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ARTICLE

# Operational externalities and counter-terrorism

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**Abstract**
In a structure involving two independent terror outfits operating in a country, we study possible implications for counter-terrorism (CT) strategy in the presence and absence of operational externalities. Inter alia, the analysis suggests a possible explanation for the widespread application of defensive CT measures and the sparing use of offensive CT. But confidence-building measures come to be ineffective against resource-constrained outfits, irrespective of the nature and magnitude of externalities. Offensive measures against resource-abundant outfits, appear to be successful in reducing the total number of terror strikes only when strong negative externalities prevail.

**Keywords** Terrorist outfit · Operational externalities · Counter-terrorism · Offensive and defensive measures · Confidence-building measures

**JEL Classification** D74 · H56 · O12

## 1 Introduction

Arce and Sandler (2005) define terrorism as the 'premeditated use or threat of use of violence by individuals or sub-national groups to obtain political, religious, or ideological objectives through intimidation of a large audience usually beyond that of the immediate victims'. Because terrorists simulate randomness to generate fear and widespread panic, it is usually a daunting challenge for the targeted country's government to design a strategy that optimally utilizes its counter-terrorism (CT) resources. Achieving this involves assessing the threat that various terror outfits pose in terms of their resources and inclination for conducting attacks.[1] Moreover,

[1] See Arce and Sandler (2007) for a similar discussion in the context of the need for targeted countries to invest in their intelligence apparatus as an essential part of their counter-terrorism efforts.

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as shall be demonstrated, the importance of understanding the magnitude and nature of operational externalities generated by terror activities in framing the appropriate CT response cannot be overstated.

Consider a situation in which a terror outfit uses a particular route to transport terrorists and materials into a conflict zone. If another outfit begins to use the same route for infiltration and/or exfiltration, the chances of the route being discovered by the security forces may increase, resulting in negative operational externalities between the outfits through the resulting increase in the expected cost of operations. There are numerous other such factors which can give rise to negative operational externalities when more than one outfit is active in the same theatre of operations. Some examples are discussed below.

In June 2014, for instance, the Islamic State of Iraq and Syria (ISIS)[2] conducted a rapid invasion of large parts of northern Iraq including Mosul. The media attention afforded to al-Qaeda declined ever since, while the focus on ISIS rose. This made recruitment more difficult and therefore more costly, for al-Qaeda. Al-Qaeda responded by escalating its rivalry with ISIS. Al-Qaeda in the Islamic Maghreb (AQIM) affiliates like Ansar Dine stepped up attacks, joining a series of efforts to regain support from the more popular ISIS.[3]

The predominantly Shiite outfit Hezbollah has, for decades, been one of the most intimate allies of the Gaza-based Palestinian Sunni group Hamas. However, their ties have suffered following the rebellion which began in March 2011 against the Syrian regime headed by President Bashar al-Assad, an Alawite Shia. The resultant overwhelmingly Sunni insurgency was supported by Hamas, while Hezbollah became deeply committed in fighting alongside Assad's forces (Karam 2014). Since then, the total number of attacks conducted by these outfits more than doubled from a combined 34 in 2011 and 2012, to a combined 88 in 2013 and 2014.[4]

Consider, conversely, the presence of a sleeper cell of a terror outfit in a city. Left to itself, the cell may be unable to conduct successful attacks given the level of security preparedness. However, if another terror outfit enters the fray and conducts attacks—successful or otherwise—the terror cell may be activated to conduct attacks of its own in the resultant conducive environment of confusion. This provides a characterization of positive operational externalities between terror outfits. There are many other circumstances in which a group can benefit due to the presence of another in the same region.

Scrutinize, for instance, the relationship between Boko Haram and its 2012 offshoot Ansaru, and AQIM. When Boko Haram initially metamorphosed into a jihadist outfit post 2009, its affiliation with AQIM and the core of al-Qaeda was largely dismissed as rhetoric by observers and analysts. The notion that inexperienced domestic insurgents from northeast Nigeria would receive backing from

[2] Also called Islamic State of Iraq and the Levant (ISIL).

[3] See Hancock (2015) and Kronk (2015).

[4] See Global Terrorism Database, Institute for Economics and Peace, (https://www.start.umd.edu/gtd/search/Results.aspx?start_yearonly=2007&end_yearonly=2014&start_year=&start_month=&start_day=&end_year=&end_month=&end_day=&asmSelect0=&asmSelect1=&perpetrator=399&perpetrator=407&dtp2=all&success=yes&casualties_type=b&casualties_max=).

transnational jihadist outfits was admonished as wishful at best. In 2010, however, AQIM leader Droukdel announced that AQIM would provide weapons, support and training to Boko Haram. This Boko Haram—AQIM alliance is validated by public statements from both outfits. Moreover, Boko Haram's suicide attack in 2011 targeting the United Nations office in Abuja, Nigeria, was tactically akin to bombings by AQIM (Aronson 2014).

The literature addressing the impact of externalities on the incidence of terrorism, and its implications on CT, is limited. Anderton and Carter (2006) demonstrate the applicability of microeconomic concepts and principles to the study of terrorism. They utilize game theory to characterize strategic interdependencies among terrorists and governments. Enders and Jindapon (2010) analyze the optimal network structure of centralized and decentralized terror outfits, and demonstrate the suboptimality of decentralized decision-making resulting from its inability to internalize important network externalities.

A substantial part of the existing literature focuses on the externalities imposed on other countries, by the CT actions of one country against a common transnational terrorist threat. Arce and Sandler (2005) demonstrate the negative externalities imposed by a country's defensive measures on other countries, by deflecting attacks towards them. On the contrary, proactive measures are shown to generate positive externalities for all other countries by degrading the capabilities of the terrorists. This is what causes the international co-ordination failure problem characterized by the oversupply of defensive measures and undersupply of offensive measures relative to the optimum, as also discussed in Sandler and Siqueira (2006). Faria et al. (2013) formulate a structure with temporal and spatial externalities to demonstrate that in steady state, intertemporal policy considerations outweigh concerns usually related to transnational CT policy. Siqueira and Sandler (2007) investigate the impact of domestic politics on the CT policy of two countries against a common terrorist threat. They demonstrate that the resulting delegation problem in which voters choose a policymaker with preferences different from their own, results in countries limiting the presumed oversupply of defensive CT measures. Similarly, Das and Roy Chowdhury (2014) apply a game-theoretic model to identify circumstances based on the impact of fear, which may render it logical to respond to increased terrorism with increased pre-emption.

