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A dynamic model of suicide terrorism and political mobilization

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Abstract

This study considers the problem of suicide terrorism, government counterterror responses, and the mobilization of recruits in support of the contending parties. A model is developed that enables predictions as to what factors should be emphasized or de-emphasized by the forces protecting society. The article presents a linear mathematical analysis of the logical interrelationships involved in the confrontation and embeds the study within the framework of previous mathematical and empirical work on the subject. It is concluded that governments should avoid inflicting collateral damage on the general population in counterterrorist activities and should pursue policies (both in counterterrorist operations and otherwise) that contribute to the political quiescence of the populace.

Keywords

Suicide terrorism, counterterrorism, political mobilization, bandwagoning, linear modeling

Introduction

Suicide terrorism poses a considerable problem for any organized society. Whether a single individual acting out of private motives, or as part of an organized group attempting to change the existing order, the tactic of suicide terrorism has been difficult to defeat or to manage for any form of government. The problem of the suicidal terrorist, acting alone, is self-limiting – he eliminates himself in the process of the attack. This article is concerned with the attempt by a government to deal with a group of people (i.e., a terrorist entity or network) organized – either loosely or tightly – for the purpose of changing the existing order, using suicide as a prime weapon. The question facing the government of a society under attack is how to protect their citizens from harm inflicted

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by individuals who deliberately harm themselves in order to harm others while simultaneously eliminating the terrorist organization.

The usual assumption is that groups bent upon self-destruction are a very small minority, at least initially, in any organized society. Barring further recruitment to the terrorist cause, such a suicide terrorist organization is bound to shrink over time, due to the self-imposed losses incurred by the suicides of its members as well as the losses imposed on it by the forces defending the society, its police and military. The question that will be addressed in this study is whether or not the government's defensive forces – which are being diminished by the attacks of the terrorist forces as they themselves attack and diminish the terrorists – will outlast the terrorists. If the forces defending the society – its military and police – shrink to zero as a result of attrition or defection before the terrorist forces vanish, the terrorists will have won. If, on the other hand, the terrorist forces diminish to the vanishing point through attrition or defection while the defensive forces are still non-zero in strength, we posit that the societal defenders have won.

It should be obvious that continued diminishment of the defender or terrorist forces is not the only possibility. Each may mobilize and recruit new strength from the general population in which both are immersed. For example, members of this population may react to collateral damage inflicted on civilians – suffered as a result of terrorist attacks on the defense forces – by joining these defensive forces and thus augmenting the strength of the defense. On the other hand, members of the general population may react to a perceived growing strength of the terrorist organization, and to collateral damage suffered as a result of attacks by the defense forces on the terrorists, by joining the terrorist ranks, thus further augmenting the forces devoted to the destruction of the existing order. This switching from a neutral (or opposing) position to an active role on the stronger or winning side is often referred to as "bandwagoning."[1] In this article, only political mobilization – or bandwagoning – internal to the state will be assumed; the possibility of either of the actively warring parties – the terrorists or the defense forces – recruiting from beyond their nation's borders will not be considered.[2]

Thus the fundamental problem facing the leaders of a government seeking to preserve the existing order or its policies against the onslaught of the suicide terrorists is how to ensure that the terrorist forces are annihilated before the defense forces are degraded or destroyed, given that both of these forces may be augmented by bandwagoning and diminished by mutual attacks. Provided this situation and a set of policy options, which option – if any – will lead to the desired outcome: the elimination of the terrorist organization while the defense forces still remain finite? In short, the intent of this article is to create a dynamic model that will mathematically express the relation between suicide terrorists, the government defense forces, and the general population – a model that can evolve with time and thus lead to useful predictions. No claim is made that this mathematical model will lead to better or different results than those obtained empirically. Indeed, the implications of the model will be compared with findings produced through empirical research and related to three case studies of actual suicide campaigns and counterterrorist responses. The purpose of the analysis is to provide useful results about a social system under specified conditions and to generate findings relevant to policy decisions.

The key elements in the model are attrition rates to both the terrorist and government forces, levels of collateral damage inflicted on the general population by the terrorist and the government forces as they try to destroy each other, and rates of replenishment to the terrorist ranks and to the government forces by members of the general population. In the following sections, this article will explore both the logical and empirical interrelationships of suicide terrorism, counterterrorist operations, and political mobilization. At the conclusion of the study, the policy implications of the model are examined.

Extant research

A growing body of research has produced mathematical and empirical findings relevant to understanding the sources of suicide terrorism, its functions, timing, and rationale, as well as policy prescriptions for governments confronting terrorist organizations that employ this tactic.

Understanding suicide terrorism

The concept of suicide terrorism impinges on questions of strategy, targets, morality, and ethnicity. For example: Does it differ strategically from other forms of terrorism or political violence (e.g., Asad, 2007; Pape, 2005)?; does it refer exclusively to attacks on civilian rather than military targets (e.g., Goodwin, 2006)?; is it morally indistinguishable from the violence employed by nation-states in war (e.g., Asad, 2007)?; is it associated primarily with a particular ethnic group (e.g., Biggs, 2005)? Suicide bombing has been variously explained as: a strategy employed by weak groups against stronger enemies (e.g., Asad, 2007: 55); akin to self-immolation insofar as it involves self-destruction on behalf of a collective cause (e.g., Biggs, 2005: 173); and as the most efficient form of terrorism designed to kill the maximum number of an opposing group with high levels of certainty (Pape, 2005: 9–10). It has been noted that in many cases the discussion of suicide terrorism is connected – implicitly or explicitly – with a moral judgment that ignores the contingent circumstances in which it takes place (e.g., Asad, 2007: 92, 94; Gambetta, 2005b: vii).

