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ABSTRACT

Governments fighting terrorists have many tactical options, yet these options often yield unintended and counterproductive consequences. This paper models a terrorist organization, a religious group from which the terrorists recruit suicide bombers, and the society in which the terrorists are embedded. The model illuminates how the choice of anti-insurgent tactics influences the incidence of attacks, paying particular attention to the direct and indirect (unintended) consequences of the government's actions. The ultimate goal of this work is to identify the best way to stop terrorist attacks

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1 Introduction

Wars involve difficult choices. Nowhere is this more evident than in fighting terrorists who commit acts of violence such as suicide attacks against civilians in pursuit of political or other objectives. Governments and other counterterrorist agents have many preemptive and deterrent options to consider, and each possible tactic can produce a different kind of externality (Arce and Sandler 2005). Yet, determining the best tactic or combination of tactics to employ against terrorist organizations is a complicated problem because the optimal counterterrorist action depends on the target's response to the tactics and on the scope and scale of indirect and unintended consequences. These factors, in turn, depend upon the structure of the terrorist organization and the nature of the society in which it is embedded. Identifying the best counterterrorist tactics require the simultaneous consideration of these many factors in their inherently strategic setting. We present a game theoretic model of a terrorist organization that specializes in suicide bombings and show how to predict the terrorists' reactions to and indirect consequences of counterterrorist efforts, thereby allowing us to identify optimal counterterrorist actions.

Though there is no standard way to classify counterterrorist activities, our reading of the military manuals suggests the following categories.[1] *Attrition* tactics focus on capturing or killing enemy combatants and taking steps to harden targets. In contemporary terms, this means stopping the suicide

[1]Roberts and Everton (2010), for example, prefer classifying by "kinetic" and "non-kinetic," while Arce and Sandler (2005) distinguish actions by the externalities they generate. We relate our classification to theirs in Section 5. Alternatively, Kydd and Walter (2006) classify counterterrorist policies by the terrorist activities they are meant to counter.

bombers before they strike and hardening infrastructure to reduce damage done by bomb blasts. *Direct action* focuses on the opposing organization, usually by capturing or killing key leaders so that the organization collapses. *Covert action* also focuses on the opposing organization, but attempts to disrupt its operations through surreptitious means, rather than killing or capturing key personnel. *Civic action* focuses on supporters (potential and current) of an organization. The idea is to offer appealing alternatives in hopes of inducing the population to cease supporting the insurgents and increasingly support the government.

The impact of these tactics depends, in part, on how the target responds to them and on other indirect and unintended consequences. Consider the following: terrorists traditionally confront attrition by avoiding contact with superior forces and beginning engagements only when they have a tactical advantage; they deal with direct action by minimizing communications among members and concealing key personnel; they resist civic action by attacking government personnel (such as aid workers, school teachers, and local officials), terrorizing civilian populations, and increasing their own efforts to attract adherents. Attacking terrorist organizations in one direction can push them in other unanticipated and counterproductive directions (Bueno de Mesquita 2005, Bueno de Mesquita and Dickson 2007). For example, Israeli counterterror measures such as aerial bombing and economic blockade have inflamed Palestinian public opinion and mobilized support for militants (Bloom 2004). Israel's bombing of southern Lebanon strengthened Hezbollah, by degrading the social and educational services provided by the Lebanese government and

increasing the population's reliance on similar services provided by the Islamic organization. The United States' military's tactics during the early stages of the insurgency in Iraq backfired: pursuing terrorists conventionally and then withdrawing from the field protected coalition soldiers from suicide bombings in the short run but ceded control of the streets to opponents of occupation.

Our model is constructed to account for various counterterrorist options and the many possible consequences of those options. We here focus on a terrorist organization that coordinates suicide attacks on civilians, a religious group from which the terrorist organization recruits suicide attackers, and the society in which both operates. The model has several salient features. Individuals choose between participating in a religious group or engaging in secular activities. Drawing from the economics of religion literature, we model the benefits that individuals receive from participating in the group's activities as positively related to their experience with the group and their allegiance to the organization. We label these factors *group capital*. The benefits that individuals receive from other activities depend on their returns in the workplace. These returns depend upon individuals education, talents, skills, and experience. We label these factors *human capital*. From the religious group, the terrorist organization recruits combatants, who then conduct suicide missions. The terrorists try to recruit suicide bombers with high group capital—which increases the likelihood that they follow through with their task—and high human capital—which increases the likelihood that they succeed. The cost of identifying, screening, and motivating suicide bombers varies with the size of the group. The cost of training the suicide bombers depends upon the candi-

date's group and human capital. Combatants with higher religious and human capital are easier to train and more likely to succeed.

The model's structure enables us to determine how the government's tactics influence the terrorist organization's ability to launch successful suicide strikes. We decompose the impact into direct consequences, which hold the behavior of the population (and all potential combatants) constant, and indirect consequences, which are those that occur after the population reacts to the side-effects of the government's actions. We also examine the terrorist organization's reaction to the government's tactics and how the government's tactical choices change when it takes the insurgent's reactions into account. Our model enables us to determine the best way to hinder an organization from recruiting, training, and motivating suicide bombers. More generally, we intend for our approach to advance our more general understanding of how to best identify counterterrorist actions for even more settings.

2 Related Literature

Our model builds on a wide-range of empirical and game theoretic work in economics, political science, and sociology. We here mention some of the most relevant sources.

Berman (2003), Iannaccone (2006), and Iannaccone and Berman (2006) draw theoretical connections between religion and violence. They propose a club good framework in which voluntary religious organizations provide public goods. The sacrifices that these groups demand from members make the groups well suited for solving the extreme principal-agent problems when

mobilizing militants. In other words, because religious groups, particularly radical ones, solve defection problems so well, they are well positioned to produce violence. This logic provides a theoretical connection between religion and violence.

Berman and Laitan (2006), Berman and Laitan (2008), and Berman (2009) examine empirical evidence of the above theoretical link. The first shows that suicide attacks are favored by the radically religious. Radical religious clubs choose suicide terrorism more often and are unusually effective at it. Suicide attacks are chosen when targets are hard to destroy without high risk of capture. The club model emphasizes the function of radical religious organizations as providers of benign local public goods. The second article presents evidence that missions organized by radical religious clubs that provide benign local public goods in the absence of competing provision by government are both more lethal and are more likely to be suicide attacks than missions organized by other terrorist groups with similar aims and theologies. Suicide attacks are chosen when targets are "hard," i.e., difficult to destroy. The final reference is a recent book that brings all of the above together.