The present paper is the first to provide a formal analysis of the implications of the presence of operational externalities on the interactions between terror outfits. As opposed to the aforementioned literature on international externalities, this paper focuses on the externalities imposed by the activities of one terror outfit, on those of another. The findings are compared with the "benchmark" case without externalities. The study then proceeds to analyze the counter-terrorism ramifications of the nature and magnitude of operational externalities, if present.

The analysis demonstrates that there is always scope for the effective employment of defensive CT, irrespective of whether or not operational externalities are present. This lends support to the "oversupply of defensive CT" hypothesis mentioned above. Moreover, confidence-building measures (CBM) are shown to be ineffective against resource-constrained outfits. In the presence of externalities, it is also demonstrated that the impact of offensive CT against a resource-abundant outfit is successful in reducing the total number of attacks of all outfits if and only if the magnitude of negative externalities on the other outfit is sufficiently high. This may explain the greater prudence with which countries, especially with strong democratic institutions, may employ offensive CT measures as compared to defensive measures.

The following section presents the basic model in the absence of operational externalities. The third section introduces externalities and analyzes the associated comparative statics. The fourth section addresses some aspects of counter-terrorism policy, both in the presence and absence of externalities. The salient findings of the paper and their implications are summarized in the fifth and concluding section.

## 2 Model

Suppose there are two independent terror outfits[5] operating in a country. Let the utility function of the $i$th terror group, $T_i$ $(i = 1, 2)$ be[6]

$$U_i = X_i + \alpha_i v_i(A_i), \quad v_i'(A_i) > 0, \quad v_i''(A_i) \leq 0, \quad \forall A_i \geq 0, \tag{1}$$

where $X_i$ is its level of consumption of the numeraire good,[7] $\alpha_i v_i(A_i)$ is the utility from conducting $A_i$ terror strikes,[8] where $\alpha_i$ $(\geq 0)$ is its intrinsic propensity for violence (this captures the fundamentalist aspect of terrorism, in terms of which some groups can be classified as more "hard-line" than others).

Suppose the cost to terror group $i$ of conducting $A_i$ terror strikes is $\beta_i C_i(A_i)$ where $C_i(A_i)$ is increasing and strictly convex in $A_i$, and $\beta_i (> 0)$ is the cost-efficiency (or operational efficiency) parameter of terror outfit $i$, such that lower (higher) $\beta_i$ represents higher (lower) efficiency.[9] Then, if $R_i$ is its initial resource endowment in terms of the numeraire good, then $T_i$'s budget constraint is:

$$X_i + \beta_i C_i(A_i) = R_i, \tag{2}$$

$T_i$'s optimization problem is to maximize its utility (1) subject to its budget constraint (2). Substituting $X_i$ in (1) using (2), we can rewrite the utility maximization problem as:

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[5] The present analysis can be extended to the case of more than two outfits, without affecting the qualitative results of the paper.

[6] This specification treats terrorism as an end in itself for the terror outfit, rather than the means to achieving some other goal. The implications cannot be too divorced from reality in a world which is witnessing increasing instances of religious fundamentalist ideology driven terror incidents. Also, the utility function is separable in its two arguments - $X_i$ and $A_i$. This implies that the marginal utility with respect to either argument is independent of the other argument, which is reasonable to expect. For example, there is no reason as to why consuming more of another good would yield a higher or lower marginal utility from conducting a terror strike, and vice versa.

[7] The numeraire good represents a basket of all goods other than terror strikes, the consumption of which provide utility to the terror outfit.

[8] To keep matters simple, we abstract away from the issue of the "success" or "failure" of a terror attack, because it is often hard to define "success" and "failure" in this context. Our implicit assumption is that the cost of any terror attack is the same irrespective of whether it is successful or not.

[9] These assumptions are fairly standard and reflect the increased difficulty in conducting each successive attack, due to the increased alertness and enhanced response of the governmental authorities and security forces after each successive terror strike. For a similar cost function, see Siqueira and Sandler (2008).

$$\text{Max}_{A_i} U_i = R_i - \beta_i C_i(A_i) + \alpha_i v_i(A_i). \quad (3)$$

If an interior optimum exists,[10] the first-order condition (FOC) is:

$$-\beta_i C_i'(A_i^*) + \alpha_i v_i'(A_i^*) = 0. \quad (4)$$

The FOC represents the equality between the marginal benefit ($\alpha_i v_i'(A_i^*)$) and marginal cost ($\beta_i C_i'(A_i^*)$) of conducting an attack (to $T_i$) in equilibrium. From Eq. (4), the optimal number of terror strikes conducted by each outfit in interior equilibrium, can be obtained. Note that the optimal number of terror attacks conducted by each outfit is independent of the other's attacks. Moreover, the second-order condition (SOC) for utility maximization is satisfied since at the optimal number of terror strikes ($A_i^*$), $-\beta_i C_i''(A_i^*) + \alpha_i v_i''(A_i^*) < 0$.

When an outfit is resource-constrained (i.e., the case of corner solution), the optimal number of attacks by this outfit can be solved from the budget constraint given by (2) by setting $X_i = 0$.[11]

The following comparative static results as given in Proposition 1 are easy to derive.

