The Interplay between Preemptive and Defensive Counterterrorism Measures: A Two-Stage Game

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Final Draft: April 2009

Abstract

A two-stage game depiction of counterterrorism is presented, where the emphasis is on the interaction between the preemptive and defensive measures taken by two targeted countries facing a common threat. The preemptor is likely to be the high-cost defender with the greater foreign interests. A prime-target country may also assume the preemptor role. The analysis identifies key factors – cost comparisons, foreign interests, targeting risks, and domestic terrorism losses – that determine counterterrorism allocations. The study shows that the market failures associated with preemptive and defensive countermeasures may be jointly ameliorated by a disadvantaged defender. Nevertheless, the subgame perfect equilibrium will still be suboptimal owing to a preemption choice that does not fully internalize the externalities.

JEL codes: D62, H40
Key words: Counterterrorism, Two-Stage game, Public goods, Preemption, Market failures

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Since 1968, the world has confronted an increasing threat of transnational terrorism as terrorists either cross borders or else attack foreign interests at home in order to gain media attention for their cause. Transnational terrorism includes incidents involving perpetrators, victims, institutions, governments, or terrorists from two or more countries. Terrorist events (e.g., skyjackings, assassinations, or bombings) with implications that transcend the venue country's borders are also transnational. Recent noteworthy transnational terrorist events include the four hijackings on September 11, 2001 (henceforth, 9/11), the Bali nightclub bombings on October 12, 2002, the Madrid commuter train bombings on March 11, 2004, and the London underground and bus bombings on July 7, 2005. Such incidents indicate the potential damage and anxiety associated with modern-day terrorism, which seeks a heightened level of death and destruction than the left-wing-dominated terrorism of the 1970s and 1980s (Enders and Sandler 2000; Hoffman 1998).

With al-Qaida and other loosely linked terrorist networks, many countries face a threat from the same terrorist group, not only at home but also abroad. When countries are mutually targeted by a group, their counterterrorism measures imply transnational externalities and associated market failures. Preemptive actions against the terrorists (e.g., infiltrating a group, destroying training camps, freezing assets, or capturing operatives) provide benefits for all at-risk countries; thus, preemption represents a public good with strong free-rider incentives (Sandler and Siqueira 2006). In contrast, defensive or protective measures (e.g., erecting barriers, scrutinizing checked airplane luggage, and fortifying embassies) may produce external costs by shifting attacks to less secure targets (Kunreuther and Heal 2003; Sandler and Enders 2004). With the formation of widely flung terrorist networks, transnational terrorism has become a crucial security concern worldwide. The enhanced movement of people, resources, and goods tied to globalization provides terrorists and their weapons with greater cover.

The primary purpose of this article is to investigate the *interplay between* preemptive and defensive countermeasures against terrorism when two countries are threatened by the same terrorist group. Targeted countries' defensive decisions depend on the level of the terrorist threat, which, in turn, is influenced by earlier preemptive actions. Moreover, a nation's preemptive decision is conditioned on how well its subsequent defensive measures protect against terrorist attacks. Given the common terrorist threat, each country's preemptive and defensive choices are also dependent on the choices in the other targeted country. Thus, strategic concerns involve not only the two types of counterterrorism policies, but also the decision makers. This strategic interplay is captured by presenting a two-stage game where each of the two at-risk countries decides preemption in the first stage and defensive responses in the second stage. In each stage, the country chooses its best response in relation to that of the other country.

We initially model the preemptive choice as preceding the defensive action because a preemptive decision may reduce or eliminate the terrorist threat by decreasing terrorist resources, thereby lessening the need for defense. Most defensive decisions do not greatly reduce the need for preemption, especially if the terrorists are determined to attack no matter how well targets are fortified. Today's fundamentalist terrorists display such determination. In Section V, we, however, show that reversing the stages – defense before preemption – does not qualitatively alter our main findings, so that the staging assumption is not driving the results.

Most of the literature examine preemptive or defensive counterterrorism measures as isolated decisions.[1] Only Arce and Sandler (2005), Sandler and Arce (2007), Trajtenberg (2006), and Poveda and Tauman (2007) allow for both preemption and defense in the same model. However, Arce-Sandler's single-stage analyses do not permit any real interaction between the classes of counterterrorism policies, because, unlike the current study, neither policy choice includes parameters (e.g., cost comparisons) from the *other* type of policy. In Trajtenberg's (2006) two-stage model, a central government eliminates any strategic interaction at the preemption stage. Unlike Poveda and Tauman's (2007) two-stage model, our analysis brings out the importance of the inter-stage cost differences in a comparative advantage viewpoint. Moreover, we are the first to include foreign interests and terrorist targeting bias when at-risk countries decide preemptive and defensive measures. Our investigation shows that a high-cost defender is apt to provide a preemption free ride for the low-cost defender. This outcome may hold even when the high-cost defender is also the high-cost preemptor. When preemption is studied in isolation, the preemptor will be the nation with the lowest marginal preemption cost. Our interplay representation shows that the market failures associated with preemptive and defensive actions are mutually interdependent. Underprovision of preemption in stage 1 may exacerbate the excessive defense in stage 2 by making for an even more insecure environment.

I. MODEL PRELIMINARIES

Terrorism is the premeditated use or threat of use of violence or force by individuals or subnational groups against noncombatants to obtain a political or social objective through the intimidation of a large audience beyond that of the immediate victims. Terrorists heighten public anxiety by making their attacks appear to be random so that everybody feels at risk. In fact, these attacks are not random and are purposely directed at "soft" targets that institute fewer precautions (Enders and Sandler 1993). This anxiety is also augmented when terrorists attack a country's assets – its people or property – at home and abroad, so that there appears to be no sanctuary. In the latter scenario, terrorism assumes a transnational form that is prevalent today and captured by our model.

We assume two nations – home (*H*) and foreign (*F*) – are the potential targets of a terrorist group. In this two-country world, the level and, thus, damage from terrorism is captured by *T*, which can be reduced in stage 1 by preemptive measures (*m*) by either country:

(1) $T = T(m), \quad T'(m) < 0$, and $T''(m) > 0$,

where $m = m^H + m^F$ and $m^i \left(i = H, F\right)$ is the preemption level provided by nation *i*. Equation (1) indicates that preemption decreases damages at a diminishing rate. Preemption is a pure public good abiding by a summation technology – i.e., preemption by either country is a perfect substitute against the common threat of terrorism. As a public good, preemption implies strong free-rider incentives.

Stage-1 preemption can reduce the terrorism threat by lowering *T*, but defensive measures are then needed in stage 2 as targeted countries take actions to deflect terrorist attacks. Defensive measures protect the defender but do not reduce terrorists' assets (but see Section V(c)). In stage 2, targeted countries thus face a constant terrorist threat *T*, determined by stage-1 preemptive measures. The defensive stage exhibits a rivalry or transference property: a rise in the level of, say, *H*'s defense will reduce its terrorism while this defense increases attacks in country *F*. This scenario is appropriate for today's loose global network of fundamentalist terrorists, who will identify and attack the most opportunistic target. As targeted nations choose their homeland security independently, there is a strong tendency to overdefend, analogous to overexploitation in a commons. This tendency may be limited somewhat when a country has people or property in the other country. This follows because deflected attacks still put a country in jeopardy, but typically by less than a home attack.

When two or more countries are at risk, the decision maker in each country independently decides counterterrorism measures.[2] We treat each country as having a unitary decision maker for the two choices. To capture the sequential decision-making process, we find the subgame perfect equilibrium for the two countries.

II. STAGE 2: THE DEFENSE GAME

Using backward induction, we must first find the Nash equilibrium for defensive choices in stage 2 for a given preemption level. Let a^H and a^F denote the defense levels of *H* and *F*, respectively. An increase in a^H reduces *H*'s likelihood, *p*, of attack, while an increase in a^F augments *H*'s likelihood of attack. The following probability function captures these properties:[3]

(2) $$p = p\left(a^H, a^F, \alpha\right) = \alpha + (1-\alpha)\left(\frac{a^F}{a^H + a^F}\right);\ 1 \geq \alpha \geq 0, \text{ and } not\ a^H = a^F = 0.$$

The α parameter allows the terrorists to have a bias (preference) to attack *H*. If, for example, al-Qaida is biased to attacking the United States over the United Kingdom (i.e., $\alpha \neq 0$), then equal defensive efforts in the two nations will result in the United States facing $p > 50\%$. The likelihood of attack in *F* is $1 - p$, given our two-country assumption.