Sandler and Arce (2003) and Sandler and Siqueira (2009) survey the game theoretic work on terrorism. Such work is concerned with the allocation of counterterrorism resources across potential targets, allocation across preemptive and deterrent activities, the influence of domestic politics, the role of informational asymmetries, and more. A few papers are particularly relevant for our purposes because they link terrorist recruitment with counterterrorist activities and the larger social setting. Inspired in part by Frey and Luechinger

(2003), Arce and Sandler (2005) emphasize the difference between preemptive and deterrence counterterrorist strategies, showing that the latter is generally chosen even though the former yield wider benefits and positive externalities. In a model that captures public support for terrorism and terrorist recruitment, Faria and Arce (2005) show that focusing on liberal ideals such as reducing repressing and improving economic opportunities are effective at reducing terrorism. By centering attention on how the counterterrorist activities affect recruiting through various channels, they can characterize the optimal level of counterterrorism policies. Bueno de Mesquita (2005) argues that government crackdowns may increase or decrease support for terrorism, depending on the relative effects of counterterrorism on economic opportunity, ideology, and the success of terrorist organizations. This model reconciles two seemingly contradictory empirical findings: terrorist operatives typically have above-average educations and incomes, yet poverty and recessions are positively correlated with terrorism.

Our analysis relies upon on a number of stylized facts about suicide bombings established by earlier studies. First, support for suicide bombings appears independent of socio-demographic and economics variables (Krueger and Maleckova 2003), though the tactic is favored by groups associated with certain forms of religion (Moghadam 2008). This suggests that factors unrelated to economic conditions also matter in an individual's decision to participate. Second, suicide bombings increase in frequency during bad economic times (see discussion in Bueno de Mesquita 2005), which suggests that economic conditions also matter. Finally, insurgent organizations typically recruit in-

dividuals with above-average educations and high human capital. Insurgents prefer high-skilled individuals because they are easier to train and more effective as operatives (Krueger and Maleckova 2003, Berrebi 2003).

We acknowledge that no simplified model can account for all features of terrorist organizations and the settings in which they recruit and conduct suicide attacks. For example, terrorist groups vary in their motives and levels of militancy, thus creating additional information asymmetries (Arce and Sandler 2007; Arce and Sandler 2010). Yet, we constructed our model to capture many of aspects of actual terrorist groups' operations as identified by Crenshaw (2007). Suicide attacks occur in larger strategic social settings, loyalty to a group can enhance the individual's commitment to follow through on terrorist acts, and many of these groups have a religious association. Our approach falls more generally in the category of economic approaches to studying terrorism (Enders and Sandler 2005; Intriligator 2010) but differs from these earlier works in important ways: we focus on a wide range of intervention options that can be used to deter the terrorist organization; our analysis is formal and analytic; and we have the express goal of producing a tractable framework in which to study the behavior or governments, terrorists and insurgents, and their populations.

3 Model

Our model examines a typical recruitment situation. A set of individuals form a population, and a subset of those individuals comprise a group that provides religious and social services for group members. The quality of the

group's services depends on the members' group capital and the efforts they expend on group production. We model the group as a religious club, along the lines of Iannaccone and Berman, because these organizations often serve as recruiting grounds for suicide bombers. We note, however, that the group need not be religious *per se*, though we believe that the religious context helps us sharpen focus. The crucial assumption is that the group produces nonrival but excludable services (i.e. club goods) using group-specific human capital. These characteristics fit a wide range of organizations that support terrorist activities.

The terrorist organization recruits individuals from the religious club to become suicide bombers. Suicide bombers operate individually, strike once, and then cease activity. The finality of these singular strikes simplifies our model, but the nature of the mission could be changed without loss of generality.

The government, which will be treated exogenously for simplicity, can intervene to affect the incidence of attacks. The terrorists, the suicide bomber, the religious club, and the population at large may respond to the government's choice of tactics.

3.1 Individuals and Religious Group Production

An individual is defined by two traits: her level of group capital, k_i, and her level of human capital, h_i. An ordered pair, (k_i, h_i), defines an individual's type. For simplicity, we treat both aspects of an individual's type to be exogenous.

An individual has one unit of a resource (such as time or effort) to allocate

between group and secular activities. Let $d_i \in [0,1]$ be the amount of resource allocated to group devotion and $1 - d_i$ be the amount devoted to secular activities. In the religious setting, devotion may correspond to study at the group's school, attendance at group services, or participation in other group events.

Each individual i chooses d_i to maximize her utility function

$$u_i(d_i) = \begin{cases} Z(d_i|h_i, \alpha), & d < D, \\ G(k_i, \beta, D) + Z(d_i|h_i, \alpha) & d \geq D. \end{cases}$$

$Z(d_i|h_i, Y)$ is individual i's secular benefits, which is decreasing in her resources allocated to devotion d_i but increasing in her human capital h_i and in an exogenous parameter α. We also assume that the cross-partial derivative with respect to d_i and h_i is negative: the loss in secular benefits from an increase in religious devotion d_i decreases as h_i increases. The exogenous parameter α captures anything, such as the extent of the secular marketplace or set of secular commodities, that positively alters her secular benefits while holding all else constant. These shift parameters will capture the influence of particular counterterrorist activities to be described later. We assume that the cross partial derivative between α and d_i is also negative. Parameter D will be described below.

We operationalize these assumptions in the following condition:

Condition 1 *(a) Secular benefits equal zero if* $d_i = 1$*:* $Z(d_i = 1) = 0$.

(b) Secular benefits strictly decrease and are differentiable in d_i*:* $Z_d < 0$.

(c) Secular benefits strictly increase and are differentiable in h_i *and* α*:* $Z_h > 0$ *and* $Z_\alpha > 0$.

(d) For secular benefits, the cross-partial with respect to h_i and d_i is negative, $Z_{dh} < 0$, as is the cross-partial with respect to α and d_i, $Z_{\alpha d} < 0$.

