
Containing Terrorism: A Dynamic Model

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Containing Terrorism: A Dynamic Model

Abstract

The strategic interplay between counterterror measures and terror activity is complex. Herein, we propose a dynamic model to depict this interaction. The model generates stylized prognoses: (i) under conditions of inefficient counterterror measures, terror groups enjoy longer period of activity but only if recruitment into terror groups remains low; high recruitment shortens the period of terror activity (ii) highly efficient counterterror measures effectively contain terror activity, but only if recruitment remains low. Thus, highly efficient counterterror measures can effectively contain terrorism if recruitment remains restrained. We conclude that the trajectory of the dynamics between counterterror measures and terror activity is heavily altered by recruitment.

Introduction

Can highly efficient counterterror measures curb terrorism? Despite intensive counterterror efforts against terror networks, the threat from these networks remains significant and constantly mutating.¹ The strategic interplay between counterterror measures and terror activity is complex. Terrorism is a dynamic process, especially in the context of how it responds to counterterror measures.² Dynamic considerations may arise from the coevolution of terrorism and counterterrorism. A cursory look at offensive counterterror measures and the incidents of terrorism highlight this interaction. Figure 1 shows that drone attacks against Al Qaeda in the Arabian Peninsula (AQAP) in Yemen hit its highest casualty in 2012. Accordingly, the incident of AQAP's terrorist activity peaked in both 2012 and 2015.³ There was a drop in the incident of AQAP's activity in 2013; however, in 2015, AQAP increased its operation.

In counterterror planning, it is not only important to estimate the rise of terror activity or how such activity may respond to counterterror measures, but also to identify the key ingredient that sustains it. The main resource of any terror group is its militants, recruited from the pool of its supporters.⁴ Brito and Intriligator identified recruitment as the primary variable in sustaining *guerrilla* warfare.⁵ Whereas Brito and Intriligator concentrate on guerrilla warfare and its territorial properties, herein, we focus on the dynamic interplay between counterterror measures and terror activity. Can highly efficient counterterror measures contain terror activity at all levels of recruitment? We argue that extremely efficient counterterror measures can contain terror activity if recruitment remains low. This is because soaring recruitment can override the impact of highly efficient counterterror measures.

¹ Kumar Ramakrishna, "Terrorism Trends and Challenges: Understanding the Emergence of Al Qaeda Galaxy," *The Journal of Defense and Security* 5:1 (2014): 1-7, available at: <http://search.proquest.com/openview/oc79c23b37eb77b9b5c306ae294486d3/1?pq-origsite=gscholar&cbl=1456373>

² Michael D. Porter, Gentry White and Lorraine Mazerolle, "Innovative Methods for Terrorism and Counterterrorism Data," in *Evidence-Based Counterterrorism Policy*, ed. Cynthia Lum and Leslie W. Kennedy (Springer: New York, 2012), 91-112.

³ "National Consortium for the Study of Terrorism and Responses to Terrorism (START)," available at: <https://www.start.umd.edu/gtd>.

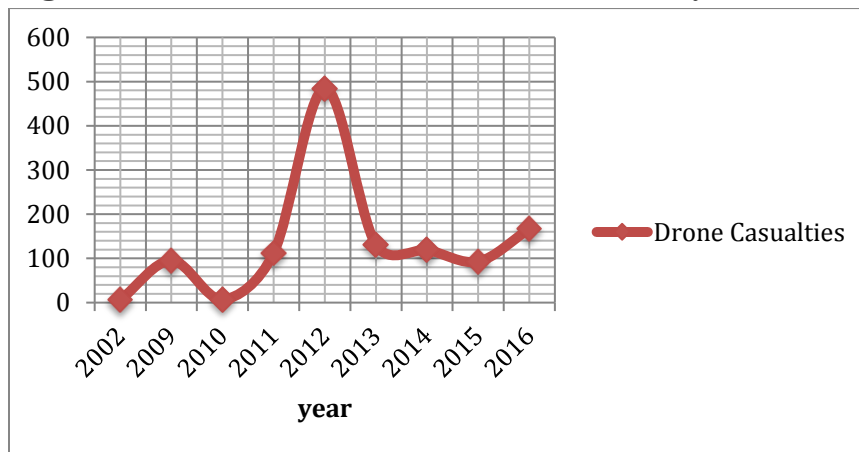
⁴ João R. Faria and Daniel G. Arce M., "Terror Support and Recruitment," *Defense and Peace Economics* 16, no. 4 (2005): 263-273. doi:10.1080/1024269052000344855.

⁵ Dagobert L. Brito, and Michael D. Intriligator, "Deterring Nuclear Weapons Proliferation," *Economic Affairs* 17, no. 4 (1997): 4-9. doi:10.1111/1468-0270.00051.