There is a general consensus that suicide terrorism is a tactic used by extremist organizations for instrumentally rational purposes.[3] It is, moreover, a form of political violence that presents advantages for a weaker party in an asymmetrical conflict. It has also been shown that suicide assaults can mobilize sympathetic populations and attract both recruits and financial support (Crenshaw, 2007: 141).

Pape (2003, 2005) presents an extensive theoretical and empirical study of the sources and outcomes of suicide terrorism. He notes that, in general, terrorism has two goals: (1) to gain supporters (mobilization); and (2) to coerce opponents (Pape, 2003: 345). However, there are tradeoffs between these objectives, and the choice of emphasis manifests itself in the different forms of terrorism: demonstrative terrorism, destructive terrorism, and suicide terrorism. According to Pape, suicide terrorism is the most aggressive form of terrorism, pursuing coercion even at the expense of losing support for the terrorist cause (cf., Asad, 2007: 55). In short, while coercion is a goal in all terrorism, coercion rather than mobilization is the primary objective of suicide terrorism. Pape maintains his findings confirm that suicide terrorism follows a strategic (instrumentally rational) logic designed to coerce democracies into making territorial concessions, and that over the periods covered by his analyses, the strategy has proved successful (Pape, 2003: 344, 355; 2005: 4–38).

Taking a different perspective from that of Pape, Bloom (2004, 2005) argues that suicide attacks serve simultaneously to harm an adversary and to legitimize militant groups who are engaged in a competition for leadership within their community. Multiple terrorist groups or factions competing for this position of dominance employ violence to increase their prestige within the community (Bloom, 2004: 61; 2005: 81). Hence, suicide bombings are a useful tactic for increasing public support and market share, and for outbidding rival organizations for the mantle of leadership. In short, Bloom's contention is that suicide attacks are strategically motivated events designed to improve the competitive position of a militant group against its rivals – as well as to coerce a governmental opponent.

As noted, most explanations of suicide terrorism accept the principle of instrumental or strategic calculation on the part of the terrorist organization.[4] Indeed, some analysts (e.g., Ferrero, 2006;

Luft, 2002) plausibly assert that rational calculation guides even individual suicidal terrorist behavior in support of a collective cause. In sum, suicide terrorism is a form of rational political violence that may be employed to coerce an adversary and mobilize popular support within a community for a terrorist organization, as well as to achieve more specific policy goals.

Effects of suicide terrorism on political mobilization

Research has shown that acts of suicide terrorism can mobilize public support for either a terrorist organization or the government. For example, Pape (2003: 345) has argued that suicide terrorism is the most aggressive form of terrorism insofar as it seeks maximum coercive effect even at the expense of gaining supporters for the terrorists' program.[5] However, Pape (2005: 81–82) recognizes that protracted campaigns of suicide terrorism require significant support from within the terrorists' community. Such support enables a terrorist organization to replenish its membership, to avoid detection by government forces, and to confer martyrdom on suicide attackers. Pape notes that a foreign military presence that "threatens core elements in a community's national identity" is usually sufficient to fulfill all of the personnel (mobilization) requirements for a lengthy campaign of suicide terrorism, despite the alienation of some sectors of the population produced by suicide attacks.

Focusing on the same issue of mobilization, Kydd and Walter (2006) maintain that terrorist violence is a form of "costly signaling." Terrorist organizations wish to convey to their adversaries by signaling through violent acts that they have the strength and will to impose heavy penalties, and thereby to alter their opponents' policies. However, Kydd and Walter note that terrorist organizations also use violence to signal their power and resolve in an effort to gain obedience and support from the population the terrorists hope to represent or control. Hence, they argue that terrorist violence constitutes a costly signal directed not only at the adversary but also at the audience of followers or potential followers and can serve to mobilize popular support for the terrorists' cause.

Empirical work by both Bloom and Pedahzur supports a connection between suicide attacks and political mobilization. Bloom (2005: 81) suggests that social support for suicide terrorism depends on how the tactic is applied, against what targets, and for what specific purposes. Again, it is her contention that suicide attacks can enhance a terrorist organization's prestige and attract recruits, publicity, and money. In essence, suicide terrorism becomes an effective means of mobilizing and expanding supportive constituencies. Pedahzur (2005: 159) similarly argues that generating social support through suicide terrorism is part of a terrorist organization's calculated strategy. Deadly suicide assaults provide populations with a vicarious outlet for the expression of grievances and hostility, and the tactic may be used deliberately by terrorist groups to cultivate and mobilize popular support.

Interestingly, Kalyvas and Sanchez-Cuenca (2005: 216–218), like Pape, note that suicide assaults may have the effect of alienating elements within the terrorists' own community and thereby undermine support for the terrorist cause. Specifically, Kalyvas and Sanchez-Cuenca argue that suicide attacks that indiscriminately target civilians can be counterproductive to the terrorist program. Although this type of violence generally is intended to deter a population from collaborating with an adversary, the very nature of suicide attacks (random, massive, indiscriminate violence) may actually turn the community against the terrorist organization.