The probability function has the following first-order and second-order partials:[4]

$$p_1(.) = -\frac{(1-\alpha)a^F}{\left(a^H + a^F\right)^2} < 0;\ p_2(.) = \frac{(1-\alpha)a^H}{\left(a^H + a^F\right)^2} > 0;$$

(3) $$p_{11}(\cdot) = \frac{2(1-\alpha)a^F}{\left(a^H + a^F\right)^3} > 0;\ p_{22}(\cdot) = -\frac{2(1-\alpha)a^H}{\left(a^H + a^F\right)^3} < 0; \text{ and,}$$

$$p_{12}(\cdot) = \frac{(1-\alpha)\left(a^F - a^H\right)}{\left(a^H + a^F\right)^3} \gtreqless 0.$$

The first-order partials indicate that self-defense decreases *H*'s attack probability, while *F*'s self-defense increases *H*'s attack probability. Inequality $p_{11} > 0$ indicates that self-defense curtails home terrorism at a diminished rate, whereas inequality $p_{22} < 0$ implies that foreign effort to deflect terrorism to *H* increases at a diminished rate. The cross marginal probability effect, p_{12}, is indeterminate in sign. If, for example, it is positive, then protection abroad raises p_1, which, in turn, reduces its absolute value since p_1 is negative. With $p_{12} > 0$, greater protection abroad thus reduces the marginal effectiveness of home defense.

In an increasingly integrated global economy, we cannot ignore that terrorism losses can occur at home or abroad, because a target country can have interests (financial and human) in other nations. Over the last decade, the United States was seldom attacked at home (despite 9/11); however, on average, 40% of all transnational terrorist attacks were against US interests, usually in foreign venues (Sandler and Enders 2006a). The terrorism damage functions for country *H* and *F* are:

(4) $$\left[\theta^H pT(m) + \delta^H (1-p) T(m)\right], \text{ and } \left[\theta^F (1-p) T(m) + \delta^F pT(m)\right],$$

respectively, where $\theta^i \left(\theta^i > 0,\ i = H, F\right)$ represents country *i*'s valuation of a unit of domestic terrorism damage and $\delta^i \left(0 \le \delta^i < \theta^i,\ i = H, F\right)$ represents country *i*'s interests abroad. If country *H* faces a constant marginal cost c^H for its defensive measures, then its stage-2 damage function, V^H, equals:

(5) $$V^H\left(a^H, a^F, m, \alpha\right) = \theta^H p\left(a^H, a^F, \alpha\right) T(m) + \delta^H \left[1 - p\left(a^H, a^F, \alpha\right)\right] T(m) + c^H a^H.$$

Consistent with the Nash equilibrium, country *H* chooses a^H to minimize V^H for a given a^F. The first-order condition is:[5]

(6) $$V_1^H(\cdot) = Tp_1(\cdot)\left(\theta^H - \delta^H\right) + c^H = 0,$$

which can be rewritten as:

(7a) $$-Tp_1\left(\theta^H - \delta^H\right) = c^H,$$

where *T*'s dependency on *m* is at times suppressed. The left-hand side of (7a) represents two contrasting influences: marginal defense benefits from reduced terrorism at home $\left(-Tp_1\theta^H\right)$ and marginal augmented risk from attacks transferred abroad $\left(Tp_1\delta^H\right)$. This cost arises because a reduced *p* augments the likelihood of attacks in *F*. Country *H*'s assets abroad temper its desire for homeland defense and the concomitant transfers of attacks abroad. The right-hand side of (7a) is the marginal provision cost (c^H) of defense. This marginal defense cost is higher when targets are more vulnerable and harder to defend. Longer borders and more entry points can also increase this marginal cost. More potential targets raise the amount of protective resources necessary to achieve a given level of defense against terrorism, thereby increasing marginal defense cost. Alternatively, equation (7a) can be expressed as:

(7b) $$-Tp_1(\cdot) = \tilde{c}^H = c^H \big/ \left(\theta^H - \delta^H\right).$$

In (7b), a higher θ^H reduces $\tilde{c}^H$ because a greater value put on damages at home lowers the effective marginal costs, $\tilde{c}^H$, of homeland defense. As *H*'s foreign concerns grow, the effective marginal costs, $\tilde{c}^H$, of homeland defense increases. By focusing on homeland attacks, DHS does not necessarily factor in this risk and, thus, may overspend on defense – a tendency augmented by strategic considerations indicated below.[6] Equation (6) implies that *H*'s stage-2 Nash reaction function $a^H = a^{HR}\left(a^F, m\right)$, depends on defensive measures abroad and stage-1 preemption. Using the implicit function theorem and (6), we derive the slope of *H*'s reaction path:

(8) $$a_1^{HR}\left(a^F, m\right) = -V_{12}^H \big/ V_{11}^H = -p_{12}/p_{11}.$$

An analogous set of steps provides the first-order condition for country *F*:

(9) $$Tp_2(\cdot) = \tilde{c}^F$$
$$= c^F \big/ \left(\theta^F - \delta^F\right),$$

analogous in meaning to (7b). The slope of country *F*'s Nash reaction path, $a^{FR}\left(a^H, m\right)$, is

(10) $$a_1^{FR}\left(a^H, m\right) = -V_{21}^F \big/ V_{22}^F = -p_{21}/p_{22} = -p_{12}/p_{22}.$$

Since $p_{11} > 0$ and $p_{22} < 0$, the slopes of the countries' reaction paths hinge on the sign of p_{12}.

We seek expressions for the reaction path slopes that allow us to sign them based on the relative value of the marginal effective costs of defense $\left(\tilde{c}^F \text{ and } \tilde{c}^H\right)$ in the two countries. We therefore derive (see Appendix A) the following expression for p_{12} at the Nash equilibrium:

(11) $$p_{12}(\cdot) = \frac{\tilde{c}^H - \tilde{c}^F}{T\left(a^H + a^F\right)}.$$

This expression implies that $p_{12} \geq 0$ if $\tilde{c}^H \geq \tilde{c}^F$ and $p_{12} < 0$ if $\tilde{c}^H < \tilde{c}^F$. Using (8) and (11) and noting that p_{11} is positive, we have:

(12) $$a_1^{HR} = -p_{12}/p_{11} \geq 0 \;\; (<0) \text{ as } \tilde{c}^H \leq \tilde{c}^F \;\; \left(\tilde{c}^H > \tilde{c}^F\right).$$

This implies that if *H*'s marginal effective costs of defense is relatively low (i.e., *H* is a comparatively efficient defender), then *H* will increase its defensive measures as *F* augments its defense. If there is no cost advantage, then *H* has no local incentive to react; if, however, *H* is relatively cost inefficient, then *H* will reduce its defensive action as *F* augments its defense. Cost effectiveness is determined by c^H being relatively low and *H* having little interests abroad (i.e., δ^H is near 0). Countries whose foreign interests grow relative to other targeted countries experience a rising $\tilde{c}^i$ and reduced cost effectiveness of home defense, which *curtails its incentives for homeland defense*. This important consideration should figure into the determination of homeland security budgets. The globalization process can alter countries' defensive actions against terrorism and, thus, their need for proactive measures (see Section III).