**Proposition 1** *When an interior optimum exists, the optimal number of terror attacks that an outfit conducts varies directly with its intrinsic propensity for violence, $\alpha_i$, varies inversely with its inefficiency, $\beta_i$, and is independent of the initial resource endowment of the terror outfit, $R_i$.*

If a group's members are inherently more (less) violent, then the group would tend to conduct more (less) attacks. An increase (decrease) in $\alpha_i$, ceteris paribus, increases (decreases) the marginal benefit ($\alpha_i v_i'(A_i^*)$) from terror attacks, thereby increasing (decreasing) the optimal number of attacks. Also, if a terror outfit is less (more) efficient, its marginal cost of conducting a terror strike ($= \beta_i C_i'(A_i^*)$) is higher (lower). Hence, the less (more) efficient the outfit, the higher (lower) is its marginal cost. Consequently, the optimal number of terror strikes that the outfit conducts would be lower (higher). The interesting observation, in case of no resource constraint, is that the number of terror strikes conducted by an outfit does not depend on the size of its initial resource endowment. The impact of variations in $R_i$ is captured completely by corresponding equivalent variations in $X_i$.

In contrast, if a terror outfit is resource-constrained, the optimal level of terror attacks varies directly with its initial resource endowment, $R_i$ but is independent of its intrinsic propensity for violence, $\alpha_i$. Such a case arises when a group does not have sufficient resources initially to conduct as many terror strikes as it would want to (given its inherent propensity for violence and efficiency). In this situation the level of terror strikes optimally conducted by the outfit would depend not on its

[10] An interior optimum exists if and only if $R_i \geq \beta_i C_i(A_i)$, $\forall i = 1, 2$, when $A_i$ is chosen optimally.

[11] We assume that the marginal cost of conducting an infinitesimal amount of terror activity is not prohibitively high. Formally, we assume $-\beta_i C_i'(0) + \alpha_i v_i'(0) > 0$. If this is not so, then we shall have a corner solution where all resources are optimally consumed and no attacks are conducted, thereby rendering the terrorism problem trivial. No "counter-terrorism strategy" would be required in this scenario.

inherent propensity for violence, but positively on the level of resources initially at its disposal. However, $\beta_i$ continues to play a similar role.

## 3 Operational externalities

In this section, we consider the existence of possible externalities in between the activities of the outfits. It is conceivable that the level of terror activity of one outfit has implications for the marginal cost of terror activities of the other outfit. Suppose the cost to terror group $i(\neq j = 1, 2)$ of conducting $A_i$ terror strikes is $\beta_i C_i(A_i, A_j)$, where $C_i(A_i, A_j)$ is increasing and strictly convex in $A_i$ (i.e.,$\frac{\partial C_i(A_i,A_j)}{\partial A_i} > 0$ and $\frac{\partial^2 C_i(A_i,A_j)}{\partial A_i^2} > 0$). The fact that $A_j$ features as an argument in $T_i$'s cost function, captures the aspect of a terror outfit subjected to cost externalities due to the presence of another terror outfit in its theatre of operations. Therefore, existence of cost externalities implies that $\frac{\partial C_i(A_i,A_j)}{\partial A_j} \neq 0$, $i \neq j$. In the present paper our focus is on the operational externalities, that is, to see how the action of one outfit is related to the action of the other outfit. Therefore, cost interdependencies will induce operational externalities by means of affecting both the total cost and marginal cost of an outfit. For positive operational externality we assume $\frac{\partial C_i(A_i,A_j)}{\partial A_j} < 0$ and $\frac{\partial^2 C_i(A_i,A_j)}{\partial A_i \partial A_j} < 0$, and negative operational externality requires $\frac{\partial C_i(A_i,A_j)}{\partial A_j} > 0$ and $\frac{\partial^2 C_i(A_i,A_j)}{\partial A_i \partial A_j} > 0$.

With externalities, $T_i$'s budget constraint is:

$$X_i + \beta_i C_i(A_i, A_j) = R_i. \tag{5}$$

Then $T_i$'s problem is to maximize its utility (1) subject to its budget constraint (5). Substituting $X_i$ in (1) using (5), we can rewrite the utility maximization problem as:

$$\text{Max}_{A_i} U_i = R_i - \beta_i C_i(A_i, A_j) + \alpha_i v_i(A_i). \tag{6}$$

When an interior optimum exists,[12] the FOC is:

$$-\beta_i \frac{\partial C_i(A_i, A_j)}{\partial A_i} + \alpha_i v_i'(A_i) = 0. \tag{7}$$

The second-order condition (SOC) for maximization holds, since on differentiating the FOC with respect to $A_i$, we get

$$-\beta_i \frac{\partial^2 C_i(A_i, A_j)}{\partial A_i^2} + \alpha_i v_i''(A_i) < 0. \tag{8}$$

From Eq. (7), the best-response (or reaction) function of each outfit $i(\neq j = 1, 2)$, $A_i = A_i(A_j)$, can be obtained. Also, along the reaction function,

[12] An interior optimum exists if and only if in equilibrium neither outfit is resource-constrained, i.e., $R_i \geq \beta_i C_i(A_i, A_j)$, $\forall i = 1, 2$.

$$\frac{\mathrm{d}A_i}{\mathrm{d}A_j} = \beta_i \frac{\frac{\partial^2 C_i}{\partial A_i \partial A_j}}{\alpha_i v_i'' - \beta_i \frac{\partial^2 C_i}{\partial A_i^2}}. \tag{9}$$

The SOC in Eq. (8) ensures that the denominator is negative. Therefore, the reaction functions are positively (negatively) sloped if and only if $\frac{\partial^2 C_i}{\partial A_i \partial A_j} < 0\ (> 0)$, i.e., if an outfits's terror activities impose a positive (negative) or cost-reducing (cost-increasing) externality on the marginal cost of the other outfit's terror activities. In this case, the numbers of attacks conducted by the outfits are strategic complements (substitutes). Further, the stability and uniqueness of the resultant equilibrium is guaranteed by assuming that the determinant of the Hessian matrix of second-order partial derivatives of the utility functions is positive,[13] i.e.,

$$H \equiv \left( -\beta_i \frac{\partial^2 C_i}{\partial A_i^2} + \alpha_i v_i'' \right)\left( -\beta_j \frac{\partial^2 C_j}{\partial A_j^2} + \alpha_j v_j'' \right) - \beta_i \beta_j \frac{\partial^2 C_i}{\partial A_i \partial A_j} \frac{\partial^2 C_j}{\partial A_j \partial A_i} > 0. \tag{10}$$

When an outfit is resource-constrained, it uses all its resources to conduct attacks, its reaction function can be obtained from its budget constraint in Eq. (5) as:

$$\beta_i C_i(A_i, A_j) = R_i. \tag{11}$$

Complete differentiation of (11) yields the slope as:

$$\frac{\mathrm{d}A_i}{\mathrm{d}A_j} = -\frac{\partial C_i / \partial A_j}{\partial C_i / \partial A_i}. \tag{12}$$

This is positive or negative according as $\frac{\partial C_i}{\partial A_j}$ is negative (which happens under positive externalities) or positive (which happens under negative externalities), respectively.