In sum, suicide terrorism is a tactic that may be used by a terrorist organization for the purpose of generating and mobilizing popular support within a community, as well as for coercing an adversary.[6] However, as noted, a number of studies suggest that the tactic can also shift public support to the government side as moderate elements within a population may reject and be repelled by this form of extremist violence.

Effects of counterterrorism policies on political mobilization

Government counterterrorism policies may also impact political mobilization on behalf of either the terrorist organization or the government itself. For example, Ethan Bueno de Mesquita (2005, 2008) and Bueno de Mesquita and Dickson (2007) present formal mathematical models of the interactions among a government, a terrorist organization, and potential terrorist volunteers. The models indicate that government counterterrorist crackdowns have competing effects on the mobilization of recruits for the terrorist organization: (1) they decrease the ability of terrorists to carry out attacks (making mobilization less attractive); and (2) they increase ideological opposition to the government and create negative economic effects (making mobilization of recruits for the terrorist organization more attractive). An implication of these models is that governments engaged in anti-terror campaigns are confronted with a profound dilemma: they may know that repressive policies are counterproductive (in the sense of increasing terrorist mobilization), but may have no other reasonable option for ensuring security. The policy recommendation derived from the models is that if socially damaging counterterror operations are unavoidable, governments should adopt additional programs that serve to reward the general population.

In an interesting analysis of strategic decisionmaking[7] with implications for political mobilization, Rosendorff and Sandler (2004) develop a two-person game model to explore the decision dynamics of a government and terrorist organization in which the government selects a level of proactive counterterrorism and the terrorists choose the type of attack, that is, normal or spectacular. The authors maintain that proactive operations that curb civil freedoms or destroy property may create grievances in reaction to these tactics. Consequently, proactive measures may enhance recruitment to the terrorist network thereby offsetting some of the favorable effects.

Moreover, Rosendorff and Sandler also suggest that recruitment to the terrorist cause depends not only on government policies and the success of terrorist assaults, but also on the nature of the events themselves: whether the events are normal (with modest impact) or spectacular (with a high death toll). The authors hold that spectacular events may increase mobilization to the terrorist ranks far more efficiently than normal events. Rosendorff and Sandler (2004: 659, 669–670) conclude that major proactive counterterror campaigns may actually promote spectacular terrorist events if the incentive for terrorist recruitment (as a consequence of successful government anti-terror policies) is sufficiently strong.

Empirical work that explores the relationship between government counterterror polices and political mobilization is found in Bloom (2005), Pedahzur (2005), and Kalyvas and Sanchez-Cuenca (2005). Bloom (2005: 82, 91) as well as Kalyvas and Sanchez-Cuenca (2005: 221) note that repressive government counterterror policies hold the promise of positive short-term effects, but over time such policies engender mass public opposition and support for terrorist operations; in essence, that political mobilization for terrorist organizations and their suicide attacks may be increased by harsh, long-term government counterterror strategies. More specifically, both Bloom (2005) and Pedahzur (2005) argue, based on their case studies, that it is imperative for governments to avoid producing civilian deaths and collateral damage to communities in their counterterrorist operations if they wish to reduce recruitment to the terrorist organizations' ranks.

In sum, it has been demonstrated mathematically that government counterterror policies that do not impact the economy negatively or that provide political or economic rewards to the general population will undercut the ability of a terrorist organization to mobilize public support for its cause (Bueno de Mesquita, 2005, 2008; Bueno de Mesquita and Dickson, 2007). Also of considerable importance are the empirical observations that it is critically important to minimize collateral damage inflicted on a community by government counterterror operations in order to constrain public recruitment to the terrorist ranks (Bloom, 2005; Pedahzur, 2005). Hence, it is clear that there

is both a mathematical and empirical interrelationship among extremist groups using the tactic of suicide bombing, government counterterrorism policies, and political mobilization to the opposing sides in a struggle for dominance within a society.

Modeling suicide terrorism, counterterrorism, and bandwagoning

Mathematical models of social structure and political conflict abound, and are often used to explain the "scaling" phenomena actually observed – the fact that some important social parameters vary as simple powers of other social factors: plotted on log-log paper, their empirical relationships are represented as straight lines.[8] For example, using network theory, it can be shown that many city parameters – such as the number of gasoline stations, the amount of road surface, the number of new patents, etc. – can be represented by simple "power" laws where the city population is the independent variable.[9] In the same manner, a power-law relation between the cumulative probability of a terrorist event producing a specified number of casualties, and the number of casualties, can be derived by assuming that terrorist groups are continuously coalescing and fragmenting.[10] However, all of these scaling models are static, not dynamic; they describe "what is," not "what will be." For the purpose of predicting "what will be," Frederick W. Lanchester (1914) has produced a very useful dynamic model of two-party conflict in which the time evolution of the strength of one of the combatants is either a linear or quadratic function of the strength of the other. A nonlinear version of such a model has been used to describe the combat between defenders and terrorists and the bandwagoning to each from the general population.[11] In that study, a general solution to the coupled, non-linear, first-order differential equation set could not be obtained. However, if the bandwagoning terms were set equal to zero, a general result was possible: the terrorist forces diminished faster than the defending forces. Hence, a sufficient condition for a successful defense against suicide terrorists is the absence of bandwagoning, provided that the starting values of the defense forces and the general population are sufficiently larger than the initial terrorist force.