$G(k_i, \beta, D)$ is individual i's benefits of religious group participation. As mentioned in the literature review above, religious groups are clubs providing excludable club goods, and because of the positive externalities in club good production, a group must solve the free-rider problem to provide benefits to its members. Our G function draws from this conception of a religious group and, in particular, from Iannaccone's (1992; 1994) work. The group confronts the free-rider problem by having a minimum level of observable devotion, denoted D, that any individual must meet in order to obtain the benefits of group membership. If an individual devotes less than the minimum ($d < D$), then she is not admitted into the group, and she receives no group benefits even if she exerts some devotion. If her devotion meets or exceeds the minimum ($d \geq D$), then she is admitted into the group and she receives group benefits.

As in the theory, the minimum level D serves as a screening device thereby altering the quality of the religious goods. First, by screening out less-committed individuals, it raises the average commitment level and decreases free-riding, thereby increasing the overall quality of the religious goods. Second, by screening out some individuals, it decreases the overall resources of the group, thereby decreasing the quality of religious goods. We assume that the first effect dominates at low D while the second effect dominates at high D, thereby making G hump-shaped in D for each individual. The exact benefits to i will depend on D, but they will also be increasing in her group capital k_i and in parameter β, which represents the strength of the first factor.

These condition are formalized as follows:

Condition 2 *(a) Religious group benefits are non-negative,* $G \geq 0$*, and equal to zero if* $k_i = 1$*,* $G(0, \beta, D) = 0$*.*

(b) Religious group benefits strictly increase and are differentiable in k_i *and* β*:* $G_k > 0$ *and* $G_\beta > 0$*.*

(c) Religious group benefits are strictly concave and twice differentiable in D *with* $G_D|_{D=0} > 0$*,* $G_D|_{D=1} < 0$*, and* $G_{DD} < 0$

3.2 The Recruiter and Suicide Bomber Recruiting

The suicide recruiter cares about the length of time required to identify a recruit and to train the recruit to become a suicide bomber. For clarity of expression, we refer to the recruiter as a male and other individuals, including the recruit, as female. We also refer to the male recruiter as if he was a person, though it can also be appropriate to consider the recruiter as an organization. Both identifying and training the recruit are necessary, and both are costly. All else equal, the recruiter prefers a shorter length of time for each, however, the time required for each depends on the size of the group and the characteristics of the recruit.

Drawing from the literature on the characteristics and motivations of suicide bombers, we further suppose that a suicide bomber is more effective at her mission if she has a high degree of social capital that ties her to the group and a high degree of human capital that is necessary to carry out the suicide mission. On the one hand, high *group* capital is necessary for the recruited individual to be willing to sacrifice herself for the goals of the recruiter and

group. The social capital provides the motive, commitment, community connectedness that leads the recruit to choose to carry out the mission. On the other hand, high *human* capital is necessary for the recruit to have the skills required to carry out the mission. Human capital provides the knowledge of explosives and nerves necessary to arrive safely at the designated location undetected and complete the task.

To capture these notions formally, we make a few assumptions. First, before selecting which individual to train, the recruiter must exert costly resources discerning the types of all individuals in the group. He must, for example, follow their daily activities to see that they are above suspicion by the government, see that their devotion to the recruiter's cause is sufficient, etc. Second, after identifying the types of all group members, the recruiter chooses to recruit that individual who will take the fewest resources to train.

We capture these features of recruiting in the recruiter's utility function

$$v = -R\left(M, \lambda\right) - T\left(k_i, h_i, \theta\right).$$

R is the time needed to discern the the social and human capital levels of all group members, and M is the (membership) size of the group. The time is increasing in group size, $R_G > 0$. T is the time required to train an individual of type (k_i, h_i) to carry out the mission. T is decreasing in k_i and h_i. Intuitively, less training is required the larger the individual's religious and human capital. Because time is costly for the recruiter, his utility is decreasing in time.

λ and θ are shift parameters that cause each entire function to increase holding all else constant, i.e., $R_\lambda > 0$ and $T_\theta > 0$. These parameters, and

the similar ones in the individual's utility function, play an important role in our analysis as they will be used to capture different types of intervention. They will capture channels through which counterterrorist activities affect the incidence of suicide attacks, including many of those identified by Frey and Luechinger (2003) and Faria and Arce (2005). For example, improving economic conditions or other opportunity costs to participation will increase α for individuals, while hardening targets will increase θ for the recruiter. We will elaborate on these possibilities below in Section 5.

Because he perfectly discerns the types of all group members and selects the easiest individual to train, the recruiter's final utility follows automatically once the group's composition is complete.

4 Equilibrium Analysis

4.1 Equilibrium

An individual's choice involves comparing the highest utility when not joining the group ($d < D$) with the highest utility when joining the group ($d_i \geq D$). Given that increasing devotion d_i decreases her secular utility Z, the best devotion d_i less than the D is $d_i = 0$. Increasing devotion d_i above D also decreases secular Z but does not affect the group benefits G, so the best devotion d_i greater than or equal to D is $d_i = D$. Thus, the best d_i is either

$d_i = 0$ or $d_i = D$. Joining is optimal if

$$\begin{aligned} u_i\left(d_i = D\right) &\geq u_i\left(d_i = 0\right) \Rightarrow \\ G\left(k_i, \beta, D\right) + Z\left(d_i = D | h_i, \alpha\right) &\geq Z\left(d_i = 0 | h_i, \alpha\right) \Rightarrow \\ G\left(k_i, \beta, D\right) &\geq Z\left(d_i = 0 | h_i, \alpha\right) - Z\left(d_i = D | h_i, \alpha\right). \end{aligned} \quad (1)$$

Because the right hand side is positive, the inequality holds only if her group capital k_i is sufficiently high. Specifically, we can define $\widehat{k}\left(h_i, \alpha, \beta, D\right)$ where the optimal devotion d^* is such that

$$d_i^* = \begin{cases} 0, & \text{if } k_i < \widehat{k}\left(h_i, \alpha, \beta, D\right), \\ D, & \text{if } k_i \geq \widehat{k}\left(h_i, \alpha, \beta, D\right). \end{cases} \quad (2)$$

We note that $\widehat{k}$ is increasing in h_i. From Condition 1(d), an increase in h_i will increase the second term of the RHS of inequality (1) by less than it increases the first term, thereby implying a rise in the RHS. The LHS does not change, thus to maintain the equality implied by the definition of $\widehat{k}$, there must be a rise in k_i.