Using (10) and (11) and noting that $p_{22} < 0,$ we can similarly express the slope of country *F*'s reaction path as:

(13) $a_1^{FR} = -p_{12}/p_{22} \leq 0 \ (>0)$ as $\tilde{c}^H \leq \tilde{c}^F \ \left(\tilde{c}^H > \tilde{c}^F\right).$

A comparison of the reaction path slopes in (12) and (13) reveals that these reaction paths are sloped in opposite directions unless the effective costs of the two nations are equal. In this latter case, we have symmetric reaction paths with zero slopes at the second-stage Nash equilibrium.[7] Employing (6) and the analogous first-order condition for *F*, and substituting for p_1 [from (3)], we can express the reaction functions of *H* and *F* as:

(14) $$a^{HR}\left(a^F, m\right) \equiv \left[\frac{(1-\alpha)T(m)}{\tilde{c}^H}\right]^{\frac{1}{2}} \left(a^F\right)^{\frac{1}{2}} - a^F, \quad a^F \neq 0, \text{ and}$$

(15) $$a^{FR}\left(a^H, m\right) \equiv \left[\frac{(1-\alpha)T(m)}{\tilde{c}^F}\right]^{\frac{1}{2}} \left(a^H\right)^{\frac{1}{2}} - a^H, \quad a^H \neq 0.$$

Relations (14) and (15) allow us to draw the second-stage reaction paths in Figure 1 for the symmetric case ($\tilde{c}^H = \tilde{c}^F = \tilde{c}$), except at the origin. *F*'s reaction path has a zero slope at the Nash equilibrium, *N*, whereas *H*'s reaction path has an infinite slope at *N*. Nash equilibrium occurs where $a^{FN} = (1-\alpha)T/4\tilde{c}$ and $a^{HN} = (1-\alpha)T/4\tilde{c}$. Based on (3) and (8), the slope of *H*'s reaction path can be shown to be positive below the 45° line (i.e., for $a^F < a^H$) and negative above the line. Using symmetry, we get *F*'s reaction path. The iso-damage curve for *H* at *N* is V^{HN} and is tangent to *F*'s reaction path at *N*. *H*'s reaction path is determined by the maximum values of its hill-shaped iso-damage curves. Given the tangency between V^{HN} and a^{FR}, *H* would still choose *N* even if it could assume the role of a Stackelberg leader, since *N* remains *H*'s best point on *F*'s reaction path. Thus, *H* has no local incentive to precommit to a defense level different than its Nash level.

[Figure 1 here]

We can simultaneously solve the second-stage Nash reaction function in (14) and (15) to obtain second-stage Nash equilibrium values of home and foreign defense levels (see Appendix B):

(16) $$a^H(m) = \frac{(1-\alpha)T(m)\tilde{c}^F}{\left(\tilde{c}^H + \tilde{c}^F\right)^2} \text{ and } a^F(m) = \frac{(1-\alpha)T(m)\tilde{c}^H}{\left(\tilde{c}^H + \tilde{c}^F\right)^2}.$$

Given that overall threat decreases with preemption (i.e., $T' < 0$), the equations in (16) indicate that heightened preemption will reduce both countries' defensive measures. By abstracting from stage-2 deflection effects, we see that greater preemption reduces *T*, which, in turn, lowers the marginal benefit of *H* from defensive actions [i.e., $\left|Tp_1\left(\theta^H - \delta^H\right)\right|$ in (6)]. Thus, greater stage-1 preemption shifts *H*'s stage-2 reaction path leftwards and *F*'s stage-2 reaction path downwards, implying that each country takes less defensive measures for each level of the other country's defense. Thus, greater preemption in stage 1 reduces the Nash equilibrium levels of defense. This is displayed for the symmetric case in Figure 2, where $m^2 > m^1$ and N^2 is associated with reduced equilibrium defense levels compared with N^1.

[Figure 2 here]

An increase in preemption moves stage-2 defense closer to the Pareto-optimal zero defense levels, found by choosing a^F and a^H to minimize the *sum* of *H*'s and *F*'s damages:[8]

(17) $$T(m)\left[\theta^H p + \delta^H(1-p) + \theta^F(1-p) + \delta^F p\right] + c^H a^H + c^F a^F.$$

In (17), added defense is costly without reducing terrorism damage. Cooperative defense levels are zero because the only role that defense has in our context until Section V is to transfer attacks abroad. This transfer motive disappears under joint maximization. By shifting *N* toward the origin in Figure 2, enhanced preemption in stage 1 ameliorates the overdefense market failure of stage 2.

III. STAGE 1: THE PREEMPTION GAME

We now turn to the preemption decision in stage 1, conditioned on the Nash equilibrium values in (16) for the defensive choice in stage 2. Preemption is a pure public good, because any action to weaken the common terrorist threat curtails the terrorism risk for both targeted countries. On the basis of our analysis, the US "war on terror" beginning on October 7, 2001 is expected to provide benefits to all targeted nations. As a public good, preemption is anticipated to be undersupplied. Moreover, corner solutions are likely where one set of nations take proactive measures (e.g., the United States and the United Kingdom) and the other set does nothing. Few nations took active steps to track down al-Qaida operatives or to destroy their infrastructure (e.g., training camps) following 9/11. To capture this scenario in our two-country model, we show that the subgame perfect equilibrium has a preemptor and a free rider. Our basic findings, however, do not change when we later relax the constant marginal preemption cost assumption and have both countries taking proactive measures.

The loss function of country *H* in stage 1 is:

(18) $$L^H\left(m^H, m^F, \alpha\right) = V^H\left[a^H\left(m\right), a^F\left(m\right), m, \alpha\right] + c_m^H m^H,$$

where c_m^H is *H*'s constant marginal cost of preemption. Marginal preemption cost reflects the technology, intelligence, and security capabilities embodied in a country's preemptive efforts. Countries with advanced preemptive technologies, sophisticated intelligence, and formidable security forces can preempt a given threat at a relatively smaller marginal cost than a country without such capabilities. In (18), V^H is *H*'s earlier defined damage function in (5), but where dependency of defense on preemption is now acknowledged. The first-order Kuhn-Tucker condition for the choice of m^H is:

$$(19)\qquad L_1^H(\cdot) = V_1^H(\cdot)\,a_1^H + V_2^H(\cdot)\,a_1^F + V_3^H(\cdot) + c_m^H \geq 0,$$

where $a_1^H = da^H/dm$ and $a_1^F = da^F/dm$. By substituting for V_2^H and V_3^H [see (5)] and accounting for $V_1^H = 0$ owing to stage 2, we can rewrite (19) as:

$$(20)\qquad c_m^H \geq -Tp_2\left(\theta^H - \delta^H\right)a_1^F - T'(m)\left[p\theta^H + (1-p)\,\delta^H\right].$$

In (20), the first right-hand side expression captures *H*'s marginal benefits from reduced defense, a^F, in country *F* owing to *H*'s preemption. Less defense in *F* lowers *H*'s probability of a terrorist attack. These benefits are tempered somewhat owing to *H*'s interests in country *F* (i.e., through the δ^H term). In (20), the second right-hand expression indicates the effect of heightened m^H for given defensive measures (and therefore a given probability of a terrorist attack, *p*). Increased preemption by *H* reduces the overall threat and provides benefits for *H* both at home and abroad.[9] These actions also protect country *F* in the same way – the absence of these influences in (20) is indicative of *preemption underprovision*.[10]

At an interior solution for m^H, we have

$$(21)\qquad L_1^H = \tilde{c}^F\left(\theta^H - \delta^H\right)a_1^F + T'(m)\left[p\theta^H + (1-p)\,\delta^H\right] + c_m^H = 0,$$

where we substituted $\tilde{c}^F$ for Tp_2 via (9). The attack probabilities in the first-order conditions are determined by the countries' relative defensive measures, and not by the preemption decision despite *a*'s dependency on *m*. This is established by substituting for a^F and a^H in (2), based on their stage-2 equilibrium levels in (16).[11] This procedure yields,

$$(22)\qquad p = \alpha + \frac{(1-\alpha)\,\tilde{c}^H}{\tilde{c}^H + \tilde{c}^F},$$

which is independent of *m*, so that $dp/dm = 0$. This insight helps to establish that the second-order condition for stage 1 (i.e., $L_{11}^H > 0$) is satisfied.[12]

Country F's stage-1 loss function is:

$$(23) \qquad L^F\left(m^H, m^F, \alpha\right) = V^F\left[a^H(m), a^F(m), m, \alpha\right] + c_m^F m^F.$$

The associated Kuhn-Tucker condition can be written as:

$$(24) \qquad L_2^F(\cdot) = -Tp_1\left(\theta^F - \delta^F\right)a_1^H + T'(m)\left[(1-p)\theta^F + p\delta^F\right] + c_m^F \geq 0,$$

where we account for $V_2^F = 0,$ stemming from *F*'s stage-2 first-order condition. The terms in (24) have analogous marginal benefit and cost interpretation to those in (20).