But practical experience indicates that bandwagoning is very common in societal conflict situations that give rise to terrorist activities. Hence, in this article, terms representing bandwagoning from the general population to either the terrorist or the defending forces are retained. However, in order to have a model that can lead to general solutions, and therefore predictions, irrespective of the values of the input parameters – which will not usually be known – only linear bandwagoning terms are kept. For the same reason, only the linear form of the Lanchester combat model is used. The result is a set of coupled, linear, first-order differential equations. The general behavior of the solutions to this model is easily obtained, leading to definite predictions as to the outcome of the suicide terrorist attempt to change the existing order.

The model prediction is that suicide terrorism is self-limiting: this is the case provided that the suicide attack rate is large compared to the defenders' combat success (kill) rate; then the ratio of terrorist forces to defense forces, which starts at a positive value, goes to zero at a finite time. Thus the societal defenders will win.

The model

Let T be the number of terrorists, D the number of defenders (military and police), and P be the population number from which the defenders and terrorists may be drawn. T, D, and P are all time-dependent variables where t represents time, the single independent variable. The fixed parameter w is the rate, per terrorist, at which they commit suicide. Assume that each suicide results in the death or incapacitation of α defenders and collateral damage of β to the general population. Thus, if only terrorist suicide is operative, the time rate of decay of T is wT, that of D

is $\alpha w T$, and that of the general population is $\beta w T$. Assume that the defenders kill or incapacitate terrorists at a rate proportional to the number of defenders, where ξ is the proportionality coefficient – the defenders' kill rate. Thus the terrorists suffer an additional decay rate (the Lanchester battle term) of ξD.

It is assumed that members of the general population will only join the terrorist bandwagon if they perceive the defenders to be losing, that is, their number is declining. Thus terrorist numbers will increase at the rate $-\zeta dD/dt$ where ζ is the positive parameter describing the bandwagoning of P to T. Note that if the defenders' number is increasing (dD/dt positive), this term implies a decline in terrorist numbers as terrorists leave their companions to join the neutral population. In a similar manner, γ is the positive parameter representing bandwagoning of the general population to the defenders: the defenders increase at a rate $-\gamma dP/dt$ because of the population's perception of its losses due to collateral damage inflicted by the terrorists; if the population is increasing, some defenders will see no further need for their services, and so they will defect to the general population.

The result of these assumptions is a set of three coupled differential equations:

$$dT/dt = -wT - \xi D - \zeta dD/dt \tag{1}$$

$$dD/dt = -\alpha wT - \gamma dP/dt \tag{2}$$

$$dP/dt = -\beta wT + \zeta dD/dt + \gamma dP/dt \tag{3}$$

The last two terms of Equation (3) represent "conservation of people:" those who bandwagon to either defenders or terrorists are lost to the general population. The three first-order equations require five positive parameters, w, ξ, ζ, α, γ, as well as the three positive initial values T_0, D_0, and P_0 to specify a solution.

The solution

The three coupled equations may be simply reduced to a system of two coupled equations by eliminating P from (2) and (3):

$$dT/dt = -aT - bD \tag{4}$$

$$dD/dt = cT \tag{5}$$

where

$$a = w\left[1 + \zeta\left(\gamma\beta' - \alpha\right)/\left(1 + \gamma\zeta'\right)\right] \tag{6}$$

$$b = \zeta \qquad c = w\left(\gamma\beta' - \alpha\right)/\left(1 + \gamma\zeta'\right) \tag{7}$$

$$\beta' = \beta/\left(1 - \gamma\right), \qquad \zeta' = \zeta/\left(1 - \gamma\right) \tag{8}$$

These in turn may be reduced to a single, second-order differential equation:

$$d^2T/dt^2 + adT/dt + bcT = 0 \tag{9}$$

which requires two input parameters, the starting values T_0 and

$$(dT/dt)_0 = -aT_0 - bD_0 \tag{10}$$

Assuming exponential solutions $T = T_0 e^{\omega t} = T_0 \exp(\omega t)$, there are two possible variation rates for T:

$$2\omega_+ = -a + \left[a^2 - 4bc\right]^{1/2} \tag{11a}$$

and

$$2\omega_- = -a - \left[a^2 - 4bc\right]^{1/2} \tag{11b}$$

If $a^2 - 4bc > 0$ and bc is positive, both ω_+ and ω_- are real and negative with the magnitude of ω_- greater than that of ω_+. In this case, T is a linear combination of decaying exponentials.

If bandwagoning from P to D is limited, that is, $\gamma < 1$, β' and ζ' are both positive. Then if $\gamma\beta' > \alpha$, that is, if the terrorists' rate of kill of defenders, α, is not too great, or if γ is sufficiently close to unity, c, therefore bc is positive. The remaining condition is

$$0 < a^2 - 4bc = w^2 + (\gamma\beta' - \alpha)[2w^2\zeta + \zeta^2 w^2(\gamma\beta' - \alpha)/(1 + \gamma\zeta') - 4\xi w]/(1 + \gamma\zeta')$$

Thus a sufficient condition that $a^2 - 4bc > 0$ is that

$$w\left[\zeta^2(\gamma\beta' - \alpha) + 2\gamma\zeta\zeta' + 2\zeta\right] > 4\xi(1 + \gamma\zeta') \tag{12}$$

Therefore if the terrorist suicide attack rate w is sufficiently large, compared to the defenders' rate of killing terrorists, ξ, there will always be two negative real exponentials, that is, the number of terrorists will exponentially decay. The important question is whether it will decay faster than the number of defenders.