To match the screening motivation for D, we also make an additional restriction that $\widehat{k}$ is increasing in D. This occurs when G_D is sufficiently low or $|Z_d|$ is sufficiently high in absolute value. For individuals at the margin, any increase in religious benefits from an increase in D must be outweighed by the loss in secular benefits from a similar increase in devotion.

After observing all individuals with $k_i \geq \widehat{k}\left(h_i, \alpha, \beta, D\right)$ join and all with $k_i < \widehat{k}\left(h_i, \alpha, \beta, D\right)$ not join, the recruiter identifies one individual from the set of those who joined the group to be the recruit. That individual is the one that gives the recruiter the highest utility (minimizes the total training time). Let i^* denote that recruited individual.

Summarizing, the equilibrium consists of two parts: a profile of devotion levels, i.e., d_i^* for each i with (k_i, h_i) according to (2), and the optimal recruit selection by the recruiter. The following example illustrates.

Example 1. Consider a set of individuals with types uniformly distributed over $[0,1] \times [0,1]$. The first dimension refers to group capital k_i, and the second dimension refers to human capital h_i. For the individual, let $G = k_i(\beta D - D^2)$ and $Z = \alpha h_i(1 - d_i)$ for the individuals. To be consistent with Conditions 1 and 2, assume $d_i \in [0,1]$, $D \in [0,1]$, $\alpha > 0$, and $1 < \beta < 3$. For the recruiter, let R equal the group's size, and let $T = \max -\lambda(1 - k_{i^*}) - (\theta - k_{i^*})(\theta - h_{i^*})$, where i^* is the individual selected to be the recruit, $\lambda > 0$, and $\theta > 0$. The parameter θ can be thought of as the level of capital needed to carry out the mission. With $\theta > 1$, some training will always be necessary because k_i and h_i are both weakly less than 1. With $\theta \leq 1$, training might or might not be necessary depending on who is recruited. Notice that this T function takes as given that k_i and h_i are both weakly less than 1.

An individual will join the group if inequality (1) is satisfied:

$$k_i\left(\beta D - D^2\right) \geq \alpha h_i - \alpha h_i(1 - D).$$

Solving for $\widehat{k}(h_i, \alpha, \beta, D)$, we obtain

$$\widehat{k} = \frac{\alpha h_i}{\beta - D}.$$

Consistent with the more general model, we observe $\frac{\partial \widehat{k}}{\partial h_i} > 0$ and $\frac{\partial \widehat{k}}{\partial D} > 0$.

Figure 1 depicts an equilibrium when $\frac{\alpha}{\beta - D} > 1$ and $\theta > 1$. The shaded area depicts those individuals who joined the group, and the unshaded area is

those individuals who did not join. The point designated by the dot at (θ, θ) represents the religious and human capital levels needed by an individual to carry out the suicide mission. Having $\theta > 1$ seems more plausible than $\theta < 1$ because we suppose that any recruit should require some training. An individual at $(k_i, h_i) = \left(1, \frac{\beta - D}{\alpha}\right)$, depicted by the dot at that point, is recruited by the recruiter because that individual minimizes the training. The recruiter's utility is

$$v = -\lambda \left(\frac{\beta - D}{\alpha} \right) - (\theta - 1) \left(\theta - \frac{\beta - D}{\alpha} \right).$$

Figure 2 depicts an equilibrium with $\frac{\alpha}{\beta - D} < 1$ and $\theta > 1$. In this case, the recruiter selects an individual with $(k_i, h_i) = (1, 1)$. The recruiter's utility is

$$v = -\lambda \left(1 - \frac{1}{2} \frac{\alpha}{\beta - D} \right) - (\theta - 1)^2 . \ \square$$

4.2 Comparative Statics

Before turning to the types of intervention, it is instructive to consider how various exogenous shocks to the model will affect the equilibrium frequency of suicide bombings. We distinguish between two types of shocks. The first type of shock is a shift in one of the model's parameters. There are four exogenous shift parameters: the secular benefits parameter α, the religious group production parameter β, the recruit screening parameter λ, and the recruit training parameter θ. We also treat the group's devotion level D as an exogenous parameter. The second type of shock is a shift in the distribution of types. As will be discussed below, a single intervention may imply shifts in multiple parameters and also shifts in the distribution of types. However,

before considering these more complicated scenarios, we will first consider single shifts.

Let us first consider the effects of shifts in those parameters that affect an individual's choice to join or not join the group, i.e., parameters α and β. An increase in α corresponds to an increase in secular benefits for all human capital levels which could be caused, for example, by improved economic conditions. Because $Z_{\alpha d} < 0$, an increase in α causes that RHS of inequality (1) to increase, which implies that $\widehat{k}$ shifts up for all values of h_i, β, and D. The size of the religious group decreases, and this has counteracting effects on the frequency of suicide bombings. The smaller group implies less time spent screening, but a smaller group also implies that the recruiter will be less likely to find an individual easy to train, thereby suggesting an increase in time training the recruit. Whether or not the frequency increases will depend on the relative costliness of screening relative to training. If screening is costly relative to training, which can be signified by a high value of λ, then the first effect dominates and suicide bombings actual increase in frequency.

Figure 3 depicts this scenario with $\frac{\alpha}{\beta - D} < 1$ and $\theta > 1$ in the model from Example 1. The increase from α to α' increases the slope of $\widehat{k}$. The lightly shaded area designates those individuals who join the group in the new equilibrium, while the darkly shaded area designates those individuals who join in the old equilibrium but not in the new equilibrium. The left-most dot is the individual selected in the new equilibrium. If λ is very large, then the decrease in screening time will more than make up for the increased training time from the point of the view of the recruiter, and the frequency of suicide

bombings will increase. But if λ is very small, then the frequency of bombings will increase because of the increased training time.

By similar logic, we observe that a decrease in economic opportunities depicted as a decrease in α will have the opposite effect of an increase in a, akin to moving from α' to α in Figure 3. Moreover, an increase in the productivity of religious goods, depicted by an increase in β, also has the opposite effect of an increase in α. An increase in D has the same effect qualitatively as an increase in α. In all these cases, the exogenous shock directly affects the individuals' decisions to join, thereby changing the size and composition of the group and indirectly affecting the screening and training of recruits. In each case there are potentially offsetting effects on the overall frequency of suicide bombings.