Crenshaw notes that recruitment is a necessity for terror group to survive over time.⁶ Terror organizations heavily rely on non-structured recruitment to guide the committed into its fold for further training and indoctrination.⁷ For example, Sageman states that Al Qaeda never entrusted much effort into a comprehensive recruitment drive, instead it relied heavily on non-structured recruitment to guide the committed.⁸ Indeed, the non-structured recruitment is a critical element in the advancement of Global *Jihad*.⁹ If restraining recruitment has a large impact on the success rate of counterterror measures, managing it should be prioritized.

This matters for key ongoing debate on efficient counterterror policies to curb terrorism efficaciously. We hypothesize that only under conditions of restrained recruitment highly efficient counterterror measures can effectively contain terrorism. This insight can help governments develop more effective strategies and to invest its valuable scarce resources in curtailing recruitment. Herein, we uncover a simple dynamic model that estimates the strategic interplay between counterterror measures and terror activity. The rest of the article proceeds as follows. First, we provide a brief review of the literature; second, we introduce our baseline model and conduct computer simulations; third, we present our main findings; and finally we conclude.

Figure 1. Drone wars (International Security 2012).¹⁰



⁶ Martha Crenshaw, "The Causes of Terrorism," *Comparative politics* 13, no. 4 (1981): 379-399, available at: <http://www.jstor.org/stable/421717>.

⁷ Marc Sageman, *Understanding Terror Networks* (Philadelphia: University of Pennsylvania Press, 2004), 201-202.

⁸ Michael Taarnby, "Recruitment of Islamist Terrorists in Europe: Trends and Perspectives," (Research Report funded by the Danish Ministry of Justice, January 14, 2005), available at: <http://www.investigativeproject.org/documents/testimony/58.pdf>.

⁹ Ibid.

¹⁰ This data is available at: <http://securitydata.newamerica.net/drones/yemen-analysis.html#page9>.

A Brief Review of Literature

Terrorism is the premeditated use or threat to use violence in order to obtain a political objective.¹¹ Earlier terrorism research focused on the definition of terrorism, the myriad causes of terrorism, terror tactics, and the identity of terror organizations.¹² Rapoport first distinguished terrorism from other forms of political violence.¹³ Thornton defined terrorism in the context of internal war and as “a symbolic act designed to influence political behavior by extranormal means, entailing the use or threat of violence.”¹⁴ Other experts focused on the evolution of terror groups as a type of social movement.¹⁵ The literature on social movements posits terrorism may appear at the end of a cycle of the rise and fall of movements of mass protest.¹⁶ Others note that local causes cannot explain global waves, and while ideology is a necessary ingredient, it does not explain it.¹⁷

Long-term analysis of terrorism trends indicate that transnational terror attacks run in cycles with peaks approximately every two years.¹⁸ Rapoport argues that over the course of modern history, characterized by expansion and contraction, waves of international terror activity last about a generation.¹⁹ Rapoport notes that, since the late 19th century, terror attacks can be divided into four waves.²⁰ A wave is defined as a cycle of activity in a given time period with expansion and contraction phases.²¹ Townshend suggests that the idea of waves of terrorism has the capacity to identify the evolution as well as the massing of terrorist events: the peaks and troughs of the waveforms echo the periods when terrorist action has intensified, peaked, and

¹¹ Bruce Hoffman, *Inside Terrorism* (Columbia University Press, 2006), 303-16.

¹² Todd Sandler, “The Analytical Study of Terrorism Taking Stock,” *Journal of Peace Research* 51, no. 2 (2013): 257–71. doi: 10.1177/0022343313491277.

¹³ David C. Rapoport, *Assassination & Terrorism* (Toronto: Canadian Broadcasting Corporation, 1971).

¹⁴ Thomas P. Thornton, “Terror as a Weapon of Political Agitation,” *Terrorism-Critical Concepts in Political Science* 3 (1964): 41-64, available at: <https://www.ncjrs.gov/App/Publications/abstract.aspx?ID=63496>.

¹⁵ Ted R. Gurr, “Sources of Rebellion in Western Societies: Some Quantitative Evidence,” *The Annals of the American Academy of Political and Social Science* 391, no. 1 (1970): 128-144, available at: <http://journals.sagepub.com/doi/abs/10.1177/000271627039100111>.

¹⁶ Martha Crenshaw, “How Terrorism Declines,” *Terrorism and Political Violence* 3, no. 1 (1991): 69-87. doi:10.1080/09546559108427093.

¹⁷ Mark Sedgwick, “Inspiration and the Origins of Global Waves of Terrorism,” *Studies in Conflict and Terrorism* 30, no. 2 (2007): 97-112. doi:10.1080/10576100601101042.