Incorporating the initial conditions, T_0, D_0, from Equation (10), the time-dependent solution for the terrorist forces becomes

$$\begin{aligned} T(t) &= T_{0\_}\exp(\omega_- t) + T_{0+}\exp(\omega_+ t) \\ &= \left\{\begin{array}{l}\left[(a + \omega_+)T_0 + bD_0\right]\exp(\omega_- t) - \\ \left[(a + \omega_-)T_0 + bD_0\right]\exp(\omega_+ t)\end{array}\right\}/(\omega_+ - \omega_-) \end{aligned} \tag{13}$$

Solving for D in Equation (4), the time evolution of the defender forces becomes

$$\begin{aligned} D(t) &= D_{0\_}\exp(\omega_{-}t) + D_{0+}\exp(\omega_{+}t) \\ &= -\{(a+\omega_{-})[(a+\omega_{+})T_0 + bD_0]\exp(\omega_{-}t) - (a+\omega_{+}) \\ &\quad [(a+\omega_{-})T_0 + bD_0]\exp(\omega_{+}t)\}/b/(\omega_{+}-\omega_{-}) \end{aligned} \tag{14}$$

By hypothesis, both $T_0 = T_{0+} + T_{0-}$ and $D_0 = D_{0+} + D_{0-}$ are positive so that the ratio T_0/D_0 is positive and presumed to be less than one: $T_0 < D_0$; initially the defenders outnumber the terrorists. The time-dependent ratio of forces is

$$T/D(t) = \left[T_{0+} + T_{0-}\exp(\omega_{-}-\omega_{+})t\right]/\left[D_{0+} + D_{0-}\exp(\omega_{-}-\omega_{+})t\right] \tag{15}$$

and since $(\omega_{-} - \omega_{+}) < 0$, the asymptotic limit ($t$ going to plus infinity) of this ratio is

$$\begin{aligned} T_{0+}/D_{0+} &= \left[(a+\omega_{-})T_0 + bD_0\right]/\left\{(a+\omega_{+})\left[(a+\omega_{-})T_0 + bD_0\right]/b\right\} \\ &= -b/(a+\omega_{+}) \end{aligned} \tag{16}$$

Since, from Equations (11), both $(a + \omega_{+})$ and b are positive numbers, it follows that the asymptotic value for T/D is negative, that is, $T(t)$ must vanish at some finite, positive time, t_c:

$$t_c = \ln\left\{\left[(a+\omega_{+})T_0 + bD_0\right]/\left[(a+\omega_{-})T_0 + bD_0\right]\right\}/(\omega_{+}-\omega_{-}) \tag{17}$$

(In a similar manner, $D(t)$ vanishes at a finite negative value, but this lies outside of the positive time realm for which the model is assumed to be valid.)

Since this model predicts that the terrorist forces vanish while the number of defenders is still finite, it follows that the model implies a win for the defending forces.

Sufficient conditions for the defeat of the terrorists

Sufficient conditions for the validity of Equation (17) and the conclusion drawn from it are that the two inequalities, $\gamma\beta' > \alpha$, and Equation (12) be valid.

The first requirement is that $\beta > \alpha(1-\gamma)/\gamma$. If $\frac{1}{2} < \gamma < 1$, $(1-\gamma)/\gamma < 1$ so that a *sufficient condition* to meet this requirement is that

$$\tfrac{1}{2} < \gamma < 1 \quad \text{and} \quad \beta > \alpha \tag{18}$$

This means that the bandwagoning from P into D must be limited – it can neither be too small nor too great. Further, the collateral rate of damage suffered by P, the general population, must be greater than the rate of kill of the defending forces by the terrorist suicide attacks. This second condition seems obvious: in order to turn the general population against the terrorists and to side with the defenders, the general population must be perceived to be suffering more harm than do the defenders. The first condition, that there be a significant recruitment from the population to the defending forces also seems obvious; it is not immediately obvious why there should be an upper

limit to this recruitment rate. Perhaps implicit in the model is the concept that if the defense forces grow too large, they will become cumbersome, excessively destructive, and too big a burden for the population.

Since, by hypothesis, $\zeta(\gamma\beta' - \alpha)$ is a positive number, Equation (12) will be satisfied if

$$\left[2\zeta\gamma/(1-\gamma) + 2\right]w > 4(\xi/\zeta)\left[1 + \zeta\gamma/(1-\gamma)\right]$$

which is equivalent to

$$w > 2(\xi/\zeta) \tag{19}$$

Thus the final sufficiency condition for the defeat of the terrorists, in this model, is that the rate of replenishment of the terrorists, by recruitment from the general population, times the rate of self-inflicted suicide loss by the terrorists, must be greater than twice the rate at which the defending force kills the terrorists.