Shifts in λ and θ do not affect an individual's decision to join the group and so do not affect the group's composition or the recruiter's selection of the recruit. They only affect the recruiter's utility and frequency of suicide bombings. An increase in λ or θ increases the time spent recruiting or training, respectively, and decreases the frequency of bombings.

A change in the distribution of types will not change a single type's optimal decision, though it can alter the group's composition and the recruiter's selection. Individual i still chooses to join according to (2), but the new population may now be such that some types no longer exist while others now exist or some types now exist in more frequency than others. In our model, a shift in the distribution that does not change the support of types may potentially affect the group size and, hence, the screening cost to the recruiter, but it will

not change the type of individual selected nor change the training cost. Only a shift in the distribution that eliminates a type that would have been selected will change the identity of the type selected and the training cost.

Revisiting Example 1 illustrates this point. Example 1 assumed a population density

$$f(k_i, h_i) = \begin{cases} 1, & \text{if } k_i \in [0,1] \text{ and } h_i \in [0,1], \\ 0, & \text{otherwise.} \end{cases}$$

But now suppose that the density is

$$f(k_i, h_i) = \begin{cases} \frac{3}{2}, & \text{if } k_i \in [0,1] \text{ and } h_i \in \left[0, \frac{1}{2}\right], \\ \frac{1}{2}, & \text{if } k_i \in [0,1] \text{ and } h_i \in \left[\frac{1}{2}, 1\right], \\ 0, & \text{otherwise.} \end{cases}$$

Only the relative frequency of types has changed, not the overall population size. This shift is akin to an even drop in human capital by half of the high human capital types. Suppose the initial equilibrium with uniform density is that depicted in Figure 1 and that Figure 4 illustrates the new equilibrium. In Figure 4, the dark area signifies density $\frac{3}{2}$, and the light area signifies density $\frac{1}{2}$. In the new equilibrium, the group composition and size is now different than in the old equilibrium. The old equilibrium had group size $\frac{1}{2}\left(1 - \frac{\beta - D}{\alpha}\right)$, and the new group has size

$$\begin{aligned} &\frac{3}{2}\left[\left(\frac{1}{2}\right)\left(1 - \frac{\alpha}{2(\beta - D)}\right) + \frac{1}{2}\left(\frac{1}{2}\right)\left(1 - \frac{\alpha}{2(\beta - D)}\right)\right] \\ &+\frac{1}{2}\left(1 - \frac{\alpha}{2(\beta - D)}\right)\left(\frac{\beta - D}{\alpha} - \frac{1}{2}\right). \end{aligned}$$

It is straightforward to see that the new group is larger because the mass at low human capital types is higher. But notice that the type selected by the recruiter is the same in Figures 1 and 4. Because a type at $\left(1, \frac{\beta - D}{\alpha}\right)$ still joins,

that individual is selected. There is no change in training as compared to the example in Figure 1. The frequency of suicide bombings decreases due to the increased time spent screening but not due to any change in training.

Now consider a shift in the distribution so that high capital types are eliminated. To be concrete, suppose the new distribution is

$$f(k_i, h_i) = \begin{cases} 2, & \text{if } k_i \in [0,1] \text{ and } h_i \in \left[0, \frac{1}{2}\right], \\ 0, & \text{otherwise.} \end{cases}$$

Again, the overall population size is unchanged; it is the only composition that has changed. Figure 5 depicts the new equilibrium. Relative to the equilibrium in Figures 1 and 4, the group is now much larger in size and the type selected $\left(1, \frac{1}{2}\right)$ now has much lower human capital. The time spent screening and training both increase, so the frequency of suicide bombings decreases. If, on the other hand, the new distribution was

$$f(k_i, h_i) = \begin{cases} 2, & \text{if } k_i \in [0,1] \text{ and } h_i \in \left[\frac{1}{2}, 1\right], \\ 0, & \text{otherwise,} \end{cases}$$

so that only high capital types exist, then the group size would shrink but the identity of the recruit would be the same is in Figures 1 and 3. The frequency of suicide bombings would increase. We thus see that it is the elimination of certain types that changes the identity of the recruit and the time spent training.

5 Types of Intervention and their Consequences

Our primary goal in this paper is to explore the impact of certain types of intervention on the incidence of suicide bombing. Interpreting v as the frequency of suicide bombings, we suppose that the intervening actor (e.g., government,

military, etc.) wants to decrease v. We distinguish four broad types of interventions: direct action, attrition, covert action, and civic action.

5.1 Direct Action

Direct action is the use of direct force to hinder the operations of the terrorist organization or eliminate it altogether. Examples include capturing and punishing leaders in the terrorist organization, disrupting the ability of the terrorist organization to train recruits, bombing the alleged headquarters of the organization, and so on. In our model, direct action consists of efforts taken to disrupt the recruiter directly or to decrease the recruiter's utility without impacting the choices or utilities of the individuals. An example would be some action that disrupts the selection or training processes, which would be manifest as upward shifts in parameters λ and θ, respectively.

Direct action of these forms has no direct effect on an individual's choice to join or not join the group; it only lowers the utility of the recruiter. Unless direct action eliminates the recruiter altogether, its overall effect will largely be to reduce the incidence of suicide bombings and not eliminate them altogether. It does not affect the equilibrium choices so much as it does the equilibrium payoffs. Of course, if we further assume that the recruiter has an outside option and, before selecting a recruit, decides whether to recruit or pursue some outside option, then sufficient direct action can eliminate suicide bombings altogether. However, that degree of direct action is likely to be very costly, especially if direct action has very diminishing returns.

Though direct action is aimed at the recruiter, we should consider the pos-

sibility of direct action indirectly affecting other parameters in the model. For example, if direct action involves military action with tremendous collateral damage, then it can have an adverse impact on overall economic conditions, effectively decreasing α. As mentioned earlier, an increase in α has an *a priori* ambiguous effect on the frequency of suicide bombings that can potentially offset the intended effect of the direct action. Similarly, suppose military action is concentrated in areas with low human capital. Then the population density may change such that the group shrinks in size due to fewer low human capital individuals, thereby shrinking the screening time but not altering the training time. Again, the indirect effect may offset the intended direct action.