To ensure that the equilibrium is both stable and unique when both outfits are resource-constrained, we shall assume

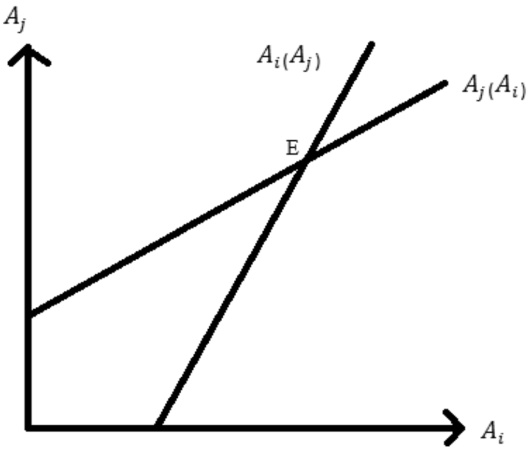
$$K \equiv \frac{\partial C_i}{\partial A_i}\frac{\partial C_j}{\partial A_j} - \frac{\partial C_i}{\partial A_j}\frac{\partial C_j}{\partial A_i} > 0 \tag{13}$$

From the above analysis, we arrive at the following lemma.

**Lemma 1** *The reaction function of an outfit remains positively sloped under positive externalities, and negatively sloped under negative externalities, even if it is resource-constrained.*

[13] For instance, suppose $\beta_i = 1,\ i = 1,\ 2;\ v_i(A_i) = A_i,\ i = 1,\ 2;$ and $C_i(A_i, A_j) = \frac{1}{\gamma} A_i^{\gamma} A_j^{\sigma},\ \gamma > 1$ and $\gamma - 1 > |\sigma|$. Then all the relevant conditions are satisfied.

**Fig. 1** Reaction functions under positive externalities




From the solution to the optimization problem of any outfit $i = 1, 2$, it can be checked [from (9) to (12)] that the absolute slope of its reaction function ($|dA_i/dA_j|$) is less if it is resource-constrained (see Appendix 1). Therefore, although externalities, if present, play a role even under resource-constraint, their ability to impact the level of terror activity is less.

It is important to mention, at this juncture that one could obtain similar reaction functions using a scenario of non-operational externalities. For example, higher terror activity levels of another outfit can lead to resentment in the ranks of the first. Alternatively, it could work as a morale booster. In such scenarios, even if there are no cost externalities, the outfits end up imposing externalities on each other via their ex-ante utilities. We discuss this issue further in Appendix 2. In the following two subsections we shall discuss comparative static effects under operational externalities.

### 3.1 Positive operational externalities (i.e., $\frac{\partial C_i(A_i,A_j)}{\partial A_j} < 0, \frac{\partial^2 C_i}{\partial A_i \partial A_j} < 0$)

As already demonstrated, the presence of positive cost externalities ensures that the best-response functions of the terror outfits are sloped positively (Fig. 1 is an illustration). Moreover, the SOCs and Eqs. (10) and (13) together ensure the uniqueness and stability of the equilibrium, as obtained by the intersection of the reaction curves.

**Proposition 2** *Assume that neither outfit is resource-constrained. Then in the vicinity of the initial equilibrium the optimal number of terror attacks conducted by either outfit, and the total number of attacks:*

(i) *vary positively with their intrinsic propensities for violence, $\alpha_1$ and $\alpha_2$;*
(ii) *vary negatively with their inefficiencies, $\beta_1$ and $\beta_2$; and*
(iii) *are independent of the initial resource endowments of the terror outfits, $R_1$ and $R_2$.*

The formal proof of the proposition is given in Appendix 3. An increase (decrease) in $\alpha_i$, ceteris paribus, raises (reduces) $T_i$'s marginal benefit from attacking ($\alpha_i v_i'(A_i)$) while leaving its marginal cost of attacking ($\beta_i \frac{\partial C_i(A_i,A_j)}{\partial A_i}$) unchanged. Therefore, it optimally conducts more (less) attacks given any $A_j$ [rightward (leftward) shift of $A_i$'s reaction function]. This, in turn, reduces (raises) $T_j$'s marginal cost of attacking ($\beta_j \frac{\partial C_j(A_i,A_j)}{\partial A_j}$) while leaving its marginal benefit from attacking ($\alpha_j v_j'(A_j)$) unchanged. Therefore, $T_j$ too optimally conducts more (less) attacks. Thus, the total number of attacks also increases (decreases).

An increase (decrease) in $\beta_i$, ceteris paribus, leaves $T_i$'s marginal benefit from attacking unchanged while raising (reducing) its marginal cost of attacking. Therefore, it optimally conducts less (more) attacks given any $A_j$ [leftward (rightward) shift of $A_i$'s reaction function]. This, in turn, raises (reduces) $T_j$'s marginal cost of attacking while leaving its marginal benefit from attacking unchanged. Therefore, $T_j$ too optimally conducts less (more) attacks. Thus, the total number of attacks also decreases (increases).

Finally, an increase (decrease) in $R_i$, ceteris paribus, leaves unaltered both $T_i$'s marginal benefit and the marginal cost of conducting attacks. Therefore, it has no impact on the optimal number of attacks. It does, however, result in an equivalent increase (decrease) in $X_i$.