This implies that an exclusive strategy of suicide terrorism is self-limiting: too much bandwagoning to the terrorist ranks and/or too high a rate of suicides (which [from Equation (18)] produces a greater rate of collateral damage to the population than to the defenders) will lead to a win by the defending forces, as long as they properly limit the bandwagoning to their own ranks.

Empirical cases: Iraq, Afghanistan, and Sri Lanka

Although a detailed empirical analysis of historical cases involving suicide terrorism resides beyond the scope of this study, many elements contained in our model are reflected in actual accounts of the suicide terrorist campaigns conducted in Afghanistan (beginning in 2001), in Iraq (beginning in 2003), and in Sri Lanka (beginning in 1987). The terrorist campaigns in Afghanistan and Iraq continue today. The campaign in Sri Lanka ended in 2009. It is instructive to see how the dynamic relationships described in the model are consonant with the empirical patterns of suicide terrorism in these three states.

Afghanistan

The recent political history of Afghanistan is a study in instability and war. A republic was established in 1973 after a military coup overthrew the traditional monarchy. A second coup occurred in 1978 followed with an invasion by the Soviet Union. Soviet troops withdrew from Afghanistan in 1989, and the successor regime was overthrown in 1992 during a civil war. Fighting among various groups continued for the next decade, with the Taliban establishing de facto rule in 1996. The suicide bombing campaign in Afghanistan began on September 9, 2001, with the assassination of Ahmad Shah Masood by members of the al-Qaida terrorist organization. Masood was the leader of the Northern Alliance – an organization in conflict with the Taliban over control of the country – and therefore a competitor with the chief sponsor and protector of al-Qaida in Afghanistan. Subsequent to the invasion of Afghanistan by the United States in 2001 and the toppling of the Taliban regime, suicide bombings constituted small and infrequent acts – until 2006. Since that year, well over 500 suicide assaults have taken place in Afghanistan.

The suicide terrorist attacks conducted by the Taliban focus almost exclusively on police and military targets associated with the central Afghan government and its North Atlantic Treaty Organization (NATO) ally rather than civilians – ostensibly because the local population offers

both safe haven and recruits to the Taliban (Pape and Feldman, 2010: 126, 129). Tactically, it is logical for the Taliban to avoid producing civilian casualties in its war against the regime of Hamid Karzai and the NATO forces, since the Taliban seek to gain the support of the Pashtun sectarian community in Afghanistan. Drafted by the United States in 2004, the Afghan constitution provides unfettered power to the central government which, in its actions, has promulgated both nepotism and corruption. Pashtuns feel little allegiance to or influence over this regime and are therefore sympathetic to the Taliban's political program.

Due to these circumstances, the Taliban have chosen a coercive strategy of suicide bombing against the police and military forces of the central government and NATO. The goal of the strategy is to weaken and discredit the Karzai regime and to provoke reactions from the both the government and NATO forces that further alienate them from the population (Pape and Feldman, 2010: 128). Any collateral damage inflicted on civilians by the regime and its allies in their military operations against the insurgents serves to support the recruitment and financing efforts of the Taliban.

In sum, the Afghan case indicates the effectiveness of suicide assaults directed against government forces in both severely weakening a regime and mobilizing public support for a terrorist organization. If grievances against the government exist within a large segment of the population, such attacks may prove to be a powerful tool in manipulating public allegiances. This strategy and tactical selection of targets closely conform to findings in our model.

Iraq

Driven by concerns generated by Saddam Hussein's past and possible future weapons of mass destruction (WMD) programs, the United States invaded Iraq in March of 2003. Over the next few years, suicide bombing attacks were directed at US military and civilian personnel as well as against Iraqi security and police forces. The objective of the suicide campaign conducted by the insurgents was to create chaos among the US and Iraqi security forces and to disrupt order and weaken or destroy the governing regime. These attacks were supported by the minority Sunni population in Iraq that sought the removal of the US-backed regime.

The frequency of suicide terrorist attacks in Iraq has varied over the years, with a decline beginning in 2007 until the US withdrawal in 2011. This decline has been attributed to different causes: (1) the US troop "surge" announced on January 10, 2007, that led to a 30,000-soldier reinforcement of the American military presence in Iraq; (2) a new counterinsurgency strategy that involved smaller bases, non-mechanized patrols, and greater security for Iraqi civilians; (3) the Sunni tribal rejection of al-Qaida in Iraq and the subsequent "Anbar Awakening;" and (4) separation of Shiite and Sunni populations (resulting in the reduction of sectarian "cleansing"). The surge and the Anbar Awakening are said to have been particularly efficacious (Biddle, et al., 2012: 7–8). The US troop surge is argued to have mitigated suicide violence simply through the military suppression of terrorist organizations and their activities. However, in the case of Anbar Province, the reduction in suicide bombings is said to have resulted from a coalition strategy (the Anbar Awakening) that sought to mobilize political support from the Sunni tribal leaders in the region. Cooperation was generated through the provision of material goods and incentives for the local population to oppose terrorist groups. The result was to transform a source of support for terrorist insurgency into a "strategic partner" for the government and coalition forces. As Sunni support for the institutional arrangements of the new regime grew, the value of suicide assaults against both government and coalition forces declined. Biddle, et al. (2012: 10–11) argue that a synergistic interaction between the surge and the Anbar Awakening produced the decrease in suicide attacks and the reduction in military and civilian casualties.