The important lesson is that for direct action to decrease the frequency of suicide bombings requires there must be minimal or minor indirect, offsetting consequences. This same lesson will apply to other types of intervention.

5.2 Attrition

Attrition is defined as the use of force or other means to reduce the impact or success of the suicide bomber's attempt. Examples include hardening targets, identifying and stopping potential suicide bombers, or even letting the bombers complete their missions in the hopes that they will not be replaced. In our model, attrition might have multiple effects. First, it would lead to an increase in θ, all else equal, as it would lengthen the time required to train a suicide bomber to penetrate a hardened target, avoid detection, and so on. Second, it might alter the composition of the group if it involves the capture and detaining of certain individuals or if it hinders the basic environment in a

way to lower the value of individual's human capital akin to a drop in α.

Reconsider Example 1. A simple hardening of anticipated targets will effectively lead to an increase in θ, i.e., an increase in the time and effort required to train a suicide bomber and a decrease in the frequency of suicide bombings. However, just as with direct action, there can be indirect consequences, such as a shift in α, that can dampen or offset the intended intervention. As with direct action, the success of attrition depends on the possible countervailing effects of indirect effects.

5.3 Covert Action

Covert action involves infiltration of the group via informants or undercover operatives with the purpose of preventing or disrupting the terrorist activities. The primary effect of such action in our model is to increase the search cost for the recruiter, represented by an increase in λ. The recruiter must exert more resources in identifying good candidates and ensure they are not or will not cooperative with the government. This leads to a reduction in the frequency of the suicide bombings. It is also possible that covert action increases the chances of trained recruits being caught, which would imply that more efforts must be exerted to train a successful recruit. This effect would be represented as an increase in θ, which acts to reduce the frequency of suicide attacks.

5.4 Civic Action

Civic action refers to attempts to work with the community, such as enhancing democracy, improving relations with citizens, educating the public, supporting community endeavors, constraining or limiting religion, and more. Civic

action may take many different forms in our model. First consider changes in particular parameters. Civic action aimed at improving the overall economic environment for individuals will increase α, while civic action with the opposite intent will decrease α. As discussed above, the shift in α has potentially counteracting effects on the screening and training of recruits. Civic action might instead focus on the religious group. Subsidizing the activities of the religious group will increase the production of religious goods for all levels of D, captured by an increase in β. Conversely, hindering the efforts of religious groups would effectively decrease β. In our model, parameters β and α work in opposite directions, i.e., an increase in β has the same qualitative effect in equilibrium as a decrease in α. A policy banning head scarves in public places, for example, could work to decrease the secular opportunities α for those dedicated to wearing them. Again, we observe potentially counteracting effects on the screening and training of recruits. Another effort might be aimed at increasing the group's minimum level of devotion D. While this would seem to be under the control of the group, the actual costs of such devotion might be at least partially determined by the larger social environment akin to how the tension between a religious group and its surrounding society depends both on the behaviors and beliefs of the religious group and those of the larger society. An increase in D will shrink the group's size and make screening easier, but it will also increase the training cost because higher human capital individual will not join.

Civic action may also lead to changes in the distribution of types. Policies that successfully increase human capital in the population, for example, would

lead individuals to switch out of the group. But this might have the effect of decreasing the screening time for the recruiter sufficiently so as to increase the frequency of suicide bombings. Alternatively, efforts to raise D could have the unintended consequence that the smaller group actually generates higher religious capital in its members. Such a shift in the composition of members' capital would partially offset the increased training cost associated with a rise in D.

5.5 Other Classifications

Comparing our classification with others made in the literature is instructive. Arce and Sandler (2005) distinguish *preemptive* and *deterrence* counterterrorist policies. The former hinder the overall operations of the terrorist organization, thereby generating a type of positive externality in a setting with multiple potential targets or multiple intervening bodies (i.e., countries). The latter provide a more private benefit for one potential target or country. In our terminology, direct action, covert action, and civic action are all forms of preemptive policy in that they reduce the overall effectiveness of the terrorist organization. Some forms of attrition are preemptive, such as identifying potential suicide attackers before the attacks, while other forms of attrition, like hardening targets, are deterrence. The possibility of externalities creates additional benefits for preemptive policies because all potential targets benefit, and we will revisit this point below when discussing optimal policies. The externalities also create additional strategic elements not considered in our paper because the intervening body is a sole actor rather than a collection of

actors. This preemptive-deterrence distinction is central to Arce and Sandler's analysis because of their focus on how those externalities influence the choice of counterterrorist policy. Our distinctions are more useful for us because of our focus on how the counterterrorist policies influence group formation and the recruitment process.

Roberts and Everton (2010) distinguish between kinetic and non-kinetic counterterrorist activities. The former are aggressive measures, such as capturing or eliminating terrorists or training security forces; the latter are more subtle and non-coercive means and include civic assistance and psychological operations. Direct action, attrition, and covert action as we conceive them are kinetic activities. Civic action is non-kinetic. Again, our distinctions are more useful for our purposes because they distinguish how the different actions affect group formation and recruitment.

6 Designing Intervention

It is apparent from the previous section that an intervention aimed at reducing the incidence of suicide bombings may have numerous indirect effects that reduce the impact of the original intervention. That fact, combined with the recognition that any intervention will entail the use of scarce resources with opportunity costs, suggests that the best approach to reducing the suicide bombings may be a particular mix of different interventions. However, without knowing the recruiter technology, religious group composition, and budget constraint of the intervening body, we cannot provide a precise recommendation. We instead first discuss some properties of an "ideal" intervention and

then offer some conditional statements about the optimal selection of a mix of interventions.

6.1 Properties of an Ideal Intervention

Our earlier discussion identifies how changes in particular variables or in the distribution of types in the population affect the incidence of suicide bombings. In particular, a reduction in suicide bombings, holding all else equal, follows from:

- an increase in the secular returns α to human capital;
- a decrease in the returns to religious group participation β;
- an increase in the screening cost λ;
- an increase in the training cost θ;
- a decrease in the correlation between religious group capital k_i and human capital h_i in the population's distribution.