Given our assumptions, when both outfits are resource-constrained, under positive externalities reaction functions will continue to be positively sloped (although these will be less steep). Then it is easy to understand that for $i = 1, 2$ in the vicinity of the initial equilibrium, $A_1^*$, $A_2^*$ and $A_1^* + A_2^*$ all will vary positively with $R_i$ and negatively with $\beta_i$, but are independent of $\alpha_i$. But if only $T_j$ is resource-constrained, $\alpha_i$ will impact positively. The reason is that an increase (decrease) in $\alpha_i$, ceteris paribus, causes a rightward (leftward) shift of $T_i$'s reaction function. Therefore, it optimally conducts more (less) attacks. This, in turn, reduces (raises) $T_j$'s cost of attacking ($\beta_j C_j(A_i, A_j)$) while leaving its initial resource endowment ($R_j$) unchanged. Therefore, $T_j$ too optimally conducts more (less) attacks. Thus, the total number of attacks also increases (decreases).

### 3.2 Negative operational externalities (i.e., $\frac{\partial C_i(A_i,A_j)}{\partial A_j} > 0$, $\frac{\partial^2 C_i}{\partial A_i \partial A_j} > 0$)

The presence of negative operational externalities ensures that the best-response functions of the terror outfits are sloped negatively (as illustrated in Fig. 2).

**Proposition 3** *If neither outfit is resource-constrained, then in the vicinity of the initial equilibrium for* $i \neq j = 1, 2$:

(i) *An increase in* $\beta_i$ *decreases* $A_i^*$, *increases* $A_j^*$, *but it decreases (increases)* $A_1^* + A_2^*$ *if and only if* $\left|\frac{\mathrm{d}A_j(A_i)}{\mathrm{d}A_i}\right| < 1 (> 1)$.

(ii) *An increase in* $\alpha_i$ *increases* $A_i^*$, *decreases* $A_j^*$, *but it increases (decreases)* $A_1^* + A_2^*$ *if and only if* $\left|\frac{dA_j(A_i)}{dA_i}\right| < 1 (> 1)$.

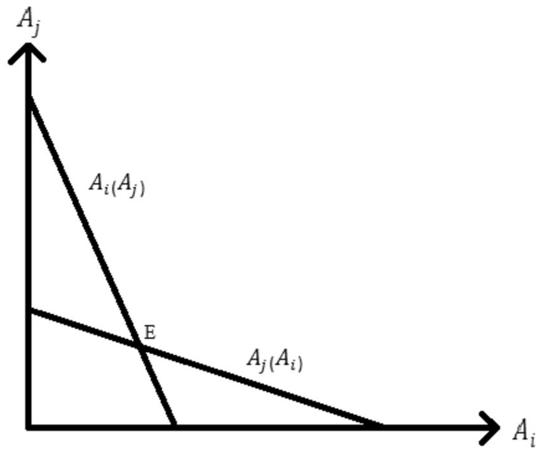



**Fig. 2** Reaction functions with negative externalities

(iii) *Changes in $R_i$ have no impact on the optimal number of attacks.*

Note that contrary to the case of positive externalities, under negative externalities the effect on $A_1^* + A_2^*$ depends on whether the absolute slope of the corresponding reaction function is greater than or less than unity. Explanation of the results underlying Proposition 3 is not difficult. An increase (decrease) in $\beta_i$, ceteris paribus, leaves $T_i$'s marginal benefit from attacking unchanged while raising (reducing) its marginal cost of attacking. Therefore, it optimally conducts less (more) attacks given any $A_j$ [leftward (rightward) shift of $A_i$'s reaction function]. This, in turn, reduces (raises) $T_j$'s marginal cost of attacking while leaving its marginal benefit from attacking unchanged. Therefore, $T_j$ optimally conducts more (less) attacks. If $T_j$'s optimal number of attacks (best-response) is sufficiently sensitive to $T_i$'s optimal decision,[14] then the rise (fall) in $A_j$ dominates the fall (rise) in $A_i$, and the total number of attacks therefore increases (decreases). Conversely, if $T_j$'s best response is sufficiently insensitive, the total number of attacks declines (increases). Similar explanation follows for an increase or decrease of $\alpha_i$.

Results for the case of resource-constrained outfits can follow similarly because the reaction functions will still be downward sloping, The important difference from the above is that now $R_i$ will impact on both $A_i$ and $A_j$. However, still the impact on $(A_i + A_j)$ will depend on the absolute slope of the respective reaction functions. When both the outfits are resource-constrained, $\alpha_i$ has no role to play, but it becomes active if only $T_j$ is resource-constrained.

To summarize the results of this section, note that in the absence of externalities the change of any of $\alpha_j$, $\beta_j$ and $R_j$ has no effect on $A_i$, but given externalities (positive or negative), $A_i$ depend on $\alpha_j$ and $\beta_j$ but not on $R_j$ (unless $T_j$ becomes resource-constrained). Further, the direction of the effect on $A_i$ of a change of $\alpha_i$ or $\beta_i$ is same irrespective of whether there are positive or negative externalities.

[14] For this, $T_j$'s reaction function must be steep enough, in particular, $\left|\frac{dA_j}{dA_i}\right| > 1$.

## 4 Counter-terrorism

We now turn our attention to the implications of the above discussion and results, for the counter-terrorism policy of the targeted country's government. It must be noted, at the outset, that counter-terrorism measures seek to reduce the level of terror activity by impacting its determinants. A broad classification of CT measures is as follows:

1. defensive measures,
2. offensive measures, and
3. CBMs and others.