We are now in a position to analyze the pattern of free riding for preemption. To do so, we first indicate under what circumstances one country will afford the other country with a free ride. Without loss of generality, country *F* will free ride on *H*'s preemption if and only if *H*'s net marginal benefits from preemption exceed those of *F*. Thus, m^H is positive and m^F is zero if and only if $L_2^F(\cdot) > L_1^H(\cdot) = 0$:[13]

$$(25) \qquad -Tp_1\left(\theta^F - \delta^F\right)a_1^H + T'(m)\left[(1-p)\theta^F + p\delta^F\right] + c_m^F >$$

$$Tp_2\left(\theta^H - \delta^H\right)a_1^F + T'(m)\left[p\theta^H + (1-p)\delta^H\right] + c_m^H.$$

Based on a series of substitutions involving stage-2 equilibrium values for a^H and a^F, inequality (25) can be written as:

$$(26) \qquad \left(\frac{c_m^H - c_m^F}{T'}\right) > \left(\theta^F - \theta^H\right)\frac{(1-\alpha)\tilde{c}^F\left(2\tilde{c}^H + \tilde{c}^F\right)}{\left(\tilde{c}^H + \tilde{c}^F\right)^2} + \left(\delta^F - \delta^H\right)\left[\alpha + (1-\alpha)\left(\frac{\tilde{c}^H}{\tilde{c}^H + \tilde{c}^F}\right)^2\right]$$

$$+\left(\theta^H - \delta^H\right)\left[\frac{(1-\alpha)\left(\tilde{c}^F - \tilde{c}^H\right)}{\tilde{c}^H + \tilde{c}^F} - \alpha\right].$$

This key relationship hinges on cost comparisons at the preemptive and defensive stages. It also involves the countries' relative valuations of domestic damages, their relative foreign interests, and the terrorists' bias to attacking *H*. We can make sense of this expression by considering some key cases.

(a) Case 1: A benchmark case, $\theta^H = \theta^F = 1$, and $\delta^F = \delta^H = \alpha = 0$

This case simplifies matters by normalizing the domestic damage valuation parameters θ^i to unity and by eliminating the foreign interests of the two countries. Thus, target countries are similarly concerned only with home attacks. Moreover, the terrorists display no bias for attacking country *H* over *F*. We apply the benchmark assumptions to (26) to give,

(27) $\left(c_m^H - c_m^F\right) / T'(m) > \left(c^F - c^H\right) / \left(c^H + c^F\right),$

in which the tildes are dropped from $\tilde{c}^i$ because $\theta^i = 1$ and $\delta^i = 0$ for *i* = *H*, *F*.

Case 1A: Identical preemption costs, $c_m^H = c_m^F$

Given identical preemption costs, (27) equals:

(28) $0 > \left(c^F - c^H\right) / \left(c^H + c^F\right).$

Thus, *H* preempts and *F* free rides when $c^H > c^F$, because *H*'s net marginal preemption benefits exceed those of *F*. As the high-cost defender, *H* has more to gain than *F* from preempting and reducing the overall threat since *H* is less able to deflect attacks in stage 2. This is illustrated in Figure 3 where MB^H is *H*'s marginal preemption benefit curve, which lies above that of *F* owing to *H*'s higher marginal defense costs and concomitant relative inability to divert attacks. For equal marginal preemption costs on line *AA* (ignoring line *BB*), we see that $m^H = m^* > 0$ while $m^F = 0$. Thus, an inefficient defender will preempt a common terrorist threat, insofar as it has more to gain from a more secure world. Even for this uncomplicated case, we begin to appreciate the interplay of preemptive and defensive decisions owing to cost comparisons.

[Figure 3 here]

Case 1B: H has lower preemption costs and higher defense cost

This case extends case 1A by giving country *H* a comparative advantage in preemption while maintaining its comparative disadvantage in defense. Since $c_m^H < c_m^F$ and $T'(m) < 0,$ the left-hand side of (27) is positive. The right-hand side of (27) is, however, negative owing to *H*'s high-cost defender status. Thus, equation (27) is satisfied so that *H*'s net marginal gains from preemption exceeds those of *F*; hence, *H* preempts and *F* free rides. This is illustrated in Figure 3 where line *AA* denotes c_m^F and line *BB* represents *H*'s smaller preemption cost of c_m^H. *H*'s defense inadequacies and preemption efficiency reinforce *H*'s role as the preemptor.

Case 1C: H has higher preemption and defensive costs

This case is less clear-cut because preemption inefficiency works against *H* becoming the preemptor while defensive inefficiency works in favor of *H* becoming the preemptor. As before, *H* will preempt provided that its net marginal preemption benefits exceed those of *F*. Based on (26) and the benchmark assumptions, *H* will preempt if the following inequality is satisfied:

$$(29) \qquad T'(m)\left(c^F - c^H\right) \Big/ \left(c^H + c^F\right) > \left(c_m^H - c_m^F\right).$$

In (29), the left-hand side reflects the extent to which *H*'s marginal preemption benefits exceed those of *F*, while the right-hand side indicates *H*'s relative preemption inefficiency. If the former is greater than the latter, then *H* preempts despite its inefficiency. This is displayed in Figure 4 where the wide separation between MB^H and MB^F and the small difference between c_m^H and c_m^F

fulfills (29). If, however, the separation between the marginal benefit curves is smaller and/or the separation between the marginal preemption cost lines is greater, then *F* will be the preemptor.

[Figure 4 here]

(b) Discussion of case 1

The essential message is that the preemption decision critically depends on the relative cost advantages (or disadvantages) between countries *H* and *F* for both counterterrorism activities, associated with the two stages of the game. *Proposition* 1 follows from the analysis thus far:

Proposition 1: With constant marginal preemption costs, $\theta^H = \theta^F = 1$, $\delta^H = \delta^F = \alpha = 0$, and preemption preceding defensive measures, the high-cost defender will afford the other targeted country a preemption free ride whenever the disadvantaged defender is not the high-cost preemptor. If, however, a country is relatively disadvantaged at preemption and defense, then it may still preempt when it is relatively more inefficient at defense.

The latter part agrees with the notion of comparative advantage that determines trade patterns in a Ricardian model. That is, a country may export a good for which it is absolutely disadvantaged (i.e., its costs are higher than the trading partner), provided that its disadvantage in the export good is small compared to that in the import good.

The United States with its long northern and southern borders and long coastline is a high-cost defender against terrorists. US isolated geographical position does not afford protection against terrorists, who can slip through lengthy hard-to-guard borders. As such, it must assume a preemptor role and has done so, especially since 9/11. As the United States continues to apply new technologies (e.g., unmanned drones in Afghanistan) to augment its preemption efficiency, these efforts will cement the US position as the key preemptor against terrorism.

(c) Case 2: Foreign interests and terrorists' bias

To simplify the analysis, we first assume that both countries have the same valuation parameters for domestic damages ($\theta^H = \theta^F = 1$) and also possess the same extent of foreign interests – i.e., $\delta^F = \delta^H = \delta$ – and that the terrorists have a bias α toward attacking country *H*. In this scenario, equation (26) becomes:

$$(30) \qquad \left(\frac{c_m^H - c_m^F}{T'(m)}\right) > (1-\delta)\left[\frac{(1-\alpha)\left(c^F - c^H\right)}{c^H + c^F} - \alpha\right].$$

Consider the case where $c_m^H - c_m^F < 0$, $c^F - c^H > 0$, and $\alpha = 0$. *H* is both a low-cost defender and a low-cost preemptor and (30) is not unambiguously satisfied. Given the cost parameters, it is obvious that the right-hand side of the inequality must fall as δ rises. Appendix C shows that preemption must rise when the nation providing it has greater foreign interests. Thus, m must rise with δ, reducing the absolute value of T' [note that $T'' > 0 \Rightarrow d\left(-T'\right)/dm < 0$]. This must increase the left-hand side of (30). Thus, (30) is more likely to be satisfied for higher values of δ. With foreign concerns, *H* gains an added benefit from preemption by reducing its losses in *F*, which corresponds to $T'(m)(1-p)\delta^H$ in (21). These foreign losses can limit the incentive of a low-cost defender in eschewing preemption. That is, as a low-cost defender, *H* may still preempt if its foreign interests are sufficiently strong and its preemption costs are comparatively low. A high δ^H means that preemption can limit *H*'s losses at home and abroad.