¹⁸ Walter Enders and Todd Sandler, “After 9/11 Is it all Different Now?,” *Journal of Conflict Resolution* 49, no. 2 (2005): 259-277, Available at: <http://www.jstor.org/stable/30045111>.

¹⁹ David C. Rapoport, “The Four Waves of Modern Terrorism,” in *Attacking Terrorism: Elements of a Grand Strategy*, ed. Audrey Cronin and James Ludes (Washington, DC: Georgetown University Press, 2004) 46–73.

²⁰ David C. Rapoport, “Terrorism,” in *Encyclopedia of government and politics*, ed. Mary Hawkesworth and Maurice Kogan (London: Routledge, 1992) 1064.

²¹ Sedgwick, “Inspiration and the Origins of Global Waves of Terrorism,” 98.

eventually diminished.²² However, a single explain-all solution for the complex problem of the transformation of terrorism remains open.²³ For example, Proshyn notes the activity of terror groups is not conducted in parallel with the dynamics of its waves.²⁴ Johnson et al. find a power-law like acceleration curves in the delay between events.²⁵ It is argued that this pattern is caused by a red queen effect, in which two sides of the conflict race through some abstract space, and the timing between events is given by how far ahead the insurgent is in the race.²⁶ Others suggest terror activities conform to a temporal pattern that can provide insight into terror attack frequencies.²⁷ Johnson et al. uncover a dynamical pattern that may be used to estimate the escalation rate and timing of fatal attacks.²⁸ They argue that the time difference between fatal attacks by insurgent groups within individual provinces in both Afghanistan and Iraq, and by terrorist groups operating worldwide, gives a potent indicator of the later pace of lethal activity. Clauset and Gleditsch identify patterns in the frequency and severity of violent attacks by aging terror groups.²⁹ The authors' analyses of terror events worldwide from 1968–2008 shows that the production of violent events tends to accelerate with increasing size.

Turning to the trends in the terrorist recruitment process, one aspect should be emphasized, that of top-down recruitment.³⁰ Absence of any top-down recruitment, joining the Jihad centers on impromptu formed clusters.³¹ Mair argues that virtually any country in the world has some potential as a recruitment pool; however, any meaningful pool requires at least three elements:

1. A lack of state capacity (particularly in the spheres of intelligence and law enforcement);
2. A mobilizing belief, such as Salafist/jihadist extremism; and
3. Agitators who can propagate those beliefs.³² On a global scale this

²² Charles Townshend, "Wave and Strain," *Terrorism and Political Violence* 28, no. 2 (2016): 225-227. doi:10.1080/09546553.2015.1112280.

²³ Denys Proshyn, "Breaking the Waves: How the Phenomenon of European Jihadism Militates Against the Wave Theory of Terrorism," *International Studies. Interdisciplinary Political and Cultural Journal* 17, no. 1 (2015): 91-107. doi:10.1515/ipcj-2015-0007.

²⁴ Ibid.

²⁵ Neil Johnson et al., "Pattern in Escalations in Insurgent and Terrorist Activity," *Science* 333, no. 6038 (2011): 81-84. doi:10.1126/science.1205068.

²⁶ Aaron Clauset, Maxwell Young and Kristian S. Gleditsch, "A novel Explanation of the Power-Law form of the Frequency of Severe Terrorist Events: Reply to Saperstein," *Peace Economics, Peace Science and Public Policy* 16, no. 1 (2010): 1-7. doi:10.2202/1554-8597.1213.

²⁷ Audrey K. Cronin, "How al-Qaida Ends: The Decline and Demise of Terrorist Groups," *International Security* 31, no. 1 (2006): 7-48. doi:10.1162/isec.2006.31.1.7.

²⁸ Johnson et al., "Pattern in Escalations in Insurgent and Terrorist Activity," 81-84.

²⁹ Aaron Clauset et al., "A Novel Explanation of the Power-Law," 1-7.

³⁰ Taarnby, "Recruitment of Islamist terrorists in Europe," 24.

³¹ Ibid.

³² Stefan Mair, "Terrorism and Africa: On the Danger of Further Attacks in Sub-Saharan Africa," *African Security Studies* 12, no. 1 (2003): 107-110. doi:10.1080/10246029.2003.9627576.

spontaneously formed clusters has resulted in a profusion of loosely connected networks.³³

This pattern of unstructured growth has immense ramifications as the strength of weak ties makes counterterror efforts difficult since it is infeasible to rattle an organizational structure that does not exist.³⁴

The recruitment process is not an isolated phenomenon but is inherently linked to issues like marginalization and questions of identity.³⁵ Empirical analyses have shown that indiscriminate repressive actions result in more terror attacks, whereas indiscriminate conciliatory actions result in fewer attacks.³⁶ Sandler notes that proactive responses against a terror threat may unleash backlash if terrorist supporters view such actions as excessive, thereby resulting in new recruits.³⁷ When this occurs, the positive benefits from proactive actions are reduced by the backlash costs.