Consistent with our model, the Iraqi case indicates the use by terrorist organizations of widespread and brutal suicide attacks against security forces for the purpose of promoting chaos and undermining or destroying the governing regime. However, as security forces impose greater constraints and costs on the activities of terrorist organizations and as major groups within the population are mobilized and brought into partnership with the government forces, the antiterrorist elements supportive of the regime grow in strength and the suicide attacks diminish in frequency.

Sri Lanka

Following independence in 1948, the government of Sri Lanka – dominated by ethnic Sinhalese – discriminated against the Tamil ethnic minority. The Sinhalese are Buddhist, whereas the Tamils are Hindu; besides religious differences, there are linguistic divisions between these ethnic groups as well. In 1983 when civil war broke out between the Sinhala and Tamil populations, an insurgent group known as the Liberation Tigers of Tamil Eelam (LTTE) began a campaign of suicide terrorism designed to create an independent Tamil state in the northern and eastern areas of Sri Lanka.

As Pape and Feldman (2010: 295, 309) note, the LTTE sought to coerce – by means of guerrilla warfare and suicide terrorism – the government of Sri Lanka into acquiescing in the creation of an independent Tamil state. The LTTE cadre of "Black Tigers" carried out suicide terrorist attacks against military, civilian, and political targets supportive of the regime. These targets included military and political leaders, government centers, and the country's political, economic, and cultural infrastructure.

The suicide terrorist operations of the LTTE were supported by the Tamil population, and the Black Tigers were viewed as advancing the interests and welfare of the Tamils. The LTTE won this allegiance in part by providing social and economic resources to the Tamil community, which responded in recruiting between 10,000 and 15,000 fighters to the LTTE cause. From 1983 until 2009 – when they were annihilated by the Sri Lankan government – the LTTE carried out 116 suicide attacks and became known as one of the deadliest terrorist organizations in the world (Pape and Feldman, 2010: 284, 308).

The case of Sri Lanka and the LTTE insurgency contains many features congruent with our model. The support generated within a sympathetic community for the LTTE by its suicide terrorist attacks against the government forces and the subsequent recruitment from that population to the organization's ranks is consistent with our model's dynamics. Moreover, the lengthy struggle leading to the utter destruction of the LTTE in its final geographical area of redoubt presents an empirical instance – in extremis – of the attritive and regenerative interactions among a regime, a suicide terrorist organization, and a population, that is described in our model.

Summary

These case studies were selected and used only as illustrative examples of the basic dynamics described by the model. The goal of mathematical models is to create broad generalizations that apply (to greater or lesser extent) in a wide number of cases. The model may fit closely or loosely with specific cases, but if it produces generalizations that are empirically accurate, and if some of those generalizations are novel or unexpected, then the model has served its purpose. It is instructive and useful to see how the dynamic relationships described in the model coincide with the empirical patterns of suicide terrorism in Afghanistan, Iraq, and Sri Lanka – even though there are significant differences as well as similarities among these cases. The fact that the basic dynamics described in the model are consistent across a broad range of cases supports the conclusion that the model captures fundamental forces at work in the real world.

Conclusion

A growing body of research has produced mathematical and empirical findings relevant to understanding the sources of suicide terrorism, its functions, timing, and rationale, as well as policy prescriptions for governments confronting terrorist organizations that employ the tactic. This article develops a linear model depicting relationships of the principal parties involved in such a confrontation: the terrorists, using the tactic of suicide assault to destabilize a society; the society's defenders (police and military); and the general population (from which replenishment for the ranks of the terrorists and defenders may be drawn). The model is a set of three, linear, first-order differential equations, whose solutions may be used to predict the outcome of the conflict, given the initial conditions. In general, the model parameters and initial conditions are not known, and so general properties of the solutions were sought that describe situations where the terrorist attack on society is self-limiting.

The key elements in the model are attrition rates to both the terrorist and government forces, levels of collateral damage inflicted on the general population by the terrorist and the government forces as they try to destroy each other, and rates of replenishment to the terrorist ranks and to the government forces by members of the general population. In essence, the model explores the logical interrelationships of suicide terrorism, counterterrorist operations, and political mobilization. Our model predicts that the defenders of the social order will win if bandwagoning from the general population to both the terrorist and defender ranks is limited; if the rate of collateral damage to the general population is greater than the rate of defender losses; and if a specified inequality between the rate factors for suicide attacks, terrorists killed by the defenders, and bandwagoning from the population to the terrorist organization, is satisfied.

Bueno de Mesquita (2005, 2008) and Bueno de Mesquita and Dickson (2007) show that government counterterrorism policies that do not negatively impact the economy or that do provide political or economic rewards to the general population will undercut the ability of terrorist organizations to recruit public support for their programs.[12]

We demonstrate a more specific result with our model: it is imperative that government counterterror operations avoid collateral damage to the general population in order to minimize political mobilization to the terrorist cause. This finding provides mathematical support for the empirical observations of both Bloom (2005) and Pedahzur (2005), and is consonant with the dynamic relationships exhibited among government forces, terrorist organizations, and the general population in the suicide campaigns conducted in Afghanistan, Iraq, and Sri Lanka.