Next, we consider the influence of terrorists' bias against attacking *H*, so that α is positive. In (22), an increase in α raises the likelihood of a terrorist attack in *H* [note that $\frac{dp}{d\alpha} = \frac{\tilde{c}^F}{\tilde{c}^H + \tilde{c}^F} > 0$]. Using *H*'s preemption first-order condition in (21) and noting that δ^H is less than θ^H, we can show that the marginal benefit from preemption rises with α. As terrorists fixate on *H*, their attack probability is greater for any combination of defensive measures by countries *H* and *F*. Thus, an increase in α shifts up *H*'s marginal benefit curve in Figures 3-4. The analysis implies:

Proposition 2: For the base model, foreign interests can induce even a low-cost defender to engage in preemption owing to losses abroad that cannot be limited through homeland security. This tendency is stronger when the targeted country is not a high-cost preemptor. Prime-target nations are more apt to provide preemption, thereby curtailing the importance of cost comparisons.

As a prime-target nation and high-cost defender, the United States has little choice but to assume the preemptor role against global terrorism. In so doing, any country must exercise care that its preemptive measures are not excessive or brutal or else negative externalities from more grievances and terrorism, not modeled here, may result (Rosendorff and Sandler 2004; Sandler *et al*. 2009).

Other interesting possibilities include $\theta^H \neq \theta^F$ and $\delta^H \neq \delta^F$, whose details we leave to the reader based on (26). Suffice it to say that a relatively higher θ^H raises *H*'s valuation of its domestic damages relative to *F*, making it more likely to preempt all else being equal. Also, δ^H augments $\tilde{c}^H$ relative to $\tilde{c}^F$. This enhances *H*'s interest in preemption to limit its terrorism vulnerabilities globally. This intuition also concurs with the United States assuming the lion's share of preemptive actions against today's transnational terrorism threat. Appendix C provides comparative static analysis of the effects of changes in α, θ^H, and δ^H on preemption.

IV. FURTHER CASES

Our comparative-statics results explain the behavior of other high-cost defenders, whose marginal preemption costs are relatively low. The United Kingdom has significant foreign interests and a long hard-to-defend coastline, which makes it a high-cost defender. United Kingdom's ability to project power abroad makes its marginal preemption costs relatively small compared with most countries. Hence, its active role as a preemptor of transnational terrorism after 9/11 agrees with our comparative statics. This is especially true when we consider the United Kingdom as a prime-target country, second to the United States. France is in a similar position and has engaged in preemption. Spain is also a high-cost defender with long borders and many entry points. Even though Spain is not a low-cost preemptor, it participated in the offensive on al-Qaida until the Madrid bombing and the change in government.

Our comparative statics indicate that low-cost defenders with high-cost preemption will not engage in preemption. Switzerland and Austria are low-cost defenders with relatively easy-to-defend borders and few entry points, compared with Spain, the United Kingdom, and France. The Alps limits defensive expense in Switzerland and Austria. Given their inability to project power to foreign lands harboring terrorists, Switzerland and Austria are high-cost preemptors. Understandably, neither country joined efforts on the war on terrorism. Other small European countries – e.g., Croatia – are in the same position.

Another example involves Pakistan and India, where Lashkar-e-Taiba poses a terrorism risk for both countries. This group is based in Pakistan and has two aims: a pan-Islamic state in South Asia and an end to India's rule in Kashmir. Lashkar-e-Taiba has conducted terrorist attacks in both Pakistan and India, and is believed responsible for the November 2008 massacre in Mumbai, India. Even though India is the prime-target country and a high-cost defender given its myriad entry points, it has not taken preemptive actions in Pakistan. This is because the marginal preemption costs of violating Pakistani territory is extremely high (maybe infinite), since such actions may ignite a nuclear war. Surely, Pakistan has much smaller preemption costs and, thus, has taken some recent actions against the group to limit hostilities with India. Pakistani actions will increase as breakaway elements from Lashkar-e-Taiba attack Pakistani interests.

V. MODEL ROBUSTNESS

In this section, we alter three key assumptions to demonstrate that the model is robust. To limit complications, we assume that the valuation parameters (θ^i) are unity, the targeted countries have no foreign interest $\left(\delta^H = \delta^F = 0\right)$, and terrorists are not biased toward attacking one country ($\alpha = 0$). Notation remains unchanged.

(a) Reversing the stages: defense before preemption

If the defense decision precedes preemption, then a nation may choose defense strategically to influence the equilibrium preemption level in stage 2, thereby affecting the level of terror. In particular, a nation may pick a high level of defense as a ploy to place the preemption burden on its counterpart. Although strategic motives change with this staging reversal, the thrust of our central findings does not change: relative defense cost and preemption cost comparisons determine the interaction between the defense and preemption choices. Moreover, a high-cost defender is apt to do the preempting.

With some algebra, we can establish[14]

(31) $$\gamma p_2 > c^F\left[\left(c_m^H/c_m^F\right)-\left(c^H/c^F\right)\right],\ \gamma=(T')^2/T''>0.$$

Since the left-hand side of (31) is positive, the equation is necessarily satisfied if

(32) $$\left(c_m^H/c_m^F\right)\le\left(c^H/c^F\right).$$

Equation (32) is a sufficient condition for *H* to preempt and for *F* to free ride in the reverse-order game. This relationship is more likely to hold when *H* is the relatively high-cost defender and/or the relatively low-cost preemptor. If, for example, the nations have identical marginal preemption costs so that the left-hand side of (32) is 1, then *H* is the preemptor if it is the high-cost defender which mirrors (28). If, moreover, *H* is the low-cost preemptor and the high-cost defender, them it will preempt as was the case in Section III(a). Similarly, *H* will preempt even as a high-cost preemptor, provided that it is more disadvantaged as the defender. In short, *Proposition* 1 holds qualitatively regardless of the order of play. Allowing for foreign interests and terrorist targeting bias will have the same influence as captured in *Proposition* 2.

(b) Nonconstant marginal preemption costs and mutual preemption

We now return to the base model with preemption preceding defense, while assuming no foreign interests or terrorists' targeting bias. Our goal is to show that allowing for nonconstant marginal preemption costs and positive preemption levels for both countries do not qualitatively change our core results. To accomplish this task, we let the marginal preemption cost functions be $c_m^j = c_m^j\left(m^j\right)$, $j = H,F$, which are increasing in m^j. When $m^F = 0$, F's marginal preemption cost is relatively low, so that its marginal preemption benefit at $m^H > 0$ likely exceeds c_m^F. Consequently, *F* is not necessarily prone to free ride on the other country's preemption, leading to interior solutions for m^H and m^F.

Stage 1 first-order conditions for m^H and m^F are, respectively,

(33) $Tp_2 a_1^F + T'(m)\,p + c_m^H = 0$, and $-Tp_1 a_1^H + T'(m)(1-p) + c_m^F = 0$.

Using substitutions identical to earlier ones to derive (29), we get

(34) $c_m^H - c_m^F = T'\left(c^F - c^H\right) / \left(c^H + c^F\right)$.

If both countries possess identical marginal preemption cost functions, then $c^H \geq c^F$ implies that $c_m^H\left(m^H\right) \geq c_m^F\left(m^F\right)$, so that $m^H \geq m^F$. That is, the high-cost defender provides the same or more preemption as compared with the low-cost defender – a result that qualitatively agrees with the free-riding case $\left(m^F = 0\right)$. The low-cost defender stands to get more spillover preemption benefits.

(c) Defensive actions and global terror reduction

We expand the basic model to allow defensive measures to reduce global terror so that the defensive stage is no longer a constant-sum contest. If hardening a target results in terrorists being captured and killed or their assets being seized during an attack, then defensive action can yield public security gains to bolster the defender's private deflection benefits. Any negative consequences to the attacking terrorists make all potential targets more secure – hence, the public characterization. Nevertheless, defender-specific gains are assumed to dominate since any terrorism reduction is fortuitous. That is, defensive measures cannot substitute for proactive operations that directly attack terrorists and their assets (e.g., bases and training camps).