Few scholars have investigated counterterrorism effectiveness of retaliatory raids.³⁸ Enders and Sandler found an intertemporal substitution, where terrorists moved attacks planned for the future to the present to protest the raids.³⁹ Thus, terror attacks rose following raids and declined months later as terrorists had to replenish exhausted resources.⁴⁰ Lum et al. studied the evaluation research on counterterror interventions, and found that not only some interventions did not achieve the outcomes sought; at times they even increased the likelihood of terrorism occurring.⁴¹ Siqueira and Sandler focused on the strategic interplay between a terror

³³ Taarnby, "Recruitment of Islamist terrorists in Europe," 23.

³⁴ Ibid., 25.

³⁵ Ibid., 49.

³⁶ Laura Dugan and Erica Chenoweth, "Moving Beyond Deterrence: The Effectiveness of Raising the Expected Utility of Abstaining from Terrorism in Israel," *American Sociological Review* 77:4 (2012): 597-624. doi:10.1177/0003122412450573.

³⁷ Todd Sandler, "The Analytical Study of Terrorism Taking Stock," *Journal of Peace Research* 51:2 (2014): 257-71. doi:10.1177/0022343313491277.

³⁸ Peter B. Rosendorff and Todd Sandler, "Too Much of a Good Thing? The Proactive Response Dilemma," *Journal of Conflict Resolution* 48, no. 5 (2004): 657-671, available at: <http://www.jstor.org/stable/4149814>; Kevin Siqueira and Todd Sandler, "Terrorist Backlash, Terrorism Mitigation, and Policy Delegation," *Journal of Public Economics* 91, no. 9 (2007): 1800-1815. doi:10.1016/j.jpubeco.2007.02.005.

³⁹ Walter Enders and Todd Sandler, "The Effectiveness of Antiterrorism Policies: A Vector-Autoregression-Intervention Analysis," *American Political Science Review* 87:4 (1993): 829-844. doi:10.2307/2938817.

⁴⁰ Todd Sandler, "Counterterrorism: A Game-Theoretic Analysis," *Journal of Conflict Resolution* 49:2 (2005): 183-200, available at: <http://www.jstor.org/stable/30045107>.

⁴¹ Cynthia Lum, Leslie W. Kennedy and Alison Sherley, "Are Counter-Terrorism Strategies Effective? The Results of the Campbell Systematic Review on Counter-Terrorism Evaluation Research," *Journal of Experimental Criminology* 2:4 (2006): 489-516. doi:10.1007/s11292-006-9020-y.

group and a government as they both vie for grassroots support.⁴² They found that when terrorists and the government act contemporaneously, the equilibrium outcome depends on the effectiveness of the government's counter measures.

The Current Study

The specification of an accurate model including most relevant factors is a prerequisite for a useful model; the particular challenge is that it can be difficult to select the relevant factors for inclusion in a conceptual model, and to define the form of the relationships between all of the factors mathematically.⁴³ Most efforts in this direction have relied on models from the time series or survival analysis.⁴⁴ Herein, we employ mathematical analysis and System Dynamics simulations. Using these measures, we study how terror activity varies over time in reaction to counterterror measures. The simulation results yield new and interesting insights into the growth and stagnation of terror activity and the challenges it poses for counterterrorism agencies. In the following section, we present the model.

Model

Let N be the number of terror activities, and C the number of counterterror measures (e.g. military and police) employed by counterterror agencies to curb the threat of terrorism. N and C interact over time $t = 0, 1, 2, \dots n$. Parameter r is the rate at which individuals can become recruited into terror organizations. The evolving terror activity is given by $\frac{\partial N}{\partial t} = \nabla r + [\mu_1(\psi_N) - \mu_2(\psi_C)]$ where ψ_N and ψ_C are functions describing changes in terrorism and counterterrorism proliferation and deduction; μ_1 and μ_2 denote the rate of change. Terror curve (\mathbb{T}), incorporates the summation of all activities at a point in time, and is triggered by a disturbance (κ), where the force (\vec{f}) of the curve is given by $\vec{f}(\kappa, t) = \omega(\kappa; \lambda)$; ω is a function denoting how the strength of \vec{f} varies across time and λ which, captures the interaction between terrorism and counterterrorism activities. Therefore, total \vec{f} at any point in time is $\therefore \vec{F}_t = \int \omega(\kappa; \lambda) d\kappa$. Reaction to terror activities can vary in accordance to their threat level (τ). Counterterrorism agencies' response is denoted by $\vec{\theta}: [0, \infty] \rightarrow$

⁴² Siqueira and Sandler, "Terrorist Backlash, Terrorism Mitigation, and Policy Delegation," 1800-1815.