An ideal intervention (or intervention mix) would do one or more of the above without unintended or countervailing effects. It would increase all individuals' secular opportunities, decrease their returns to religious group participation, make it more difficult for the recruiter to identify and train good candidates, and alter the make-up of the population so that there were no individuals with both high human capital and high group capital. All of these work in the appropriate direction. Noticeably absent from this list is a

change in the screening cost D because that alone has an ambiguous effect on the incidence of suicide bombings.

None of the interventions mentioned in the previous section met all of these conditions. Direct action, attrition, and civic action all had the potential to raise unintended consequences that work against the purpose of the intervention. The only intervention that did not appear to have any unintended consequences was covert action, which is both very difficult and costly because it is both highly specialized and very risky. Whether or not a government or military's optimal intervention consists solely of covert action would depend, of course, on the marginal impact of such action and the relevant resource constraints, and this is ultimately an empirical question. In general, however, it appears that the optimal intervention given the intervening actor's constraints will consist of a multi-pronged approach.

6.2 Two Cases

If no single action matches the ideal, then the constrained optimal intervention will involve selecting multiple actions, some of them intended, in part, to counter the effects of unintended consequences of other actions. If the intervention designer has complete information about all functions and parameters of the game, then the optimal intervention is found by solving a maximization problem. We can, however, make statements if we make assumptions about the sizes of certain parameters.

Case 1: $\theta >> \lambda$ (high marginal cost of training). In this scenario, the marginal cost of training recruits is very high but the screening and selec-

tion costs are not. For example, it might be easy to spot those characteristics that make a good, reliable suicide recruit, but carrying out the mission requires highly specialized skills that must be learned by the recruit at a high cost to the recruiter. We observe in this case that a reduction in the size of the religious group reduces the recruiter's screening cost but yields a much larger increase in the training cost, thereby reducing the frequency of suicide bombings. Moreover, unintended consequences that result in a shrinking of the group's size will work in the intervening body's favor.

We can now reassess the viability of particular types of intervention. For example, with a relatively high marginal cost of training, the potentially counteracting effects of an increase in the returns to secular opportunities will balance in favor of a reduction in the frequency of suicide bombings. The best candidates to be suicide bombers (i.e., those easiest to train) will shift out of the religious group. From the point of view of the intervening actor, the recruiter's easier time spent screening is more than offset by the recruiter's increased amount of time spent training the individual who is selected. Civic action aimed at improving economic conditions can now be seen as a clear viable intervention. By similar logic, other types of intervention that unintentionally hinder economic conditions will be at least partially undermined. Direct action and attrition, should they unintentionally reduce the returns to secular activities will find their efforts partially or completely offset. Without some civic action aimed at improving economic conditions, direct action and attrition will be less effective than hoped.

Case 2: $\theta << \lambda$ **(high marginal cost of screening).** This scenario

is the opposite of Case 1. The recruiter now prefers a smaller group because screening is so difficult. Civic action aimed at improving economic conditions will be less effective and may in fact increase suicide bombings. Indeed, civic action that reduces the returns to secular activities will be more appropriate because it leads to an increase in the size of the religious group, thereby making it much more difficult for the recruiter to identify good candidates. Moreover, if a worsening of economics conditions is an indirect effect of direct action and attrition, then the indirect effect may actually work in the favor of the intervening actor.

Observe that many of the effective interventions identified above match the notion of preemptive (rather than deterrence) policies emphasized by Frey and Luechinger (2003), Arce and Sandler (2005), and Faria and Arce (2005). There are many such preemptive policies, and our analysis suggests that a well-chosen mix of such policies will have the largest impact on the incidence of suicide attacks. Our findings thus complement those in the literature.

7 Conclusion

This paper presents a model of terrorist recruitment from a religious group in order to assess the viability of four types of counterterrorist intervention. We use the model to demonstrate how various types of intervention may have unintended consequences that work against the purposes of the intervention. The model identifies certain aspects of an ideal intervention. It would increase all individuals' secular opportunities, decrease their returns to religious group participation, make it more difficult for the recruiter to identify and train

good candidates, and alter the make-up of the population so that there were no individuals with both high human capital and high group capital. No simple intervention does all of the above, so the optimal intervention is likely to be a mix of different types of interventions.

We intend to push this work forward in many directions. First, our model assumes that the religious group and recruiter are separate entities, but it might be the case that they are the same or at least have similar preferences. In this case, the recruiter might respond to an intervention by altering features of the religious group (e.g., parameter D) that aid in the production of suicide bombers. This will put additional constraints on the intervening actor's ability to reduce the frequency of suicide bombers and may even change the policy conclusions discussed earlier.

Second, we have not considered other relevant forms of heterogeneity in the population. For example, it is reasonable to suppose that some individuals, holding religious capital equal, are more susceptible to suicide bomber recruitment than others. This can be added to the model as another dimension in the individuals' type space. The recruiter would then want to identify those individuals with high religious and human capital and this other particular trait.

Third, our analysis ignores the role that suicide bombings may play in competing for resources. As discussed by various authors in Gambetta (2005), an organization's decision to use suicide bombings as a political or military tactic depends in part on the degree of extremity of the group's main constituents such that groups with more radical constituents are more likely to use suicide

bombers. Our model could be adapted to consider such a setting. The recruiter's resources may depend on the make-up of its constituents, and the recruiter may have to compete with another recruiter or group for resources. Indeed, Bloom (2005) argues that competition for resources between organizations helps explain the proliferation of suicide bombings in Palestine. This suggestions the incorporation of inter-group competition into the model.

Finally, our analysis considers only one intervening body. Having multiple actors choosing interventions creates additional externalities in intervention choice (e.g., Arce and Sandler 2005) and results in still more strategic complexities (Bruck 2005).