The level of terrorism is now $T = T(m, A)$, where $m = m^H + m^F$, $A = a^H + a^F$, $T_1 < 0$, $T_2 < 0$, and $T_{11} > 0$. For tractability, *T* is assumed to be linear in *A*, so that $T_{12} = T_{21} = T_{22} = 0$. The stage-2 first-order conditions for defense are:

(35) $V_1^H = Tp_1 + pT_2 + c^H = 0$ and $V_2^F = -Tp_2 + (1-p)T_2 + c^F = 0$.

Compared with earlier stage-2 first-order conditions for defense, there is an additional marginal benefit arising from the reduced terrorism (i.e., T_2 term). While this influence creates a private incentive to increase defense, there is also a public incentive to free ride on the actions of others. This public benefit attenuates the tendency to oversupply defense. Simultaneous solution of the first-order conditions yield stage-2 equilibrium defense levels: $a^H = a^H(m)$ and $a^F = a^F(m)$. Stage-1 solutions are similar to the basic model and are not repeated. Using (35), the $a^j(m)$ equilibrium levels, and the first-stage first-order conditions, we can show that

(36) $\left[\left(c_m^H - c_m^F\right)/T_1\right] > \left[\left(c^F - c^H\right)/\left(c^H + c^F\right)\right]\mathrm{Z}$,

where $\mathrm{Z} = -Tp_1/c^H > 0$. Relation (36) is qualitatively similar to (27), so that the conclusions that follow from (27), including *Proposition* 1, hold with a nonconstant-sum contest where defensive measures can reduce terrorism.

VI. CONCLUDING REMARKS

This is the first paper to investigate the interaction between the mix of preemptive and defensive counterterrorism policies in a comparative advantage framework when countries confront the same transnational terrorist threat. The analysis identifies five key determinants: the countries' relative defensive costs, their relative preemption costs, their relative assets abroad, their relative damage assessment at home, and terrorists' attack preferences. Our two-stage game representation shows that, ceteris paribus, the high-cost defender will often provide preemption that benefits both targeted countries. In addition, the prime-target country is prone to preempt in order to reduce its subsequent defense spending. Lower preemption costs are not sufficient to determine the preemptor, because high defense costs and/or prime-target status can overcome the influence of comparatively low preemption costs. Countries with greater interests abroad have higher effective marginal defense costs, which bolsters their preemption efforts. Moreover, countries that place more value on terrorist damage at home will, ceteris paribus, preempt. In practice, prime-target countries with long borders, many entry points, and high levels of foreign direct investment are the likely preemptors, a prediction that fits the United States and the United Kingdom. The analysis shows that studying preemptive and defensive counterterrorist measures in isolation provides only a partial picture, because the interplay of the two decisions are ignored. By relaxing key assumptions in Section V, we show that the order of play, variable preemption costs, and terrorism-reducing defensive measures do not qualitatively affect our results.

Our study also offers novel insights into the market failures associated with preemptive and defensive countermeasures. Countries that are least prone to oversupply defensive actions – the high-cost defenders – are motivated to preempt a common threat owing to their defensive disadvantage, thereby lessening the undersupply of preemption. Preemption in stage 1 limits the overprovision of defense in stage 2. The corner solution that may characterize preemption in stage 1 means that the market failure associated with undersupplied preemption is not completely eliminated – one at-risk country is still free riding and the preemptor is not internalizing the benefits conferred on the other country. Nevertheless, there is some amelioration of the market failure owing to the interplay of the two stages. Even when both countries preempt, the preemption levels are still insufficient owing to incomplete internalization of external benefits.

Our analysis demonstrates that effective counterterrorism policy must assume a broader viewpoint that integrates defensive and preemptive choices. This requires much greater cooperation between the agency charged with homeland security and that charged with defense (Hoffman 2006, p. 16). For transnational terrorism, this integration must involve counterterrorism institutions in all targeted countries.

APPENDIX A: DERIVATION OF EQUATION (11)

To derive (11), we use (7b) and (9) to give:

(A1) $-Tp_1 - \tilde{c}^H = Tp_2 - \tilde{c}^F$,

which implies that

(A2) $T\left(p_1 + p_2\right) = \tilde{c}^F - \tilde{c}^H$.

Next, we use (3) to substitute for p_1 and p_2 in (A2) to give:

(A3) $$a^F - a^H = \frac{\left(\tilde{c}^H - \tilde{c}^F\right)\left(a^H + a^F\right)^2}{T\left(1-\alpha\right)}$$

Equation (11) in the text then follows from substituting the right-hand side of (A3) for $\left(a^F - a^H\right)$ in the expression for p_{12} in (3) and simplifying.

APPENDIX B: DERIVATION OF EQUATION (16)

Taking the ratio of (7b) and (9) gives:

(B1) $-p_1/p_2 = \tilde{c}^H/\tilde{c}^F$.

Substituting for p_1 and p_2 from (3) yields:

(B2) $-p_1/p_2 = a^F/a^H$.

(B3) then follows from (B1)-(B2):

(B3) $a^F/a^H = \tilde{c}^H/\tilde{c}^F$.

By (7b) and (3), we have

(B4) $$\frac{T\left(1-\alpha\right)a^F}{\left(a^H + a^F\right)^2} = \tilde{c}^H,$$

which can be transformed to

(B5) $$\frac{T(1-\alpha)a^F}{\left(a^F\right)^2\left[\left(a^H/a^F\right)+1\right]^2}=\tilde{c}^H.$$

Rearranging and substituting for $\left(a^H/a^F\right)$, via (B3), gives:

(B6) $$\left(\frac{T}{a^F}\right)\left(\frac{1-\alpha}{\left[\left(\tilde{c}^F/\tilde{c}^H\right)+1\right]^2}\right)=\tilde{c}^H.$$

Upon cancellation and cross multiplication, we obtain:

(B7) $$a^F=\frac{(1-\alpha)T\tilde{c}^H}{\left(\tilde{c}^H+\tilde{c}^F\right)^2}.$$

To find a^H, we rearrange (B3) to give

(B8) $$a^H=a^F\left(\tilde{c}^F/\tilde{c}^H\right).$$

Replacing a^F in (B8) with the right-hand side of (B7), we get the formula for a^H in (16).

APPENDIX C: COMPARATIVE STATICS IN STAGE 1 WITH RESPECT TO α, θ^H, AND δ^H

Suppressing parameters other than α, θ^H, and δ^H, we can express *H*'s first-order condition in (21) as:

(C1) $$L_1^H\left(m^H,m^F,\alpha,\theta^H,\delta^H\right)=0.$$

With the help of (C1) and the knowledge that $L_{11}^H>0$, we have:

(C2) $$dm^H/d\alpha=-L_{13}^H/L_{11}^H\geq 0$$

if and only if $L_{13}^H\leq 0.$ Using (21), we obtain:

(C3) $$L_{13}^H=\left(\theta^H-\delta^H\right)T'(m)\left(\frac{\tilde{c}^F}{\tilde{c}^H+\tilde{c}^F}\right)^2<0.$$

Thus, $dm^H / d\alpha > 0$, as required.

Similarly, we have:

(C4) $$dm^H / d\theta^H = -L_{14}^H / L_{11}^H \geq 0$$

if and only if $L_{14}^H \leq 0$. Using (21), we derive

(C5) $$L_{14}^H = \tilde{c}^F \left[a_1^F + \left(\theta^H - \delta^H\right) \frac{\partial a_1^F}{\partial \theta^H} \right] + T'(m) \left[p + \left(\theta^H - \delta^H\right) \frac{\partial p}{\partial \theta^H} \right],$$

which reduces to:

(C6) $$L_{14}^H = \tilde{c}^F \left[\frac{2(1-\alpha)\left(\tilde{c}^H\right)^2 T'(m)}{\left(\tilde{c}^H + \tilde{c}^F\right)^3} \right] + T'(m) \left[\alpha + (1-\alpha) \left(\frac{\tilde{c}^H}{\tilde{c}^H + \tilde{c}^F} \right)^2 \right] < 0,$$

so that $dm^H / d\theta^H > 0$.