⁴³ Porter, White, and Mazerolle, "Innovative Methods for Terrorism and Counterterrorism Data," 91-112.

⁴⁴ Carlos P. Barros, "An Intervention Analysis of Terrorism: The Spanish ETA Case," *Defense and Peace Economics* 14:6 (2003): 401-412. doi:10.1080/1024269032000085170; Gary LaFree, Laura Dugan and Raven Korte, "Is Counter Terrorism Counterproductive? Northern Ireland 1969-1992," *Criminology* 47:1 (2009): 501-530, available at: <https://ccjs.umd.edu/sites/ccjs.umd.edu/files/pubs/Published%20Article%20Northern%20Ireland.pdf>.

\mathbb{R} . Hence, $\theta(\tau; \lambda) = \frac{\tilde{\theta}(\frac{\tau}{\lambda})}{\lambda} \therefore \int \tilde{\theta}(\tau; \lambda) d\tau = \lambda$. Thus, the normalized campaign function is parameterized by λ .

Our computer simulation is based on a modified adaptation of the Lotka-Volterra.⁴⁵ Specifically, we employ the predator-prey model.⁴⁶ The Lotka-Volterra model parameters specify a dynamic system.⁴⁷ This model is a fine baseline structure to probe the impact of interaction between terrorism and counterterrorism.⁴⁸ Tsebelis and Sprague adapted the predator-prey model to the problem of revolution and coercion in order to capture the dynamic characteristics of the interactions between the state and rebels.⁴⁹ We assume that terror organizations need recruits to conduct their activities; N can increase at a rate $d_N = rNd_t$ over time.

In a study by Asal and Rethemeyer, the authors found that organizational characteristics such as size and alliance connections are important predictors of terror group lethality.⁵⁰ Here, we incorporate a term for alliances (ζ), since alliances can support terror organizations' activities. We assume that counterterror measures confront terror activities at a rate(φ), then $\therefore d_N = -\varphi N C \zeta d_t$. Agencies can reduce counterterror measures at a rate (d_C), where $d_C = -\mu C \gamma$; μ is the rate at which agencies reduce operations and γ denotes the level of counterterror spending. Herein, spending reflects both the depth and scope in the funding of counterterrorism programs in order to detect, prevent, deter, and reduce the risk of terror-related violence. C inflates at rate α when $d_C = \alpha N C \vartheta d_t$; ϑ denotes the rate at which counterterror measures efficiency expands. The result of these assumptions is a set of two coupled differential equations:

$$\begin{pmatrix} d_N/d_t = & rN - \varphi N C \zeta \\ d_C/d_t = & -\mu C + \alpha N C \vartheta \end{pmatrix}$$

⁴⁵ Alfred J. Lotka, "Contribution to the Theory of Periodic Reactions," *The Journal of Physical Chemistry* 14:3 (1910): 271-274. doi:10.1021/j150111a004; Vito Volterra, *Theory of Functionals* (London and Glasgow: Blackie and Sons, 1930).

⁴⁶ "NetLogo Wolf Sheep Predation (Docked Hybrid) Model," *Center for Connected Learning and Computer-Based Modeling*, available at: [http://ccl.northwestern.edu/netlogo/models/WolfSheepPredation\(DockedHybrid\)](http://ccl.northwestern.edu/netlogo/models/WolfSheepPredation(DockedHybrid)).

⁴⁷ Hiroyuki Matusda, Peter A. Abrams, and Michio Hori, "The Effect of Adaptive Anti-Predator Behavior on Exploitative Competition and Mutualism between Predators," *Oikos* (1993): 549-559. doi:10.2307/3544924.

⁴⁸ Ronald A Francisco, "Coercion and Protest: An Empirical Test in Two Democratic States," *American Journal of Political Science* 40:4 (1996): 1179-1204. doi:10.2307/2111747.

⁴⁹ George Tsebelis and John Sprague, "Coercion and Revolution: Variations on a Predator-Prey Model," *Mathematical and Computer Modeling* 12:4 (1989): 547-559. doi:10.1016/0895-7177(89)90424-X.

⁵⁰ Victor Asal and Karl R. Rethemeyer, "The Nature of the Beast: Organizational Structures and the Lethality of Terrorist Attacks," *The Journal of Politics* 70:2 (2008): 437-449. doi:10.1017/S0022381608080419.