Defensive CT measures include "hardening" of potential targets,[15] deployment of governmental intelligence agencies against the outfit on a priority basis, covert tactical operations aimed at disrupting the operational capabilities of the terrorists and their handlers, etc. The construction of a double-row concertina wire fence about 700 m from the Line of Control (LoC) separating the Indian State of Jammu and Kashmir from Pakistan Occupied Kashmir (POK), called the Anti-Infiltration Obstacle System (AIOS), by the Indian Army during 2003–2005, is an example of such efforts. Such counter-terrorism efforts attempt to reduce the optimal number of terror strikes by rapidly increasing the terrorists' (ex-post) operational inefficiency, $\beta_i$. Even though such measures may sometimes occur behind enemy lines and involve an element of pre-emption, they are limited in size and scope, and aimed primarily at disrupting the terrorists' operational efficiencies rather than degrading their aggregate resources. The "surgical strikes" conducted by the Indian Army on 29 September, 2016, against multiple terrorist launch pads in POK, to thwart the efforts of terrorists seeking to "carry out infiltration and conduct terrorist strikes inside Jammu and Kashmir and in various metros in other states", provides an example of such cross-border defensive measures.[16]

The targeted country's government may alternatively take the more offensive approach of imposing financial and other sanctions, or even conducting strategic pre-emptive strikes to destroy the assets of terror outfits.[17] A case in point is that of the American airstrikes conducted in 2001 in the aftermath of the 9/11 attacks, to topple the Taliban regime in Afghanistan through the massive destruction of its resources and the elimination of its leadership. Such measures are mostly strategic in scope, as opposed to the tactical nature of most defensive measures. This would result in a rapid reduction of resources, $R_i$, available with the terrorists. However,

[15] This involves increasing the security levels of potential targets or enhancing surveillance, etc., thereby rendering these targets more difficult or costly for a terror outfit to attack.

[16] These details are as mentioned by the Indian Director General of Military Operations (DGMO), in the immediate aftermath of the surgical strikes.

[17] On the other hand, localized or tactical pre-emptive actions do not usually create any major dent in the resources available with terror outfits, and fall under the category of the afore-discussed defensive CT measures.

offensive measures may potentially alienate the larger civilian population in the area of operations and this, over a period of time, may make it easier for terror outfits to recruit and indoctrinate locals. This would be reflected in decreased ex-post operational inefficiencies, $\beta_i$. Also, in the aftermath of any major military offensive, there is often a "terrorist backlash"[18] (increased number of attacks) due to increased intrinsic propensity of violence, $\alpha_i$.

In December 2014, in the aftermath of the carnage carried out by NDFB(S) militants killing over 80 people, a major offensive was allegedly planned in Assam, Nagaland and Bhutan. The Assam State Government had also increased the reward amount on information regarding the whereabouts of the NDFB(S) top brass by four times to Rs. 20 lakh (Acharya 2014).

The government may also adopt the softer approach of winning the "hearts and minds" of the alienated population living in a terror-affected geographical area, to reduce the support for the terror outfit(s) operating in that area and/or to reduce the outfit's motivation to maintain a very high level of terror activity. To this end, so-called CBMs may be undertaken. Religious institutions of learning may be nudged to accept greater state regulation and to modify their curriculum and academic discourse, in exchange for greater State support. Public spending on social and economic infrastructure may be enhanced, along with special economic assistance for the affected region. All such measures are targeted at reducing the intrinsic propensity of violence, $\alpha_i$, of an outfit active in that area.

In January, 2007, for instance, President Arroyo of the Phillippines credited the success in countering Abu Sayyaf partly to larger developmental initiatives involving trade and investment, targeted at increasing the security sphere while inhibiting that of "terror and transnational crime". She called on other countries combating terrorism to learn from the successful use of both "soft and hard power" in the Phillippines (Calica 2007).

The government's CT approach towards an outfit is contingent upon the specifics of that outfit such as its intrinsic propensity for violence, its operational efficiency, and the resources available to it. Therefore, if the specifics of two outfits vary, then the government's CT approach towards them may vary. In reality, a government's CT strategy may involve a combination of different types of CT measures. For instance, governments often embark on and/or maintain "back-channel" negotiations with certain terror outfits, even as operations against those outfits continue on the ground. Moreover, the CT measures (as well as the CT strategy as a whole) chosen by the government to target an outfit may evolve over time, driven by changes in the outfit's nature. For example, an outfit that previously was not resource-constrained, may begin to suffer from paucity of resources over a period of time due to a decline in its operational efficiency. This change would necessitate a corresponding evolution of the CT strategy employed against the outfit.

The choice of CT strategy also depends on the cost of each CT measure as well as the resources committed towards CT efforts. Finally, the overall nature of response to terrorist threats depends crucially on the nature of the government itself. Some governments, for instance, are more willing and/or able to commit to a sustained

[18] See Mesquita (2005) for a formal explanation of the causes of terrorist backlash.

effort to counter terrorists than others. Therefore, although we often see a similarity in the immediate response of various governments after a major terrorist incident, discrepancy between the approaches of different regimes may creep in with the passage of time. Hence, the chosen CT strategy may vary based on the extent of the government's bias towards immediate/short-term or ad hoc/piecemeal responses as opposed to a more sustained anti-terror campaign.

From the results presented in the second and third sections, it emerges that defensive measures can be effectively utilized against any terror outfit irrespective of the nature of externalities (if any) and the quantum of resources with the terrorists because under any scenario, as long as the equilibrium is stable, there is at least one outfit against which defensive measures can be used effectively to reduce the total number of terror attacks. This explains the universality of defensive measures. For instance, in the immediate aftermath of a terrorist event where the government is unaware or unsure about the perpetrator(s), a "safe" choice of an ad hoc CT strategy involves hardening of potential targets and increasing surveillance. It is another matter that given the extent of public outrage after a major terrorist event, the government may find it politically untenable to stick to defensive CT measures alone.

On the other hand, in the absence of externalities as well as in the presence of positive externalities or sufficiently weak negative externalities, offensive measures are effective if and only if the targeted outfit is resource-constrained. However, in the presence of sufficiently strong negative externalities the reduction in the targeted outfit's attacks would be more than compensated by the increase in the other outfit's attacks, due to a decline in its cost of operations. This would, therefore, result in an increase in the total number of attacks. Hence, defensive instead of offensive measures would be preferable in such cases. Further, although the application of offensive measures against resource-rich outfits generally leads to an increase in attacks due to a terrorist backlash in the absence of externalities, such measures can decrease the overall attacks in the presence of sufficiently strong negative externalities. Interestingly, in such cases, the higher the terrorist backlash by the targeted outfit, the greater the decline in the other outfit's attacks due to higher operational costs. In the presence of externalities, therefore, a necessary and sufficient condition for offensive CT to be effective against an outfit that is resource-abundant is the presence of sufficiently strong negative externalities.