Finally, we have:

(C7) $$dm^H / d\delta^H = -L_{15}^H / L_{11}^H.$$

It can be shown that:

(C8) $$L_{15}^H = \frac{T'(m)(1-\alpha)\left(\tilde{c}^F\right)^2 \left(3\tilde{c}^H + \tilde{c}^F\right)}{\left(\tilde{c}^H + \tilde{c}^F\right)^3} < 0 \Rightarrow dm^H / d\delta^H > 0.$$

These results indicate that *H*'s preemption increases with greater targeting risks, higher values on terrorist damages at home, and larger foreign interests.

ACKNOWLEDGEMENTS

Bandyopadhyay is a Research Officer; Sandler is the Vibhooti Shukla Professor of Economics and Political Economy. This research was partially supported by the US Department of Homeland Security (DHS) through the Center for Risk and Economic Analysis of Terrorism Events (CREATE) at the University of Southern California, grant numbers N00014-05-0630 and 2007-ST-061-000001. However, any opinions, findings, and conclusions or recommendations are solely those of the authors and do not necessarily reflect the views of the DHS, the Federal Reserve Bank of St. Louis, or of the Federal Reserve System. The authors also profited from comments from two anonymous referees.

NOTES

1. For example, the following papers do not address preemption: Bier *et al*. (2007) and Kunreuther and Heal (2003). Rosendorff and Sandler (2004) do not allow for defensive measures. In primarily a domestic setting, Keohane and Zeckhauser (2003) consider both preemptive and defensive measures as noninteractive choices.

2. The model can easily capture the case where targeted nations divide into two groups, in which one group cooperates and the other acts independently (see Poveda and Tauman 2007).

3. This attack probability function is similar to, but different than, contest success functions (CSFs), where success hinges on the ratio of *own* to total effort (Clark and Riis 1998; Hirshleifer 2000; Skaperdas 1996).

4. We use the convention that f_i denotes *f*'s first-order partial with respect to its *i*th argument and that f_{ij} is the partial derivative of f_i with respect to its *j*th argument.

5. The second-order condition for *H*'s independent choice, $V_{11}^H = T\left(\theta^H - \delta^H\right)p_{11} > 0,$ is satisfied since $p_{11} > 0.$

6. The Department of Homeland Security (DHS) is not charged with protecting Americans or their property abroad; hence, DHS efforts to make Americans or their assets more secure at home may make them more vulnerable abroad. Recent statistics on the geographical dispersion of US-directed attacks following 9/11 support this vulnerability worry (Enders and Sandler 2006b).

7. This follows from the constant overall threat assumption so that stage 2 is a constant-sum game – see Dixit (1987). This constant-sum assumption is relaxed in Section V(c).

8. The first-order conditions for joint optimization can be analyzed to show that we have a corner solution at the cooperative equilibrium. Given that the Nash defense levels in (16) are

strictly positive as long as terrorism (*T*) remains, we can infer that there is overdefense in the noncooperative Nash equilibrium.

9. The term $-p\theta^H T'(m)$ is the marginal benefit from terrorism reduction in *H*, while $-(1-p)\delta^H T'(m)$ indicates *H*'s marginal benefit from terrorism reduction in *F*.

10. Given that the cooperative defense levels are zero, the probability of attack between the two targets can differ only due to the bias parameter so that p is $p(\alpha)$. With all parameters suppressed, the joint loss for stage 1 takes the form: $L^C = \mu T(m) + c_m^H m^H + c_m^F m^F$, where μ is a positive constant (given the parameters). Assuming without loss of generality that $c_m^H < c_m^F$, we have $m^F = 0$ and $m^H > 0$ in the cooperative equilibrium (whenever $|T'|$ is sufficiently large as *m* tends to zero). This means that the nations will jointly assign preemption to the lower marginal preemption cost nation. Clearly, our noncooperative preemption outcome is distinct (and therefore not surplus maximizing), because unlike the first-best case, marginal defense costs also play a role in determining the pattern of provision.

11. *H* endogenizes (16) in its stage-1 decision making owing to backward induction.

12. This follows from (1), (16), and (21) because $T'' > 0$. Similarly, $L_{22}^F > 0$.

13. In (25), a positive value of L_2^F means that *F*'s net marginal preemption benefits are negative, since marginal cost must then exceed the two negative terms representing marginal benefits.

14. Details are available from the authors upon request.

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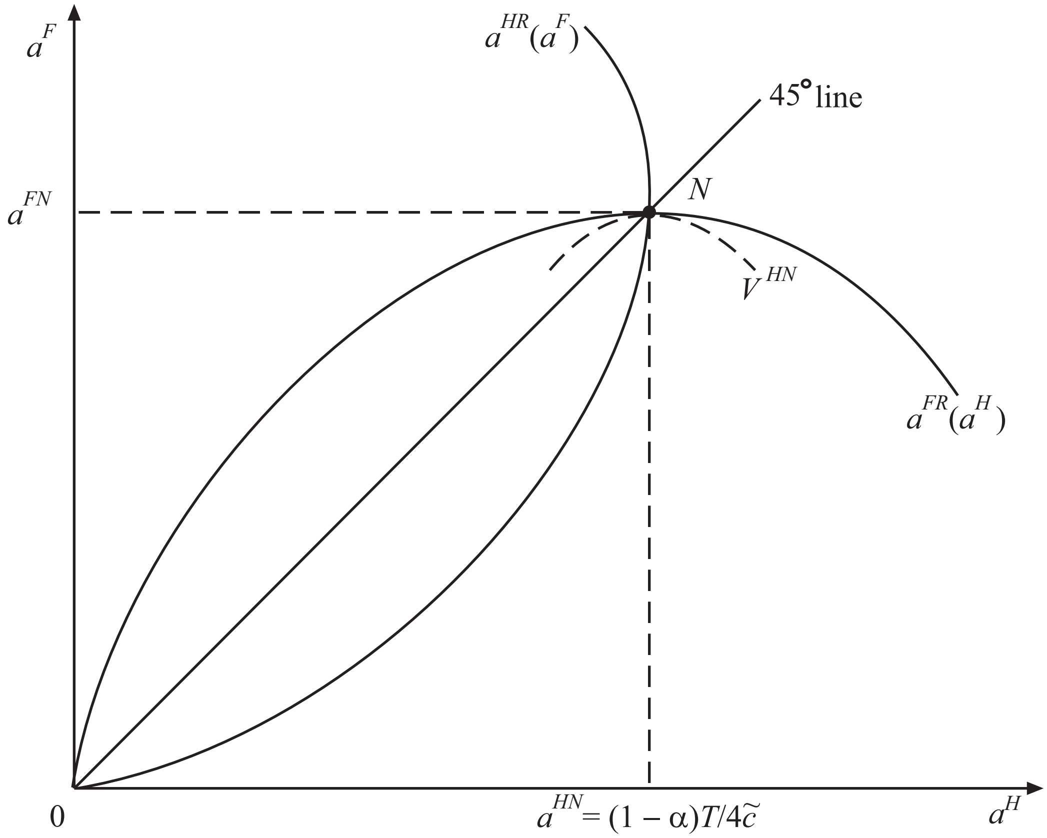

Figure 1. Stage 2: Identical (effective) marginal defense costs ($\tilde{c}^H = \tilde{c}^F = \tilde{c}$)