Results

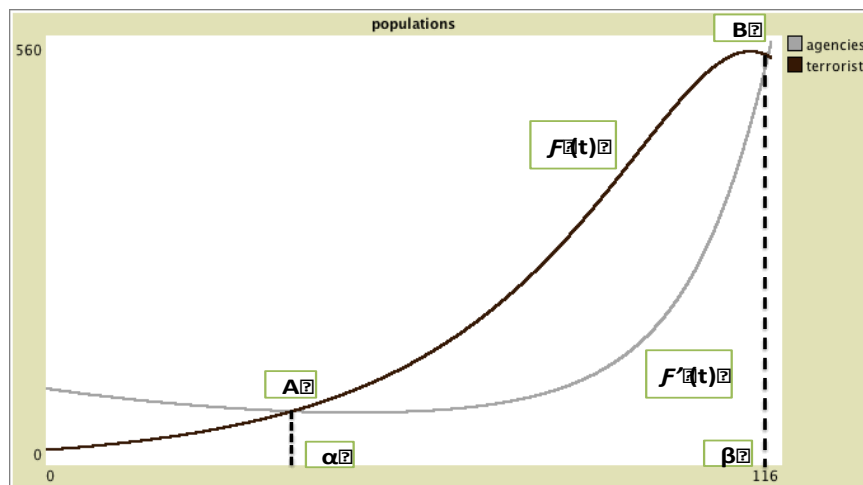
We examine two distinct anti-terror policies: *Inefficient* and *efficient*. The modeler presents the emergent aggregate level behavior of terror activities and counterterror measures. The simulation results of the System Dynamics modeler draw the peaks and troughs of both counterterror and terror activities.⁵¹ Several manipulations of the parameter values of the model are implemented in the simulations below.

Simulations

Inefficient Counterterror Measures (VIa).

We set the efficiency of counterterror measures (ϑ) and terrorist recruitment (r) at some low value ($\vartheta = 0.5$, $r = 0.04$). Terror $f(t)$ and counterterror $f'(t)$ curves intersect twice (see figure 2).

Figure 2. Terrorism and counterterrorism agencies' dual equilibria

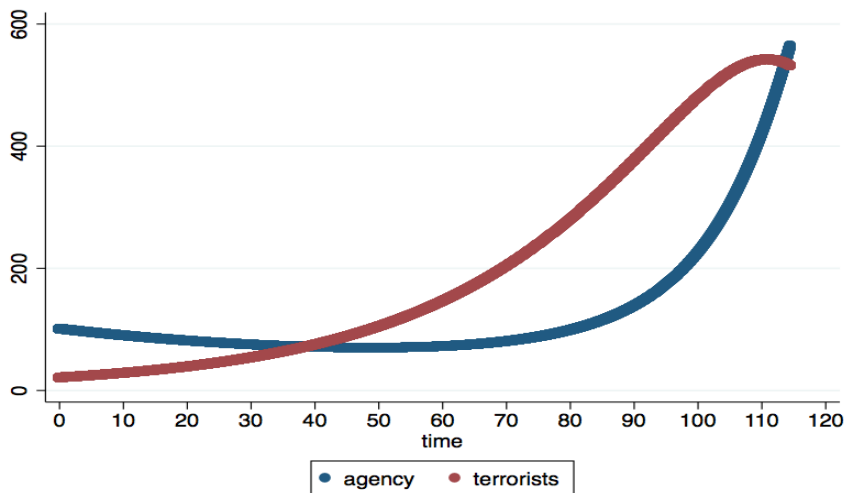


Points A and B are local equilibria points. The level of counterterror measure is lower on the left side of point B but exponentially overtakes $f(t)$ on the right side of B. We name point B a *counterterror trap*. The segment between A and B is the *terror funnel*. The terror funnel denotes the period where terror enterprises enjoy gains and counterterror agencies lag behind. At point B, counterterror agencies overtake terror activities; for the terrorists, the curve becomes steeper, while counterterror measures rise exponentially. The discrepancy between terrorists' high level of activity and counterterrorism's low response level in the terror funnel is denoted the *terror trap* (Ξ).

⁵¹ NetLogo 5.3.1 User Manual, available at: <http://ccl.northwestern.edu/netlogo/5.0/docs/systemdynamics.html>.

Thus, $\Xi = \int_{\alpha}^{\beta} f(t)dt - \int_{\alpha}^{\beta} f'(t)dt$ is where counterterror measures lags behind terror activities. In *VIa*, the time to reach the first equilibrium (point A) is long (40 time units); point B is reached at 110 (time units). Measurement of time is built on units, but is not specific to years, months, days, hours, or minutes. Time represents the unit itself, rather than the nature of the unit. Thus, when comparing the utility of various counterterror measures, we are intensely concerned with the length of time. This allows us to compare the relative utility of various counterterror measures. Thus, the terror funnel is large (70 time units). In this scenario, terror enterprises enjoy a long period of activity (figure 3). Terror activities reach above 500.