Finally, CBMs can be effectively utilized only if the targeted outfit is not resource-constrained, irrespective of whether externalities are present or not. In the vicinity of the interior equilibrium in the absence of externalities, the sensitivity of the outfit's optimal number of attacks to the outfit's inefficiency is greater or lesser than that to the outfit's intrinsic propensity for violence according as the intrinsic propensity for violence is greater or lesser than the outfit's inefficiency in interior equilibrium, since from Eq. (4):

$$\left|\frac{\partial A_i^*}{\partial \beta_i}\right| = -\frac{C_i'}{\alpha_i v_i'' - \beta_i C_i''} \gtrless -\frac{v_i'}{\alpha_i v_i'' - \beta_i C_i''} = \frac{\partial A_i^*}{\partial \alpha_i} \leftrightarrow \alpha_i \gtrless \beta_i. \tag{14}$$

Hence, the deployment of CBMs is optimal in the absence of externalities if and only if the targeted outfit is resource-rich and sufficiently inefficient. This is because the incentive of a resource-rich outfit to respond to CBMs is stronger (weaker), the lesser (greater) the impunity with which it can carry out terror attacks. Also, offensive measures against such an outfit would result in an increase in the number of attacks in the vicinity of the initial equilibrium via an increase in the outfit's intrinsic propensity of violence, as mentioned earlier.

In the presence of externalities, although CBMs would result in the reduction of attacks by the targeted outfit, the other outfit will overcompensate by increasing its attacks by an even greater magnitude in the presence of sufficiently strong negative externalities. Here, defensive measures would be optimal. In all other situations in the presence of externalities, CBMs are effective in the vicinity of the initial equilibrium.

## 5 Conclusion

Given the limited literature investigating the role of externalities in CT, a simple formalization of operational externalities has been attempted in this paper. The insights, however, are compelling. The analysis demonstrates that the policy ramifications of CT measures are directionally the same both in the absence of externalities, and under positive externalities. It is, however, demonstrated that the magnitude of the impact in the latter regime is never less than that under the former. In fact, the direction of impact of CT measures is also the same under negative externalities unless the optimal response of one outfit is sufficiently sensitive to changes in the parameters of the other. The magnitude of the impact, however, would never exceed that in the absence of externalities. This is because the response of one outfit to a CT measure runs contrary to that of the other under negative externalities.

The universality of defensive CT measures is also explained by the structure, thus lending credence to the possibility of oversupply of defensive CT. It is also argued that CBMs are ineffective against resource-constrained outfits. Moreover, the possible limitations of offensive CT in the vicinity of the initial equilibrium have been demonstrated. Offensive measures can be effectively used against resource-constrained outfits both in the absence of externalities and under positive externalities. This result also holds under negative externalities if the magnitude of externalities is sufficiently low. Most interestingly, the phenomenon of terrorist backlash can render offensive CT effective even against resource-abundant outfits, in the presence of sufficiently strong negative externalities. Examples including Phillippines' use of both "soft and hard power" against Abu Sayyaf, American airstrikes targeting the Taliban in 2001, and the surgical strikes conducted by the Indian Army against multiple terror launch pads in PoK in 2016 have been provided as evidence of the above findings.

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## Compliance with ethical standards

**Conflict of interest** On behalf of all authors, the corresponding author states that there is no conflict of interest.

## Appendix 1

$T_i$'s optimization problem is to maximize its utility (1), with respect to its resource constraint (5), and non-negativity constraints $X_i \geq 0$ and $A_i \geq 0$. This is equivalent to the unconstrained maximization of the Lagrangean function:

$$L = X_i + \alpha_i v_i(A_i) + \lambda\{R_i - X_i - \beta_i C_i(A_i, A_j)\} + \gamma X_i + \mu A_i, \tag{15}$$

where $\lambda$, $\gamma$ and $\mu$ are non-negative Lagrangean multipliers.

Solving the FOCs, the slope for the reaction function can be obtained as:

$$\frac{\mathrm{d}A_i}{\mathrm{d}A_j} = -\beta_i \frac{\frac{\partial^2 C_i}{\partial A_i \partial A_j}}{\beta_i \frac{\partial^2 C_i}{\partial A_i^2} - \frac{1}{1+\gamma}\alpha_i v_i''}, \tag{16}$$

where $\gamma = 0$ when the resource constraint (5) is not binding, and $\gamma > 0$ when (5) is binding. Invoking Eq. (8), the result follows. Q.E.D.

## Appendix 2

In this scenario, $T_i$'s budget constraint is given by Eq. (2). However, its utility is:

$$U_i = X_i + \alpha_i v_i(A_{i,} A_j), \quad \frac{\partial v_i(A_i, A_j)}{\partial A_i} > 0, \quad \frac{\partial^2 v_i(A_i, A_j)}{\partial A_i^2} \leq 0, \quad \forall A_i, A_j \geq 0, \tag{17}$$

$T_i$'s optimization problem is to maximize its utility (17) subject to its budget constraint (2). Substituting $X_i$ in (17) using (2), we can rewrite the utility maximization problem as:

$$\mathrm{Max}_{A_i} U_i = R_i - \beta_i C_i(A_i) + \alpha_i v_i(A_i, A_j). \tag{18}$$

If an interior optimum exists, the first-order condition (FOC) is:

$$-\beta_i C_i'(A_i) + \alpha_i \frac{\partial v_i(A_i, A_j)}{\partial A_i} = 0. \tag{19}$$

From (17), the best-response (or reaction) function of each outfit $i(\neq j = 1, 2)$, $A_i = A_i(A_j)$, can be obtained. Also, along the reaction function, $\frac{\mathrm{d}A_i}{\mathrm{d}A_j} = \alpha_i \frac{\frac{\partial^2 v_i}{\partial A_i \partial A_j}}{\beta_i C_i'' - \alpha_i \frac{\partial^2 v_i}{\partial A_i^2}}$. The SOC ensures that the denominator is positive. Therefore, the reaction functions are positively (negatively) sloped if $\frac{\partial^2 v_i}{\partial A_i \partial A_j} > 0$ (<0), i.e., if an outfits's terror activities impose a positive (negative) externality on the utility of the other outfit's terror activities. In this case, the numbers of attacks conducted by the outfits are strategic complements (substitutes). Q.E.D.