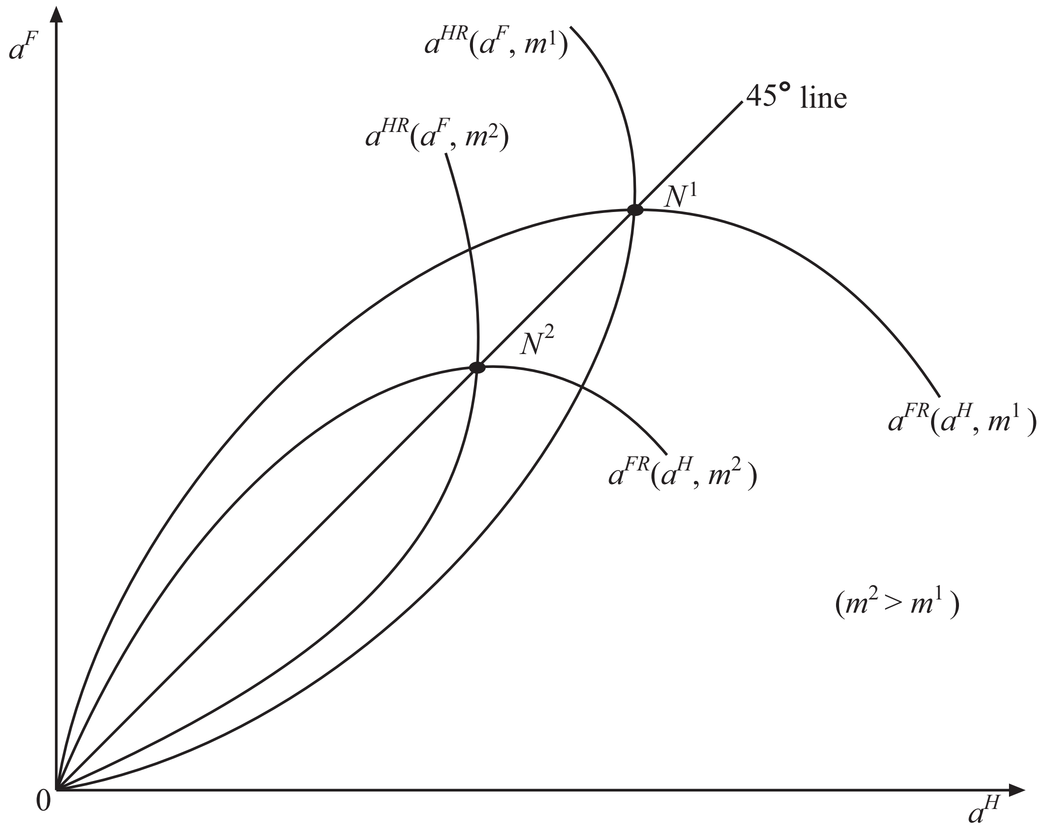

Figure 2. Stage 2: Influence of proactive measures on defensive response

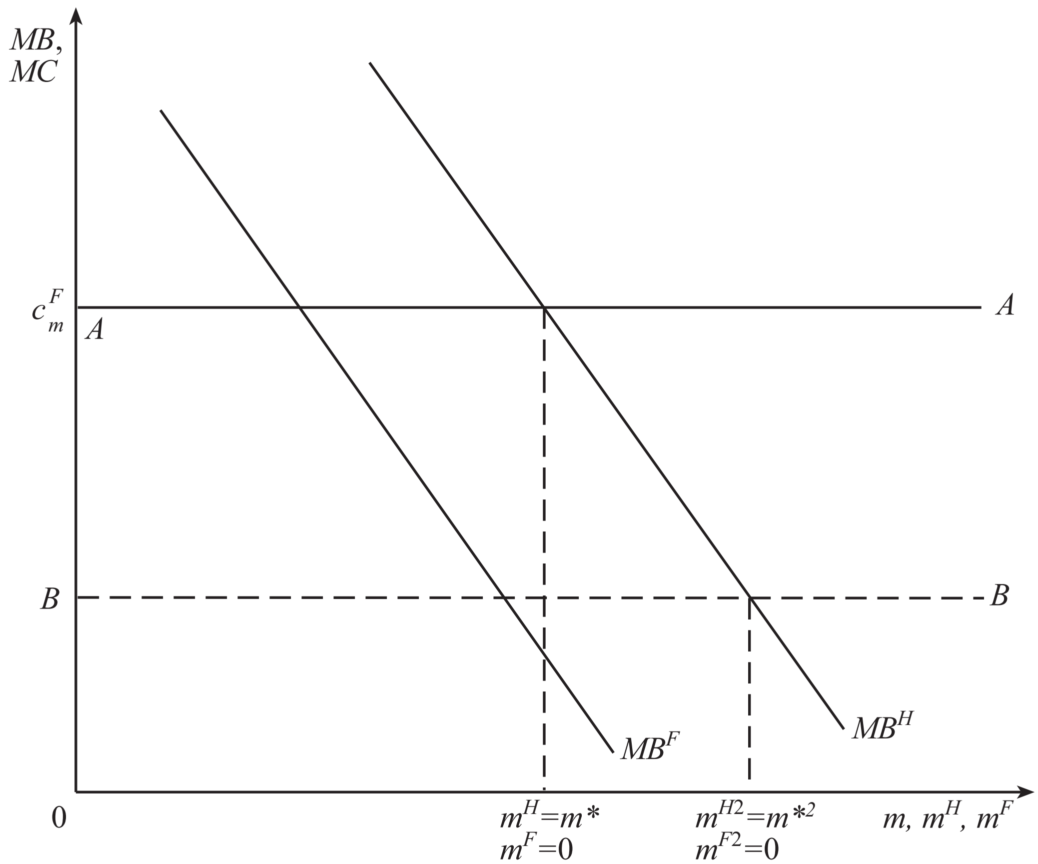

Figure 3. Stage 1: Two alternative preemption marginal cost scenarios with $c^H > c^F$

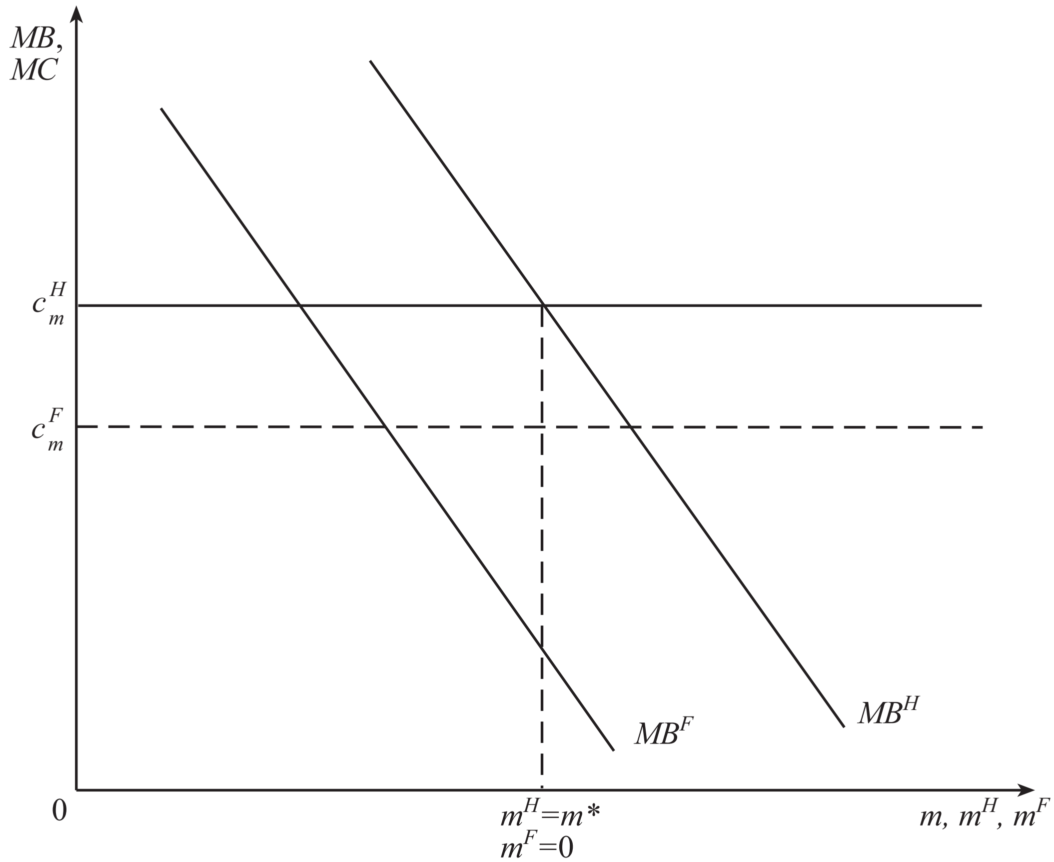

Figure 4. Stage 1: Premption decision with *H* the high-cost preemptor and defender