Hence, the model identifies a serious dilemma for a government engaged in counterterrorist operations: it needs to vigorously pursue the destruction of the terrorist organization, but it simultaneously knows that harm inflicted on the general population alienates the populace from the government's cause and mobilizes support for the terrorist group.[13] The clear policy implication of the model is the need for central authorities to engage in carefully calibrated counterterror campaigns that minimize the number of civilian deaths.

In addition, an interesting and novel counter-intuitive finding of the model is that bandwagoning from the population to the defense forces cannot be too great if the government is to win the conflict. An explanation for this unexpected finding revolves around an unanticipated outcome following the growth of the government forces and their increased counterterror capabilities. Specifically, as the civilian population bandwagons to the side of the government, this permits the state to unleash its forces and engage in more intrusive anti-terror operations. However,this development shifts the initiative to the insurgents who now need to increase their violent acts in order to gain coercive leverage (Rosendorff and Sandler, 2004). In short, bandwagoning encourages escalation, especially by the weaker side (Zhukov, 2013). Hence, extreme bandwagoning to the side of

the defense forces leads to increased levels of violence by the insurgents and to a weakening of the government. Indeed, the implication is that the government forces do better if the general population remains at relatively low levels of mobilization. Therefore, a second prescription for the government derived from the model would include the recommendation to pursue policies (both in counterterrorist operations and otherwise) that contribute to the political quiescence of the general population.

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Notes

1. For example, see Wright ([1942] 1964: 136).
2. Also see Saperstein (2008).There are two possible sources for the government and the insurgents to draw additional personnel: sources external to the state and sources internal to the state. The model makes use of the simplifying assumption that all significant personnel increments will come from the population base internal to the state's boundaries. With regard to insurgent forces, the assumption of principally internal augmentation is not unrealistic in most cases of suicide bombing campaigns (e.g., the 18 cases cited by Pape, 2003, 2005 and Pape and Feldman, 2010). The question of the relevance of external augmentation of personnel for the government forces (and, hence, the accuracy of the assumption limiting mobilization to internal sources) is a more ambiguous issue. Focusing on the 18 suicide bombing campaigns discussed by Pape (2003, 2005) and Pape and Feldman (2010), only in the cases of Afghanistan and Iraq did the government forces receive support personnel from external sources. However, these two cases were unique among the set of suicide bombing campaigns insofar as the governments in these two states were established as the result of interstate wars (2001 and 2003) and subsequent foreign military occupation. The United States defeated the extant governments in Afghanistan and Iraq and fought, thereafter, alongside the newly established regimes against domestic insurgencies. In short, the US military and its creations (the Afghan and Iraqi governments) were allied entities that competed against insurgent groups for support from the indigenous populations.
3. There is, however, little agreement among scholars and analysts as to what constitutes the phenomenon of "suicide terrorism" (e.g., Crenshaw, 2007; Goodwin, 2006). For example, Goodwin (2006: 317–318) argues that a focus only on the tactic of suicide itself in an attack and not on the identity of the target leads some scholars (e.g., Bloom, 2005; Pape, 2003, 2005) to conflate terrorism (directed at civilians or noncombatants) with guerrilla warfare (directed at soldiers, police, and political leaders). By way of contrast, Gambetta (2005a: 263–264) distinguishes between "suicide terrorism" and "suicide military missions." This distinction creates differences in case sets and the conclusions that are drawn in both quantitative and qualitative analyses (Crenshaw, 2007: 134).
4. In a different (non-strategic) approach, Thayer and Hudson (2010) argue that the following factors explain Islamic suicide terrorism: high levels of gender differentiation; polygyny; religious sanction for suicide; and obstructed marriage markets. These conditions, promulgated by Islamic culture, contribute to the growth and spread of terrorist organizations using suicide attacks.
5. Pape's definition of suicide terrorism has been criticized by Goodwin (2006) and Crenshaw (2007).
6. Also see Siqueira and Sandler (2006) on this point.
7. A number of studies, some empirical and some mathematical, focus on the strategic relationship between terrorist and government decisions. For example, see Arce M. and Sandler (2005), Enders and Sandler (1993), and Powell (2007).

8. For example, see Clauset, et al. (2007).
9. For example, see Arbesman, et al. (2009).
10. For example, see Saperstein (2010b) and Clauset, et al. (2010).
11. See Saperstein (2010a).
12. An empirical test of Bueno de Mesquita's (2005) model by Benmelech, et al. (2012) indicates that poor economic conditions support more destructive suicide terror attacks by permitting the recruitment of better-qualified terrorists.
13. Ellsberg (1970) presents an early appreciation of this dilemma. A similar dynamic is reported by Condra and Shapiro (2012) in their empirical analysis of the military consequences of collateral damage in civil war. Specifically, collateral damage inflicted on civilians by government forces during a civil war predicts higher subsequent levels of attacks directed against counterinsurgency forces. However, Valentino, et al. (2004) argue that intentional mass killing of civilians by government forces during guerrilla wars may be a strategic decision designed to inhibit civilian cooperation with the insurgents. When less violent tactics fail to abort the insurgency, the incentives for government forces to engage in the mass killing of civilians rise. Zhukov (2013) explores the logic for both governments and insurgents to either intentionally harm or avoid harming civilians in civil wars as well as the choice of civilians to either oppose or join with the party that is inflicting the most punishment. He concludes that with perfect information, civilians are always better off opposing the victimizer, and government and insurgent forces are better off avoiding punishment to the population.

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