Figure 3. Low efficiency counterterror measures and low recruitment

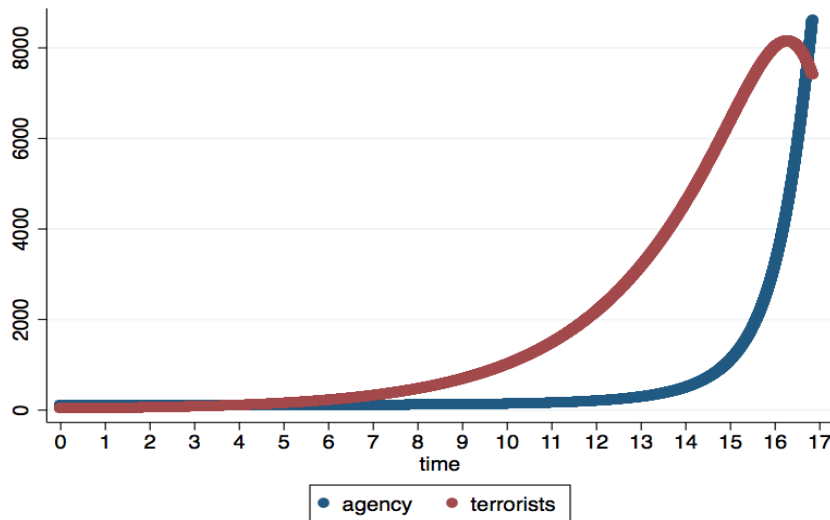


Inefficient Counterterror Measures (VIb).

Next, we increase recruitment into terror groups by 164 percent while controlling for ϑ ($\vartheta = 0.5$, $r = 0.4$).⁵² Because recruitment into terror groups is high, the time it takes to reach point A is shorter (four time units) and the terror funnel is smaller than in *VIa*. However, terror activity is 174 percent higher than in *VIa*. This suggests that while terror enterprises enjoy a short terror funnel, these enterprises exhibit a high level of activity (figure 4).

⁵² All benchmark values of the model are derived from Wilensky (2005) and adjusted to our model. See NetLogo Wolf Sheep Predation (System Dynamics) model, available at: [http://ccl.northwestern.edu/netlogo/models/WolfSheepPredation\(SystemDynamics\)](http://ccl.northwestern.edu/netlogo/models/WolfSheepPredation(SystemDynamics)); Wilensky (1999) available at: <http://ccl.northwestern.edu/netlogo/>; here the percent difference for our benchmark is calculated as $(|0.04 - 0.4| / ((0.04 + 0.4)/2)) * 100$.

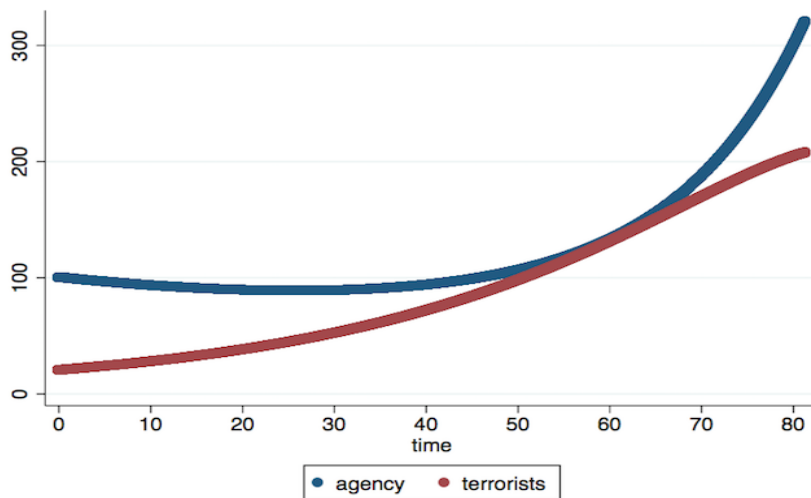
Figure 4. Low efficiency counterterror measures and high recruitment



Efficient Counterterror Measures (VIc).

In this scenario, we increase the efficiency of counterterror measures by 75 percent while keeping recruitment level at a low value ($\vartheta = 1.1, r = 0.04$). The simulation results show that the counterterror curve builds a tangent with the terror curve and thus, avoids the creation of a terror trap. Only here, terrorism is contained (figure 5). Thus, terror activities are effectively managed by the counterterror measures.