## Appendix 3

Differentiating the FOCs for $T_i$ [given by Eq. (7)] and $T_j$ [obtained by interchanging subscripts $i$ and $j$ in Eq. (7)] with respect to $\alpha_i$ $(i \neq j = 1, 2)$, and solving the resulting pair of Equations, we obtain

$$\frac{\mathrm{d}A_i^*}{\mathrm{d}\alpha_i} = -\frac{v_i'\left(\alpha_j v_j'' - \beta_j \frac{\partial^2 C_j}{\partial A_j^2}\right)}{H} > 0, \tag{20}$$

invoking the SOC, Eqs. (1) and (9). Under positive externalities,

$$\frac{\mathrm{d}A_j^*}{\mathrm{d}\alpha_i} = -\beta_j v_i' \frac{\frac{\partial^2 C_j}{\partial A_j \partial A_i}}{H} > 0. \tag{21}$$

Obviously, the total number of attacks also increases if $\alpha_i$ increases, since

$$\frac{\mathrm{d}(A_i^* + A_j^*)}{\mathrm{d}\alpha_i} = -\frac{v_i'\left(\alpha_j v_j'' - \beta_j \frac{\partial^2 C_j}{\partial A_j^2}\right) + \frac{\partial^2 C_j}{\partial A_j \partial A_i}}{H} > 0. \tag{22}$$

In the context of $\beta_i$ $(i \neq j = 1, 2)$, Eq. (7) can similarly be utilized to obtain

$$\frac{\mathrm{d}A_i^*}{\mathrm{d}\beta_i} = -\frac{\left(\alpha_j v_j'' - \beta_j \frac{\partial^2 C_j}{\partial A_j^2}\right)\frac{\partial C_i}{\partial A_i}}{H} < 0. \tag{23}$$

And under positive externalities,

$$\frac{\mathrm{d}A_j^*}{\mathrm{d}\beta_i} = \beta_j \frac{\frac{\partial^2 C_j}{\partial A_j \partial A_i}\frac{\partial C_i}{\partial A_i}}{H} < 0. \tag{24}$$

Obviously, the total number of attacks also decreases if $\beta_i$ increases, since

$$\frac{\mathrm{d}(A_i^* + A_j^*)}{\mathrm{d}\beta_i} = -\frac{\left(\alpha_j v_j'' - \beta_j \frac{\partial^2 C_j}{\partial A_j^2}\right)\frac{\partial C_i}{\partial A_i} + \frac{\partial^2 C_j}{\partial A_j \partial A_i}\frac{\partial C_i}{\partial A_i}}{H} > 0. \tag{25}$$

Lastly, for $(i \neq j = 1, 2)$, $\frac{dA_i^*}{dR_i} = \frac{dA_j^*}{dR_i} = \frac{d(A_i^* + A_j^*)}{dR_i} = 0$. Q.E.D.

## References


Acharya, D. (2014). Assam live: security forces, NDFB(S) encounter in Chirang along India-Bhutan border. Firstpost. http://www.firstpost.com/india/assam-live-security-forces-ndfbs-encounter-in-chirang-along-india-bhutan-border-2013001.html. Accessed 26 Dec 2014.

Anderton, C. H., & Carter, J. R. (2006). Applying intermediate microeconomics to terrorism. *Journal of Economic Education, 37*(4), 442–458.

Arce, D. G., & Sandler, T. (2005). Counterterrorism: A game-theoretic analysis. *Journal of Conflict Resolution, 49*(2), 183–200.

Arce, D. G., & Sandler, T. (2007). Terrorist signalling and the value of intelligence. *British Journal of Political Science, 37*(4), 573–586.

Aronson, S. L. (2014). AQIM's threat to western interests in the Sahel. Combating Terrorism Center. https://www.ctc.usma.edu/posts/aqims-threat-to-western-interests-in-the-sahel. Accessed 28 Apr 2014.

Calica, A. (2007). Defeating Abu Sayyaf is biggest contribution to world security. *Philstar headlines.*

Das, S. P., & Roy Chowdhury, P. (2014). Deterrence, preemption and panic: A common-enemy problem of terrorism. *Economic Enquiry, 52*(1), 219–238.

Enders, W., & Jindapon, P. (2010). Network externalities and the structure of terror networks. *Journal of Conflict Resolution, 54*(2), 262–280.

Faria, J. R., Silva, E. C. D., Arce, D. G. (2013). Terrorism and counterterrorism: History dependence, spillovers and coordination failures. *Alberta School of Business research paper no. 2013-1313*.

Hancock, R. (2015). Putting the ISIS & Al-Qaeda rivalry into context. *Muftah*. http://www.muftah.org/putting-isis-al-qaeda-rivalry/#.VuCEMOq6bqB. Accessed 4 Mar 2015.

Karam, Z. (2014). Hezbollah tells Israel: Continuing in Gaza is suicide. *Business insider*. http://www.businessinsider.com/hezbollah-hamas-israel-gaza-war-2014-7?IR=T. Accessed 25 July 2014.

Kronk, H. (2015). Al-Qaeda responds to ISIS, escalates Jihadist rivalry. *HNGN*. http://www.hngn.com/articles/163980/20151227/al-qaeda-responds-isis-escalates-jihadist-rivalry.htm#ic-nav. Accessed 27 Dec 2015.

Mesquita, E. B. (2005). Conciliation, commitment, and counter-terrorism: A formal model. *International Organization, 59,* 145–176.

Sandler, T., & Siqueira, K. (2006). Global terrorism: Deterrence versus pre-emption. *Canadian Journal of Economics, 39*(4), 1370–1387.

Siqueira, K., & Sandler, T. (2007). Terrorist backlash, terrorist mitigation, and policy delegation. *Journal of Public Economics, 91*(9), 1800–1815.

Siqueira, K., & Sandler, T. (2008). Defensive counterterrorism measures and domestic politics. *Defence and Peace Economics, 19*(6), 405–413.