can provide is the study of the emer-
gent properties of social, economic, and political systems. On the one hand, complex-
ity science allows for more reality-relevant mathematical models, which can illustrate
the specific characteristics of “emergent properties,” thus enhancing analysis and pre-
diction and allowing us to “expect the unexpected” in a precise, scientifically defined
fashion. Even where these models do not directly enhance predictive capabilities they
may in many instances provide unexpected, counter-intuitive, heuristically valuable
solutions. We shall see several examples of this type of behavior in the latter portion
of the book where Dr. Bar-Yam has applied such models to regional and ethnic vio-
lence as well as to a novel and extremely powerful explanation of the “Arab Spring”
and the current fluid political situation in the Middle East.

A less immediately evident direction for the development of the applications of
complex systems ideas in theoretical and applied considerations for policymaking
arises out of qualitative or “soft” complexity ideas. The value of these new inputs is
especially visible when reflexivity and self-reflexivity must be taken into account in
order to understand the behavior of the parts of the system involved in terrorism and
thus can be very useful in formulating counter-terrorism activities. One conclusion
which this line of research leads us to is that sophisticated mathematical models of
terrorism should embody the roles of cognition, reflexivity, and self-reflexivity
somewhere within their structure. Later in this book, we will see specific examples
of this kind of functioning in the mathematical models developed by Fellman et al.,
Ezell and Parnell. It must be added that the incorporation of such reflexivity is not
limited to the study of terrorism alone, but refers to all manner of studies of modern,
complex society.

As a result of the foregoing discourse, it seems that for the future of research in
terrorism, more attention should be given to the epistemological foundations and
qualitative interpretations of complexity than has been done in the past. This atten-
tion will help in developing a broader comprehension of the context in which the
applications of complexity-based mathematical models take place. Further, it may
be added that a synthesis of “hard” complexity with “soft” complexity could become
a new instrument of better understanding terrorism, prediction of terrorist activities
and counter-terrorism.

The final argument for developing a qualitative–quantitative methodology for
complexity-based modeling in terrorism studies stems from the increasing signifi-
cance of the need to understand the consequences of the cognitive processes of the
actors involved. Modern complex systems modeling, especially CAS Research,
allows for more advanced investigations into the cognitive processes of agents—
whether they be terrorists or policymakers. What remains unknown is how the pat-
terns of collective behavior are influenced or determined by the cognitive processes
of the agents, i.e., how individual learning determines collective learning and what kind of behavior may emerge from that learning. A mixed approach, based upon a quantitative–qualitative complexity methodology offers substantial promise for future developments in this area of inquiry.

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