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Figure 1: An Equilibrium with $\alpha/(\beta\text{-}D) > 1$ and $\theta > 1$

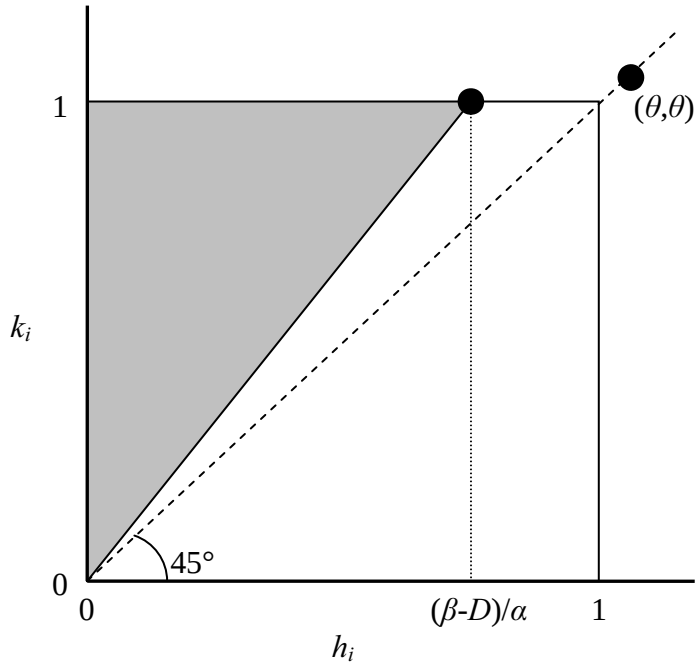

Figure 2: An Equilibrium with $\alpha/(\beta\text{-}D) < 1$ and $\theta > 1$

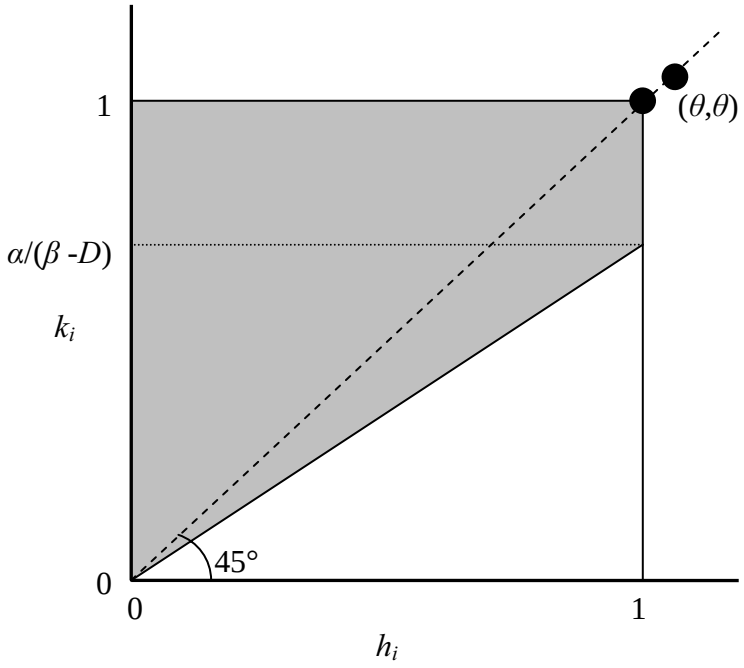

Figure 3: The Equilibrium Effect of an Increase in α with $\alpha/(\beta\text{-}D) > 1$ and $\theta > 1$

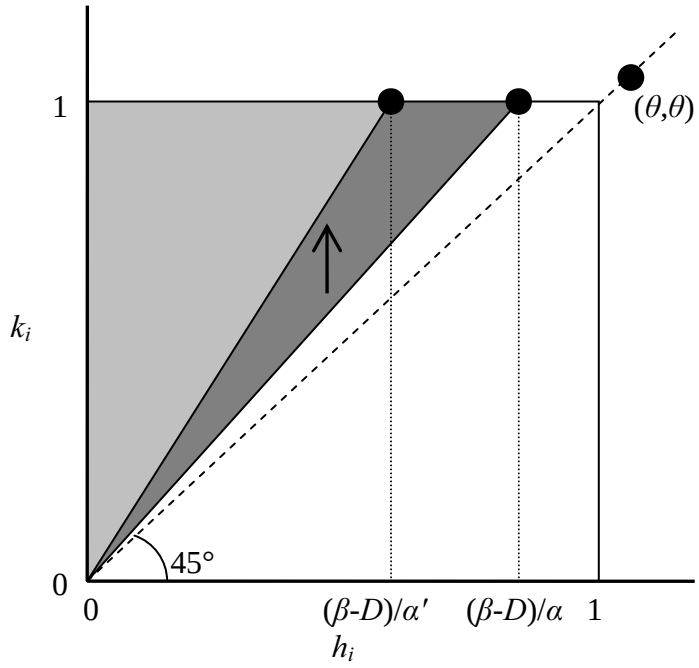

Figure 4: The Equilibrium Effect of a shift in the Population Density with $\alpha/(\beta\text{-}D) > 1$ and $\theta > 1$

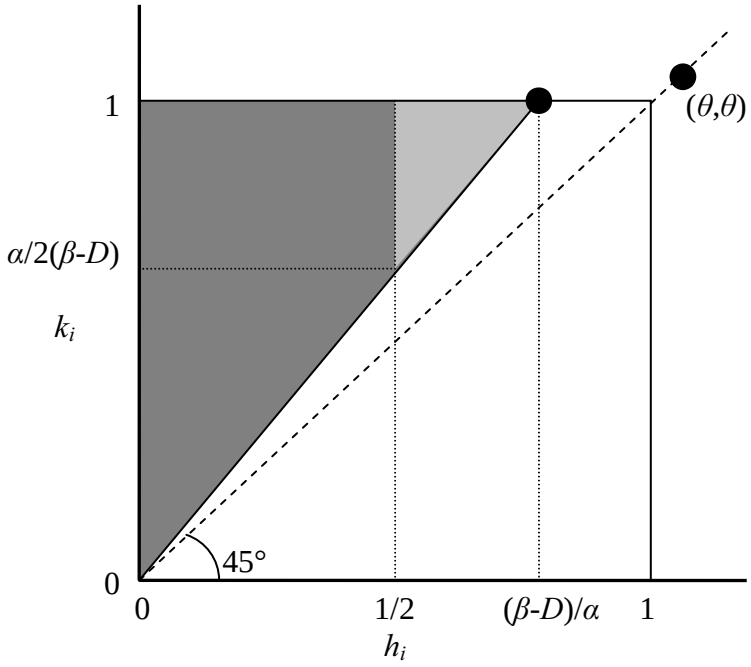

Figure 5: The Equilibrium Effect of Another Shift in the Population Density with $\alpha/(\beta\text{-}D) > 1$ and $\theta > 1$