Figure 5. High efficiency counterterror measures and low recruitment

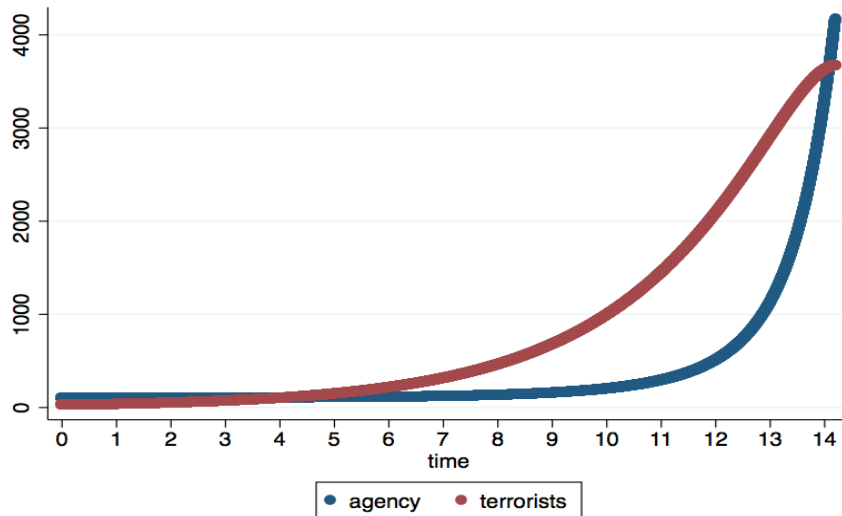


Efficient Counterterror Measures (VIId).

Finally, we test the interplay between high recruitment and highly efficient counterterror measures ($\vartheta = 1.1, r = 0.4$). We find that the time it takes to reach the counterterror trap (Point B) is short (14 time units); thus, a small terror funnel is

created. Terror activity is 78 percent lower than *VIb* but higher than *VIa* and *VIc*. Under this condition, highly efficient counterterror measures can significantly reduce the time span of terror activity—even though recruitment into terror groups is still high (figure 6).

Figure 6. High efficiency counterterror measures and high recruitment



Conclusion

The strategic interaction between counterterror measures and terror activity is complex. Our model depicts this dynamic interaction. We find that under conditions of inefficient counterterror measures, terror groups enjoy longer periods of activity. For this condition to hold, recruitment into terror groups must remain restrained. Inflated recruitment shortens the period of activity but boosts the number of such enterprises. Highly efficient counterterror measures can effectively contain terror activity, but only if recruitment remains restrained. Thus, recruitment profoundly alters the trajectory of the dynamics between counterterror measures and terror activity. We conclude that highly efficient counterterror measures can be remarkably successful, if recruitment into terror groups remains depressed.

The interplay between counterterror measures and terror activity may coevolve and can contribute to the fluctuations in growth and decline of terror enterprises. This coevolution happens over time in which each side employs adaptations in response to escalations. The force of counterterror measures may instigate selective pressures on recruitment that can influence the dynamics of their relationship. Population cycles can lead to fluctuating selection, so that the evolution of terrorism may occur indefinitely and can reciprocally influence counterterror dynamics. It is important to note that interactions governing ecological dynamics continually change through

rapid evolution.⁵³ Predicting the outcome of such interactions is of interest to counterterrorism researchers as they try to understand sustained recruitment. In this context, testing effectiveness of policies and targeted actions will help researchers design robust adaptive guidelines against terrorism. In parallel, researchers must also understand the evolutionary dynamics of terrorist recruitment.

This article demonstrated that studying the interplay between terrorism and counterterrorism has much policy relevance. First, the knowledge of terrorist trends can inform forecasting and counterterror policies on the inherent risks of different levels of counterterror campaigns in shaping future terror attacks. Second, governments must ascertain the effectiveness of its counterterror measures with regard to terrorist recruitment, so that it can discontinue ineffective programs. It is important to take measures to counter the alienation of communities where terror groups recruit. Instituting counter measures is vital in curtailing terror groups' membership. The recruitment process is not an isolated phenomenon; it is immanently linked to issues such as marginalization and questions of political and religious identity.⁵⁴ Anti-terror operations are the visible elements in curbing the threat of terrorism, however, while indispensable, may not address the roots of the problem.⁵⁵ Taarnby argues that it is at the level of socially disparate groups that recruits to Jihad can be found, and this is outside the scope of the security services.⁵⁶ Furthermore, the recruitment efforts of a group will not be mitigated, or halted by a one-size-fits-all prescription; this necessitates the incorporation of various counter recruitment measures.⁵⁷ Much more research is needed to understand the complexities involved in the process of recruitment. Herein, we have offered ways to study the patterns of terror activities and the conditions under which they can be contained. We hope to formulate effective responses to counter recruitment in future studies.

⁵³ Gregor F. Fussmann, Michel Loreau, and Peter A. Abrams, "Eco- Evolutionary Dynamics of Communities and Ecosystems," *Functional Ecology* 21:3 (2007): 465-477. doi:10.1111/j.1365-2435.2007.01275.x.

⁵⁴ Taarnby, "Recruitment of Islamist terrorists in Europe," 49.

⁵⁵ Ibid.

⁵⁶ Ibid.

⁵⁷ Scott Gerwehr and Sara Daly, "Al-Qaida: Terrorist Selection and Recruitment," in *The Homeland Security Handbook* (New York: McGraw-Hill, 2006), 73-89.